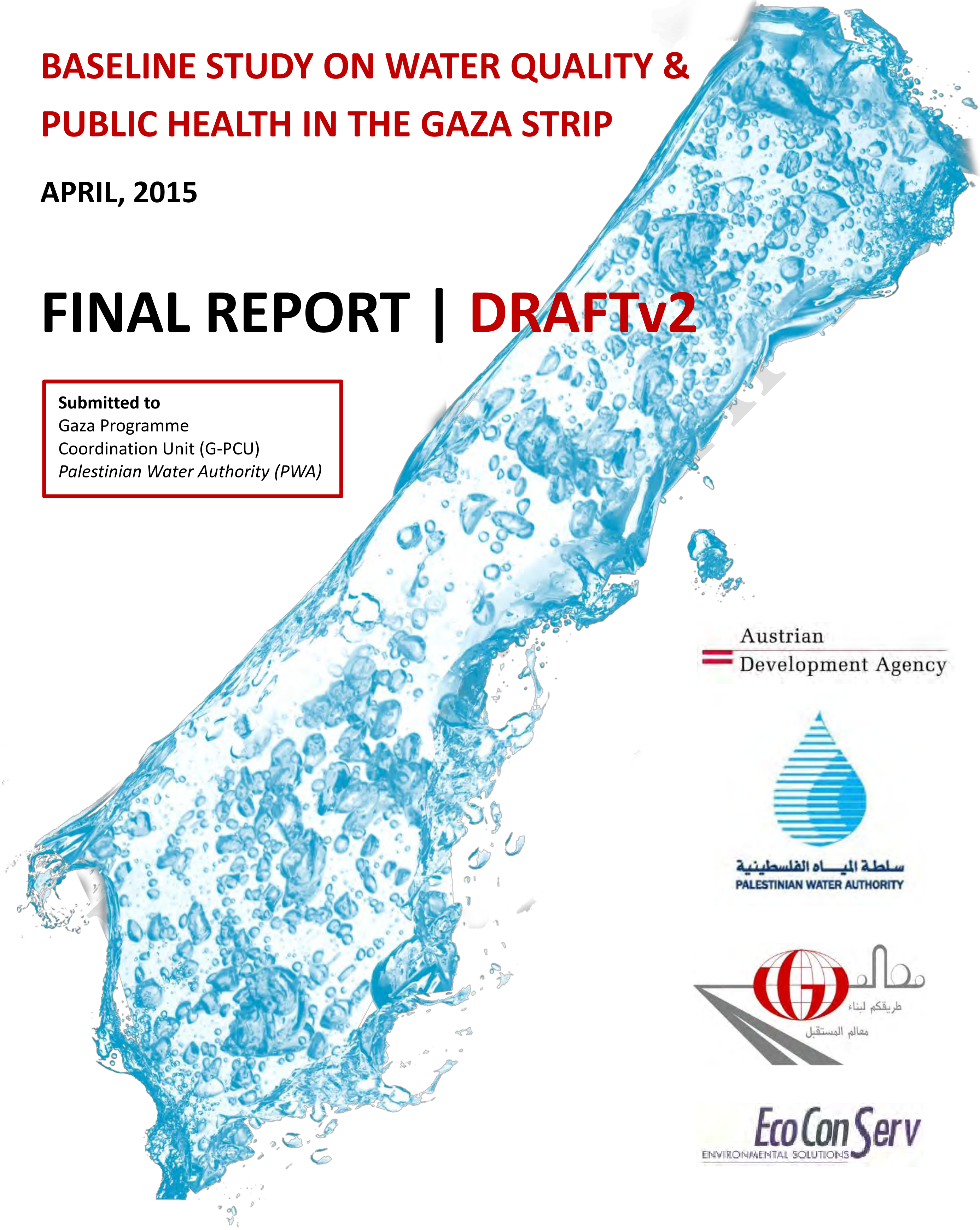
# BASELINE STUDY ON WATER QUALITY & PUBLIC HEALTH IN THE GAZA STRIP

**APRIL, 2015**

# FINAL REPORT | DRAFTv2

**Submitted to**
Gaza Programme
Coordination Unit (G-PCU)
*Palestinian Water Authority (PWA)*



Austrian Development Agency

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

طريقكم لبناء معالم المستقبل

EcoConServ
ENVIRONMENTAL SOLUTIONS

# A Letter of Appreciation

We, the research team, on behalf of the Palestinian people, extend our gratitude and thanks to the Austrian Development Agency (ADA) for their generous funding and sponsorship of this endeavor.

Austrian Development Agency

*Thank You*

# PREFACE

وجعلنا من الماء كل شيء حي

**{And from water, We made every living thing}**
Quran (21:30)

The Palestinian people have suffered tremendously over the last 67 years and they continue to suffer today from shortages, deprivation, and loss of livelihood resources. In the Gaza Strip, the public's health is worsening, and access to safe drinking water, which is a basic human right, is becoming an even bigger challenge.

The Palestinian Water Authority (PWA) is sparing no effort in trying to provide safe and affordable drinking water to the Palestinian people in the Gaza Strip. Through a rolling program of interventions, the PWA aims to make sure that this vulnerable population has access to a sustainable source of drinking water for the current generation and the generations to come.

One of the most important steps in achieving PWA's goal is to setup a monitoring program that will identify the locations in the Gaza Strip which are most in-need of immediate intervention by linking the rapidly deteriorating water quality to the changes in the public's health.

This project is a cornerstone in a program that will arm the decision makers with the right set of tools to make informed decisions for the tasks ahead, and this is what this baseline report aims to do. We have collected and analyzed the data, and produced the results and recommendations that will be useful for the next steps on the journey ahead to alleviate the Palestinian people's suffering.

We would like to thank all the people that made this endeavor possible, and especially to the Palestinian people for their patience, hope, and perseverance, demanding justice, independence, and freedom.



We remain faithfully yours,

| | |
|---|---|
| Dr. Bassam Abu Hamad | Team Leader – **UG** |
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The list of dedicated and committed individuals and institutions responsible for the completion of this work is large, and they all deserve our deepest regards, thanks, and gratitude. However, there are a few that we would like to thank personally, for their continuous cooperation, assistance, and unwavering support during the span of this project.

*Special thanks to;*

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| Eng. Nizar Alwhaidi | Ministry of Agriculture |
| Dr. Saeed Ghabayen | GIS Expert |

We thank you all for your generous support and feedback,

Sincerely yours,
**Dr. Bassam Abu Hamad**
Team Leader

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| | |
|---|---|
| ADA | Austrian Development Agency |
| ANERA | American Near-East Refugee Aid |
| ASR | Age Standardized Ratio |
| BLL | Blood Lead Levels |
| Ca | Calcium (element) |
| Cl | Chlorides (element) |
| CMWU | Coast Municipalities Water Utility |
| Cr | Chromium (element) |
| CSO-G | Comparative Study of Options – Gaza |
| EPA | Environmental Protection Agency |
| EQA | Environmental Quality Authority |
| ER | Entity Relationship (Diagram) |
| FAO | Food & Agriculture Organization |
| Fe | Iron (element) |
| G-PCU | Gaza-Programme Coordination Unit |
| GIS | Geographic Information System |
| Hb | Hemoglobin |
| ICD 10 | International Classification of Diseases |
| IDA | Iron Deficiency Anemia |
| INGO | International Non-Governmental Organization |
| K | Potassium (element) |
| KFW | Kreditanstalt fur Wiederaufbau |
| MCM | Million Cubic Meters |
| Mg | Magnesium (element) |
| Mg/L | Milligrams per liter |
| MOH | Ministry of Health |
| MOA | Ministry of Agriculture |
| Na | Sodium (element) |
| NIPH | Norwegian Institute of Public Health |

| | |
|---|---|
| NGO | Non-Governmental Organization |
| $NO_3$ | Nitrate |
| PA | Palestinian Authority |
| PCA | Plate Count Agar |
| pH | Power of Hydrogen |
| PHC | Primary Health Care |
| PHG | Palestinian Hydrology Group |
| PNIPH | Palestinian National Institute of Public Health |
| PWA | Palestinian Water Authority |
| RPI | Rolling Program of Interventions |
| RO | Reverse Osmosis |
| $SO_4^{2-}$ | Sulfate |
| Sr | Strontium (element) |
| OCHA | Office for the Coordination of Humanitarian Affairs |
| TDS | Total Dissolved Solids |
| UG | Universal Group for Engineering and Consulting |
| UNDP | United Nations Development Programme |
| UNICEF | United Nations Children's Fund |
| UNRWA | United Nations Reliefs and Work Agency for Palestine Refugees in the Near East |
| USAID | United States Agency for International Development |
| WHO | World Health Organization |

# EXECUTIVE SUMMARY

Based on available geospatial data collected from all relevant stakeholders regarding two important themes; water quality and water use related public health diseases, this report, with the assistance of Geographic Information System software, aims at finding any potential associations between these two themes in the Gaza Strip. This report concludes the findings derived from a comprehensive Baseline Study on Water Quality and Public Health in the Gaza Strip, which is conducted to document the present public health status in relation to the agreed water quality parameters, showcased on GIS-based mapping. The study also aims at establishing baseline information that link water quality to the public health and to explore the health impacts attributed to the existing poor quality of water in the Gaza Strip in order to suggest corrective strategies that might decrease mortalities and morbidities attributed to water use. This comprehensive baseline study acts as the copestone for a public health and water quality monitoring program. This study builds upon a brainstorming and consensus building meeting with the key stakeholders that was held in December 2014, which resulted in developing a consensus about the water quality parameters and the public health diseases that we need to focus on in this study, a systematic literature review that was achieved in March 2015, which has informed the research team and the stakeholders about the status of water quality and public health diseases at the local, national, regional, and international levels. The study took 7 months to complete.

The rapidly increasing Gaza's 1.8 million residents depend on the Coastal Aquifer to supply them with water but overuse and contaminants seeping into the ground, in addition to restriction on using the Palestinian water rights by the Israeli authorities, are threatening this vital resource. United Nations agencies and the Coastal Municipal Water Utility (CMWU) estimate that the aquifer's supply of water, which is suitable for human consumption, will not be livable in just few years (PWA, 2014). Exacerbating the problem is the decrepit state of Gaza's sanitation services. Due to the blockade imposed on the Gaza Strip for several years, many essential water, sanitation, and hygiene materials & equipment face continuous entry delays/denial, which have further complicated the situation and pushed Gaza's water & wastewater systems to the edge of collapse. This caused a delay for major projects that can assist in facing the aquifer deterioration.

Lack of electricity, modesty of experience, scarcity of economic resources, and supplies of essential materials such as cement, pipes, spare parts and special electro-mechanical treatment equipment, in addition to the significant tension between Israel and the Palestinians over the ownership of water rights and adherence to agreements over water management, constitute additional barriers. These factors have rendered the water and wastewater services unreliable and hazardous, which poses a formidable challenge for the population to obtain adequate clean water. Ninety eight percent of Gazans are connected to the municipal water network but supply is in complicated intermittent schemes and the quality is deteriorating, making its drinkability questionable. Currently, most households do not use municipal water supplies for drinking; rather it's being used mainly for hygiene and sanitary purposes. Municipal water is considered unfit for domestic consumption due to high and rising levels of chlorides and nitrates; as high as six times the World Health Organization (WHO) standard levels. In fact, there are several parameters far over the limits recommended by the WHO and even by the Palestinian Water Authority Guidelines which are more liberal than the WHO standards. In mid-December of 2014, UG organized a "Brainstorming and Consensus Building Meeting" and have acquired from the participants a list of parameters to consider for the GIS Analysis task under this assignment. The results of the nominal grouping and group discussions activities in the meeting yielded 9 water quality parameters and 11 public health diseases (detailed in the subsequent sections). Although the list of water quality parameters and the list of public health issues had been developed after discussion and based on comprehensive criteria, still it sometimes wasn't feasible to collect data pertaining to some of these water quality parameters and public health diseases. The group discussion in the brainstorming meeting also produced a schematic water supply map for the Gaza Strip (Annex 1) which shows water sources and possible sources of contamination associated with these sources.

Armed with the list of parameters, UG and EcoConServ collected all available data from all the relevant stakeholders, and constructed a geospatial database, noting all the gaps, limitations, and assumptions, to analyze the current situations in the Gaza Strip. Serious gaps in the quality of the data exist. The research team invested a lot of efforts and energy to get the needed data about the agreed list of public health diseases and water quality parameters. For some parameters, like biological contamination, skin diseases and malnutrition, it wasn't possible to find any reliable and consistent data that can be used for GIS application. The collected data regarding the other parameters is also questionable. However, the team applied the collected data to the GIS and produced 91 maps for health, 46 maps for water, 3 regression maps showing the linkage between water and public health data, and 10 basic maps (Annex 3). Statistical Regression testing indicated that there are strong positive statistically significant associations between the nitrate levels and the occurrence of parasitic infestations (adjusted r-squared =4; p value 0.001) in the reported data from UNRWA clinics in 2011. It could be concluded that the higher nitrates level in water is more associated with parasitic infestations. This could be related to seawater intrusion into the wells which is accompanied by higher level of nitrates, chloride and TDS. Also, nitrate contamination usually results from runoff of agricultural fertilizers or from human or animal wastes. Also, data pertaining to the year 2012 derived from UNRWA clinics show similar positive association between nitrate level and parasites with strong statistically significant associations (P value 0.0002). In the same year, according to data collected from UNRWA clinics, there were also statistically significant positive associations (Adjusted R-square 0.134 and p value 0.043) between the incidence of hepatitis and nitrate levels in the year 2012. Hepatitis is usually transmitted through oral-fecal route and is associated with water and food contamination. However, other non-significant correlations can't be rolled out completely; it rather reflects the gaps and inaccuracy of the data.

It could be concluded from this study that there is a link between the quality of water and public health diseases. An effective national strategy to improve data management processes at the health system and water related agencies should be developed. Also, the results of this study could be used as a basis for future comparisons and also for assessing the effects of interventions. The study highlighted areas with significantly high parameters which could stimulate further investigations and interventions to address such vulnerabilities as much as possible.

# BACKGROUND

Adequate sanitation, together with good hygiene and safe, reliable, affordable, and easily accessible water supply, are essential for good health. Widely, it is believed that improving water resources can improve health and reduce attributed death as well. In the Gaza Strip, water quality is affected by many different issues including soil/water interaction in the unsaturated zone due to recharge and return flows, mobilization of deep brines, and sea water intrusion.

In the absence of other significant water resources in the Gaza Strip, the aquifer is considered the main water supply source for all kind of human usage, which is currently facing a serious challenge in terms of quantity and quality. The available water quantities for the population in the Gaza Strip are inadequate due to the over-exploitation of the natural aquifer, and the water quality falls below the accepted international guidelines for potable water, which poses a risk on the public health of about 1.8 million people living in the Gaza Strip. This population is expected to grow at a rate of around 3.5% per year, and the domestic water demand is projected to grow from 91 million cubic meters per year (MCM) to more than 199 MCM in year 2035. Further to the lack of additional water resources, the situation is aggravated by the damaged or destroyed infrastructure due to the ongoing political conflict and blockade. The ongoing blockade of the Gaza Strip which has been intensified since 2007, has further complicated the situation and resulted in the delayed entry of many essential water, sanitation, and hygiene related materials. Also, the lack of electricity, limited experience and the scarcity of resources, in addition to the significant tension between Israel and the Palestinians over the ownership of water rights and adherence to agreements over water management, all these issues combined had negatively affected the quantity and quality of water supply for human use.

Currently, the issue of insufficient water for household usage is being dealt with through storage and strict rationing, yet the quality deterioration is still perceived as a major issue that cannot be addressed at the household level. Since most of the population in the Gaza Strip cannot afford to treat the water themselves, nor should they be expected to do so, they mostly depend on the private water vendors for their drinking and domestic use, which, due to the improper handling and storage practices, poses a risk of contamination (UNDP, 2004; MOH, 2014). These factors have posed a formidable challenge for the population to obtain adequate clean water. Although these circumstances require more long term strategic interventions from the public health and water sectors, the current population of Gaza is still dependent on the existing water resources, despite the insufficient quantity and the bad quality.

PWA conducted a comprehensive study of options for an additional supply of water for the Gaza Strip (CSO-G). The study developed a rolling program of interventions involving nine projects that are inter-linked, and in combination, form a coherent programme to address the critical issues in the water sector in Gaza. These projects include: establishment of a Gaza Programme Coordination Unit (G-PCU), introduction of an integrated water and health monitoring project, upgrading and/or provision of the domestic water distribution and supply network, enhanced levels of water imports from Israel to Gaza, introduction of short-term low-volume (STLV) desalination of sea water, phasing-in of higher levels of sea water desalination through the construction of two regional facilities, introduction and/or extension of pilot schemes for the reuse of treated wastewaters plants, accelerated completion of the major wastewater treatment plants, and finally, review of the use of water in the agricultural sector.

Thanks to the generous funding of the Austrian Development Agency (ADA), the Gaza-Programme Coordination Unit (G-PCU) at the Palestinian Water Authority (PWA) undertook this initiative by tasking Universal Group for Engineering and Consulting (UG), in cooperation with EcoConServ, to provide technical assistance to G-PCU's efforts in the implementation of the Rolling Program of Interventions for Additional Supply of Water for the Gaza Strip (TA-G-PCU), in Palestine.

## AIMS & OBJECTIVES

This comprehensive study on water quality and public health in the Gaza Strip is conducted to document the present public health status related to existing water quality showcased on GIS-based mapping. The study aims at establishing baseline information that links water quality to the public health and to explore the health impacts attributed to the existing poor quality of water in the Gaza Strip in order to suggest corrective strategies that decrease mortalities and morbidities attributed to water use.

**The scope of the study includes the following**;

- Review the existing studies.
- Develop a general water supply schematic diagram.
- Develop a comprehensive geo-database of the collected data.
- Conduct a GIS mapping study to develop a decision support system.
- Explore any possible correlation between water quality and water related diseases.

**In more specific terms, the study mainly focuses on the following tasks;**

- The collection all available data related to the chosen water quality and public health parameters focusing mainly on the past five years (2009 to 2013), but also covering data prior to 2009 where available, from various partners including the UN agencies, Ministries, Universities, CMWU, INGOs, NGOs, and others.
- Develop a comprehensive geo-database of the collected data by importing all of the collected data into the GIS database
- Analysis, interpretation, identification of the present public health and water quality situation, and predicting the future
- GIS maps production, discussion, and interpretation.
- Explore any possible correlation between water quality and water related diseases.

## STUDY PHASES & TASKS

The study was conducted in four phases/tasks. The first task was the Systematic Literature Review. A multidisciplinary review team lead by our public health expert and our water quality expert conducted the systematic review of the existing studies (online resources and gray literature) on water quality and public health in the Gaza Strip. Following administrative procedures, we solicited comments and data from all relevant parties to collect up-to-date reports for already conducted studies and key documents on water quality and public health. We then prepare a draft report that incorporates all the comments made by the client and the relevant parties, to summarize the key findings, identify information gaps, present the conclusions, provide recommendations, and list all references (Annex 4).

The second task was the Brainstorming and Consensus Building Meeting where we scheduled a meeting in mid-December of 2014 with relevant partners working on water quality and public health. The purpose of the meeting was to develop a general water supply schematic diagram, to identify potential areas for health risks, to classify the main water quality parameters, to associate the possible poor water quality effects on the public health, to develop a criterion for diseases' prioritization and outline a disease list attributed to biological and chemical contamination, and to identify the required epidemiological statistics and spatial data to be used for the GIS mapping study. Based on the brainstorming and consensus meetings results, we developed a water supply chain flow diagram (Annex 1) where areas for potential contamination are displayed, as well as, developing the list of anticipated water related health diseases.

The third task is the GIS Mapping, where using all the collected data about the developed list of parameters form the second task, we generated thematic maps, water sources location maps, spatially-distributed water-related disease maps, water quality maps, overlaying & integrated maps, and maps showing interpolated trends over the past five years. We then conducted an analysis of the GIS maps, using the best available methods needed for the GIS-layer analysis, to find potential correlations between water quality and related diseases.

The fourth and final task is the dissemination of the baseline study results. This report was circulated beforehand among key stakeholders and relevant experts for close validation and review, once all the comments have been inquired, this report was then disseminated in a meeting with the prominent key stakeholders and decision makers.

# STUDY METHODOLOGY

The first step in the study was to choose which water quality and public health parameters we are going to focus on, this was done by way of a brainstorming and consensus building meeting with all the relevant stakeholders. Participants were diverse and included 61 attendees from public health and water quality backgrounds. The team conducted a desk review analysis which resulted in developing a study based on the literature review. The next step was to collect all the available data for the chosen parameters from all relevant stakeholders such as UN agencies, Ministries, Universities, CMWU, INGOs, NGOs, and others, focusing on, but not limited to, the period from 2009 to 2013. After collecting all the required data to both our and PWA's satisfaction, the next step was to import the data into the GIS database. Once the geo-database has been developed, we then held numerous internal technical meetings and discussions to analyze, interpret, and identify the present public health and water quality situation in the Gaza Strip, and also, using trends and interpolations of the data, attempt to predict the future situation. We have also looked for areas of possible correlation between the chosen water quality parameters and public health diseases and produced GIS maps for further discussion to formulate results, conclusions, and recommendations.

## CHOOSING THE PARAMETERS

When choosing the parameters, for either water quality or public health, one can find that there are tens of parameters and diseases that can be analyzed and studied. However, studying them all would not be feasible. Hence, what had to be done was to narrow the list of parameters and diseases down to a manageable and reasonable amount. To do this, we enlisted the help of local experts and stakeholders to bring down the number of parameters and diseases. Although, the literature review already gives us an idea of which water quality and public health parameters are usually studies in the Gaza Strip, and which parameters are suspected to be linked to each other, the reasoning behind conducting the "brainstorming and consensus building meeting" was to focus this study to the list of parameters that were subject to a predetermined criteria that can be applied to Gaza's situation and hence can help us to choose the parameters most relevant to the Gaza Strip. The criteria these parameters were subject to are as follows:

1. **Vitality**: Is the parameter a vital one (vital few), does it have significant impact on the health status (such as mortality and morbidity)?
2. **Urgency**: Should the issue be solved as soon as possible?
3. **Feasibility**: Is it feasible to solve the issue (time, context, culture, monetary, and non-monetary resources)?
4. **Applicability**: Is it an action-oriented one (moving from analysis to action)?
5. **Sustainability:** Is there a possibility of having sustainable effects?
6. **Mitigation**: Is it preventability or is there a possibility for improvement?
7. **Prominent:** Is the issue regarded as important by stakeholders (policy, media, clients, providers)?
8. **Risk**: Is it a high risk (could have the most negative effect if the quality is poor)?

9. **Sizable**: Is it high volume (takes place often and affects a large number of people)?
10. **Problematic**: Is it problem prone (an activity susceptible to errors)?

The stakeholders rated the brainstormed list of ideas according to the criteria listed above and the results (highest scoring) of this activity yielded a list of 9 water quality parameters and 11 public health diseases. The list is outlined in Table (1) below.

*Table (1): List of chosen Public Health and Water Quality Parameters*

| Public Health Diseases | Water Quality Parameters |
|---|---|
| Diarrhea | Nitrates |
| Malnutrition | Fluorides |
| Hepatitis A | Bacteria |
| Typhoid and paratyphoid | Parasites |
| Parasitic diseases | Heavy Metals |
| Oncology | Light Metals |
| Meningitis | Chloride |
| Skin diseases | Total Dissolved Solid |
| Dental caries | pH |
| Renal diseases | |
| Anemia | |

This resulting list was then circulated to key stakeholders and decision makers and was endorsed by all, which allowed us to commence the next step, which is collecting the required data.

## DATA COLLECTION

Collecting the required data proved to be the most difficult task on this endeavor. The required raw data that is needed for the accurate construction of the GIS database and system had to be collected from Municipalities, NGOs, Governmental Organizations, UN agencies, and many others. The difficulties met can generally be attributed to the administrative bureaucracy and lack of availability of data at a central level, which required further commutation at a peripheral level with continuous support from the PWA. In addition, working strikes at some institutions required further coordination and re-scheduling of the meetings.

Although a written signed letter was issued by the PWA to the respective bodies, numerous attempts at obtaining the data was required, and in many instances, strings had to be pulled by way of professional working connections. Our team at UG and EcoConServ was adamant in the struggle for utmost completeness in the collection of all available data in the most detailed form available.

The purpose of this assignment is to attempt at establishing geographic links that can then be studied in details between water quality parameters, and public health diseases, hence geographically accurate and precise data was very important. The research team's approach strived to acquire the data at its most detailed level which will help the decision makers better assess the situation and hence construct better action plans of mitigation and corrective measures. In other words, we were not satisfied to collect data at a large scale, general levels, (i.e. governorates), but as detailed as possible with regard to the date and precise geographic location. We were successful at collecting most of the data in the form of neighborhood addresses, and clinic catchment areas for the public health list of diseases, and at exact coordinates for the water quality parameters.

Other collected data that was required for the completion of this study is the Gaza Strip neighborhood populations for the past 6 years, locations for municipal wells, agricultural wells, main water carriers (feeders), water desalination plants, water vendors supply units, wastewater pumping stations, wastewater carriers, discharge points, wastewater treatment plants and lagoons, solid waste dumping sites, and Ministry of Health (MOH) and United Nations Relief and Works Agency (UNRWA) clinics locations.

## Public Health Diseases

Although we have contacted numerous agencies, the data pertaining to the list of disease mentioned above was collected mainly from the MOH clinics, UNRWA clinics, NGO clinics, and the Hospitals. The main challenges encountered during the data collection process is the deep bureaucracy involved as well as the continuous strikes that occurred which delayed and rescheduled meetings. Moreover, the sensitivity of the data, especially data concerning renal diseases and oncology, were extremely difficult to obtain and strings had to be pulled by way of professional working connections.

Our team worked endlessly to acquire all the available data from both the MOH and UNRWA. Multiple visits to the MOH and UNRWA officials were needed to get permission to access the data. Along with the list of diseases submitted, we also asked MOH and UNRWA to supply us with the locations of all their clinics and their respective catchment areas. UNRWA's data, 21 clinics' locations, and geographic & population catchment areas for each clinic were relatively readily available. On the other hand, MOH data was not readily available. Apart from the epidemiology department at MOH, our team had to schedule meetings with administrative representatives of the 54 MOH clinics in the Gaza Strip to collect geographic and population catchment area information. Although the geographic catchment areas were identified, the actual served population per clinic was not precisely known, and hence the incidence values for the diseases may not be accurate.

It is first important to note that UNRWA's data was found to be much more credible than MOH's data. This is due to the fact that UNRWA has much better records keeping and reporting, and the fact that the MOH lacks resources, and is very sensitive to the political instability, which greatly influences its efficiency. The list of the selected diseases, their source, range, accuracy level, gaps, assumptions, limitations, and encountered data collection challenges are listed below.

1. <u>**Diarrhea:**</u>
    - **Source(s):** MOH Clinics & UNRWA Clinics
    - **Range:** Monthly from January 2009 to December 2013, compiled as cumulative yearly for years 2009 to 2013. All types of diarrhea for all age categories.

- **Accuracy Level:** The accuracy level of the reported data can be judged as not satisfactory with wide variations in accuracy and credibility. UNRWA data is accurate. Data is per UNRWA clinics catchment areas.
- **Gaps:** MOH and UNRWA data is only per clinic catchment areas.
- **Limitations:** MOH clinics do not have the actual number of served populous for each clinic, hence the incidence values will not be accurate.
- **Assumptions**: The total population for each MOH clinic catchment area will be used to calculate the incidence values. Plotted incidence rates for all types of diarrhea for all age categories.
- **Data Collection Challenges:** Bureaucratic delays to acquire the data from the respective epidemiological departments and clinics. Some delays encountered at UNRWA to obtain data access permissions.

2. **<u>Malnutrition:</u>** Data not available. There does not exist a systematic data collection at the Gaza strip level strategy for this disease. Only sample study data was found at the nutrition department, some clinics at MOH and UNRWA, NGOs and the World Health Organization (WHO). Mostly, data are collected through projects that focus on specific years with specific focus on certain groups. Some data are available at the household level but on samples of beneficiaries. Nutritional surveillance system at MOH is not active in monitoring and reporting data about malnutrition at the Gaza Strip level.

3. **<u>Hepatitis A</u>**
   - **Source(s):** MOH Clinics & UNRWA Clinics
   - **Range:** Monthly from January 2009 to December 2013, compiled as cumulative yearly for years 2009 to 2013.
   - **Accuracy Level:** The accuracy level of the reported data can be judged as not satisfactory with wide variations in accuracy and credibility. UNRWA data is accurate. Data is per UNRWA clinics catchment areas.
   - **Gaps:** MOH and UNRWA data is only per clinic catchment areas.
   - **Limitations:** MOH clinics do not have the actual number of served populous for each clinic, hence the incidence values will not be accurate.
   - **Assumptions**: The total population for each MOH clinic catchment area will be used to calculate the incidence values.
   - **Data Collection Challenges:** Bureaucratic delays to acquire the data from the respective epidemiological departments and clinics. Some delays encountered at UNRWA to obtain data access permissions.

4. **<u>Typhoid and Paratyphoid</u>**
   - **Source(s):** MOH Clinics & UNRWA Laboratories
   - **Range**: Monthly from January 2009 to December 2013, compiled as cumulative yearly for years 2009 to 2013.

- **Accuracy Level:** The accuracy level of the reported data can be judged as not satisfactory with wide variations in accuracy and credibility. UNRWA data is accurate. Data is per UNRWA clinics catchment areas.
- **Gaps:** MOH and UNRWA data is only per clinic catchment areas.
- **Limitations:** MOH clinics do not have the actual number of served populous for each clinic, hence the incidence values will not be accurate.
- **Assumptions:**
  - The total population for each MOH clinic catchment area will be used to calculate the incidence values.
  - The UNRWA laboratories collected both the suspected and confirmed cases of typhoid fever. Our team chose to plot the suspected number of cases since for some years the number of confirmed cases was zero, which may convey a misleading case for the decision makers.
- **Data Collection Challenges:** Bureaucratic delays to acquire the data from the respective epidemiological departments and clinics. Some delays encountered at UNRWA to obtain data access permissions.

5. **Parasitic Diseases**
   - **Source(s):** MOH & UNRWA Laboratories
   - **Range:** Monthly from January 2009 to December 2013, compiled as cumulative yearly for years 2009 to 2013. The values for the parasitic diseases is the combined number of cases of amebiasis, ascariasis, giardiasis, hymenolepiasis, strongyloidiasis, toxoplasmosis, and trichuriasis.
   - **Accuracy Level:** The accuracy level of the reported data can be judged as not satisfactory with wide variations in accuracy and credibility. UNRWA data is accurate. Data is per UNRWA clinics catchment areas.
   - **Gaps:** MOH and UNRWA data is only per clinic catchment areas.
   - **Limitations:** MOH clinics do not have the actual number of served populous for each clinic, hence the incidence values will not be accurate.
   - **Assumptions:** The total population for each MOH clinic catchment area will be used to calculate the incidence values. List of included parasitic diseases to be included on maps.
   - **Data Collection Challenges:** Bureaucratic delays to acquire the data from the respective epidemiological departments and clinics. Some delays encountered at UNRWA to obtain data access permissions.

6. **Oncology**
   - **Source(s):** MOH (Sensitive Information)
   - **Range:** All cases from 1995 to 2013.
   - **Accuracy Level:** Street & neighborhood addresses through cross-checking the name and ID numbers of the patients with the Civil Registry.

- **Gaps:** 3,186 cases of the total 14,086 cases had missing address & ID information.
- **Limitations:** The 3,186 cases with missing address information. About 20% error in the data; therefore excluded. All efforts to find a way to get the correct IDs number of addresses were in vain.
- **Assumptions:**
    - The remaining 10,900 cases were used as the prevalence value for cancer.
    - We performed two cases for the study, one for a cumulative 1995-2013 total (prevalence) over the 19 years using the mean population, and another case for the 5 years (2009 to 2013) as annual incidence, year by year.
- **Data Collection Challenges:** Highly sensitive information. Professional working relations with trusted ministry officials were used to obtain the data. Data remains highly sensitive. However, we have stripped the data from all personal information and only used the number of cases, date of diagnosis, and addresses. The calculated annual incidence is less than the reported one due to the exclusion of cases with wrong IDs.

7. **<u>Meningitis</u>**
    - **Source(s):** Hospitals & UNRWA Clinics
    - **Range**: All cases from 2009 to 2013
    - **Accuracy Level**: Street and neighborhood addresses for Hospitals, and catchment areas for UNRWA clinics.
    - **Gaps**: Approximately 5% missing addresses due to poor record keeping in Hospitals. No data in UNRWA records for year 2012 in Rafah and Khan Younis.
    - **Limitations**: Case definition may be inaccurately considered
    - **Assumptions**: The available data is representative
    - **Data Collection Challenges:** Some delays to acquire the data from the Hospitals.

8. **<u>Skin diseases</u>**: Data not available. There does not exist a systematic data collection strategy for this disease. Only some NGOs collected data for skin related diseases (scabies), hence the data was deemed not suitable for our purposes. It was only available for certain areas in Rafah, Shajaia, and Darraj neighborhoods.

9. **<u>Dental Caries</u>**: Data not available. There does not exist a systematic data collection strategy for this disease. The available data was more research based on samples of populations, and hence was not appropriate for GIS applications.

10. **<u>Renal Diseases</u>**
    - **Source(s):** Hospitals
    - **Range**: All cases for patients undergoing hemodialysis from 2009 to 2013, and all cases for patient deaths in year 2013; 553 cases. To increase statistical power, the research team requested the data of deaths resulted from renal failure in the concerned years. MOH provided the deaths of the year 2013 only.
    - **Accuracy Level**: Street & neighborhood addresses through cross-checking the name and ID numbers of the patients with the Civil Registry.
    - **Gaps**: For the cases of patients undergoing hemodialysis, 160 cases of the total 553 cases had missing address & ID information.
    - **Limitations**: The 160 cases with missing address information. About 29% error in the data.
    - **Assumptions**: The remaining 393 cases were used to project one map for the distribution of kidney failure (number of cases only), and a second map showing the number of patients undergoing hemodialysis combined with the number of deaths among cases with end stage renal failure for year 2013.
    - **Data Collection Challenges:** Highly sensitive information. Professional working relations with trusted ministry officials were used to obtain the data. Data remains highly sensitive. However, we have stripped the data from all personal information and only used the number of cases, date of diagnosis, and addresses.

11. **<u>Anemia:</u>** Data not available. There does not exist a systematic data collection strategy for this disease. Mostly, data are collected through projects that focus on specific years with specific focus on certain groups. An anemia surveillance system at MOH is not active in monitoring and reporting data about anemia at the Gaza Strip level.

The public health data, as seen in the list above, has questionable accuracy level. The MOH and UNRWA clinics were given clinic catchment areas in the Gaza Strip that each respective clinic served. UNRWA had the areas and populations which they served already tabulated which they sent to us, mostly serving 80% of the refugees in the respective areas. MOH on the other hand did not have their definite catchment area data readily available, hence, UG conducted a field survey by conducted meetings with administrative representatives from all MOH clinics over three days to try to establish the geographic boundaries of each clinic's catchment areas, and with the help of population data available at PCBS, each catchment area for each clinic was assigned a population number serviced by the respective clinic. The need for populations served by each clinic is important as to calculate the incidence of the disease rather than rely on the absolute number of cases in each area (we only used absolute numbers for renal diseases because of the limited number of cases). This is to ensure that a correct relative comparison between the areas can be performed, and hence, more accurate results can be produced. The utilized method is congruent with the MOH and UNRWA calculation approach.

## Water Quality Parameters

The water quality parameters had to be collected for all water sources in the Gaza Strip as discussed and outlined in the Schematic Water Supply Diagram (ANNEX 1). Where available, UG's team collected the required parameter data for municipal wells, agricultural wells, main water carriers (feeders), water desalination plants, water vendors supply plants, wastewater pumping stations, wastewater carriers, discharge points, wastewater treatment plants and lagoons, and solid waste dumping sites. With the exception of the water main carriers and the water vendors, all of the listed sources for water have an accuracy level of a geographically coordinated location point (x-y coordinates) which is the best level of accuracy one can achieve for a water source. Water vendors' plant locations were estimated based on written neighborhood and street addresses supplied to us by the MOH. Moreover, the parameter data concerning water vendors is only collected at the plant itself and not the users' outlets; at the consumer locations. This is problematic since the quality of the water might change during the water delivery process, and hence, the susceptibility for pollution and contamination may increase during the delivery, distribution and storage processes at the household level. Oxfam produces yearly reports on the end user water quality for this water source, but their data was not usable in our model since every year they perform a limited number of tests on a changing sample population.

Regarding the matter of the water main carrier lines, we have acquired the digital maps for their locations and service areas, however, there does not exist a supply scheme for these networks. In other words, municipal water wells, public desalination plants, and other sources of water that feed directly into the municipal carrier network lines are subject to supply delivery schemes. These schemes are important to better pinpoint the exact areas which use the supplied water. For example, a desalination plant being built currently in Beit Lahia will actually serve the residents of western Gaza City. Hence, due to the lack of this vital information at the municipalities and CMWU in useable format for this study, only the locations of the water sources will used as an indicator of their service areas, which is not an extremely inaccurate assumption to make, and is sufficient for the purpose of constructing the baseline database and report.

It is also important to note that for wastewater desalination plants, CMWU only supplied us the data for one plant for one year (2013) and has stated that data for the remaining plants for the remaining years does not exist. Moreover, there was no available data for solid waste dumping sites and lagoons apart from their geographic locations.

It is also important to note that out of all the parameters, heavy metals were the only parameter with no source of information since this data is not collected on a regular basis and has only risen as an important parameter due to the repetitive aggressions the Gaza Strip was subjected to by the Israeli military. It is noted that the effects of the heavy bombardment of the Gaza Strip released large amounts of heavy metals into the environment, which led to the contamination of the soil, and hence, the drinking water aquifer.  Also it is important to note that biological contamination was an issue as well.

Listed below are the water sources, the parameters we were able to acquire for them, and their source, range, accuracy level, gaps, assumptions, limitations, and encountered data collection challenges.

1. **Municipal Wells**
    - **Source(s)**: PWA, CMWU, & Municipalities
    - **Range**: From 1990 to 2014, including all chosen water quality parameters apart from heavy metals and bacterial contamination (microbiology).
    - **Accuracy**: Geographically coordinated location
    - **Gaps**: Some periods for some wells had missing data results. No heavy metals and bacterial contamination data.
    - **Limitations**: No supply scheme available.
    - **Assumptions**: Missing periodic data for available parameters was interpolated. The data reflects the quality situation of the water aquifer rather than the actual supply scheme.
    - **Data Collection Challenges**: Bureaucratic delays caused by the lack of a centralized and easily accessible data bank.

2. **Agricultural Wells**
    - **Source(s)**: PWA & Ministry of Agriculture
    - **Range**: From 1990 to 2014, including all chosen water quality parameters apart from heavy metals and bacterial contamination.
    - **Accuracy**: Geographically coordinated location
    - **Gaps**: Some periods for some wells had missing data results. No heavy metals and bacterial contamination data.
    - **Limitations**: N/A
    - **Assumptions**: Missing periodic data for available parameters was interpolated. The data reflects the quality situation of the water aquifer.
    - **Data Collection Challenges**: Bureaucratic delays caused by the lack of a centralized and easily accessible data bank.

3. **Main Water Carriers**
    - **Source(s)**: CMWU & Municipalities
    - **Range**: Latest 2014 AutoCAD files. Pipes, pumping stations, and boosters.
    - **Accuracy**: Geographically coordinated locations
    - **Gaps**: Supply scheme not yet available, this is a work in progress at CMWU and Municipality of Gaza. No water quality data available at consumer-end.
    - **Limitations**: No supply scheme.
    - **Assumptions**: Will use the geographic location of the network as the only factor when looking for potential linkages.
    - **Data Collection Challenges**: Major bureaucratic delays due to flawed perception of data ownership by CMWU and MoG with regard to the supply scheme database (being constructed).

4. **Water Desalination Plants**
    - **Source(s)**: CMWU & MOH
    - **Range**: All private (licensed & unlicensed) and public desalination plants for the years from 2009 to 2013.
    - **Accuracy**: Hand written street addresses.
    - **Gaps**: Bacterial contamination (microbiology) tests (coliform and total coliform) are not complete due to lack of funding of MOH laboratories.
    - **Limitations**: Completed bacterial contamination tests are for the plants' output water rather than the quality of water the end user receives. This limits the study significantly since it has been cited numerous time (refer to the Literature Review) that major quality deterioration occurs during the handling, delivery, and storage process.
    - **Assumptions**: Will use the geographic location of the vendors and estimate each plant's delivery catchment area. The chemical data for the water will be plotted but the microbiology data is inconclusive.
    - **Data Collection Challenges**: Some delays in obtaining the microbiological tests

5. **Water Vendor Supply Units:** Many organizations and governmental bodies were contacted in the effort of trying to find quality data for the locations where the water vendors sell the water they produce. However, no such data exists apart from subjective sampled report data that some organizations (mainly NGOs) perform in the Gaza Strip. This is a major setback to the decision makers as many studies showed that majority of Gazans purchase and drink this water. Oxfam does perform a few chemical and microbiological tests for these supply units, however, they only do a random sample of about 20 to 30 locations per year across the Gaza Strip, and they only show the average values of the results they get. This is not suitable for the purposes of this study, and we recommend taking immediate action in introducing a better method for water quality tests on this source specifically.

6. **Wastewater Pumping Stations, Discharge Points, and Carriers**
    - **Source(s)**: CMWU
    - **Range**: Latest 2014 AutoCAD maps for the specific locations of all wastewater pumping stations, discharge points, and carriers.
    - **Accuracy**: Accurate and precise geographically coordinate locations.
    - **Gaps**: No chemical or microbiological data exists.
    - **Limitations**: We are unable to assess the type, magnitude, location, and quality of effluent potentially contaminating the water aquifer.
    - **Assumptions**: Will use the geographic locations of the wastewater pumping stations, discharge points, and carriers only.
    - **Data Collection Challenges**: None

7. **Wastewater Treatment Plants**
    - **Source(s)**: CMWU
    - **Range**: The exact location of all wastewater treatment plants. Only one treatment plant only for year (2013) had chemical and microbiological data.
    - **Accuracy**: Accurate and precise geographically coordinate locations.
    - **Gaps**: CMWU stated that they do not have any other quality data.
    - **Limitations**: We are unable to assess the type, magnitude, location, and quality of effluent potentially contaminating the water aquifer.
    - **Assumptions**: Will use the geographic locations of the wastewater treatment plants only.
    - **Data Collection Challenges**: Major delays and promises regarding the effluent quality records, however, we only received one record for one plant.

8. **Solid Waste Dumping Sites**
    - **Source(s)**: PWA
    - **Range**: The exact location of all dumping sites in the Gaza Strip.
    - **Accuracy**: Accurate and precise geographically coordinate locations.
    - **Gaps**: No leaching data, and no comprehensive soil tests data.
    - **Limitations**: We are unable to assess the type, magnitude, location, and quality of effluent potentially contaminating the water aquifer.
    - **Assumptions**: Will use the geographic locations of the solid waste dumping sites.
    - **Data Collection Challenges**: N/A



The water quality data mentioned above is severely suffering from the lack of adequate central records and bureaucratic administrative operations. These factors affect both the quality and completeness of the data, and hence hinder the decision makers from making informed corrective decisions. The relevant stakeholders must immediately come to an agreement about the improvement of the data collection process and provide easy access to the information for future studies. It is a heavy burden on every researcher to have to go through the data collection process we went through in trying to find valuable information. Although the systematic factor of this issue is an integral part of the problem, there is a more concerning problematic issue, which is the poor understanding of some institutional officials about the importance of this data, and the nature of it. The data recording methods need to be improved, and all relevant parties need to come to the understanding that the data, by its nature, should be accessible by all, for the benefit of all, especially in a disaster stricken part of the world.

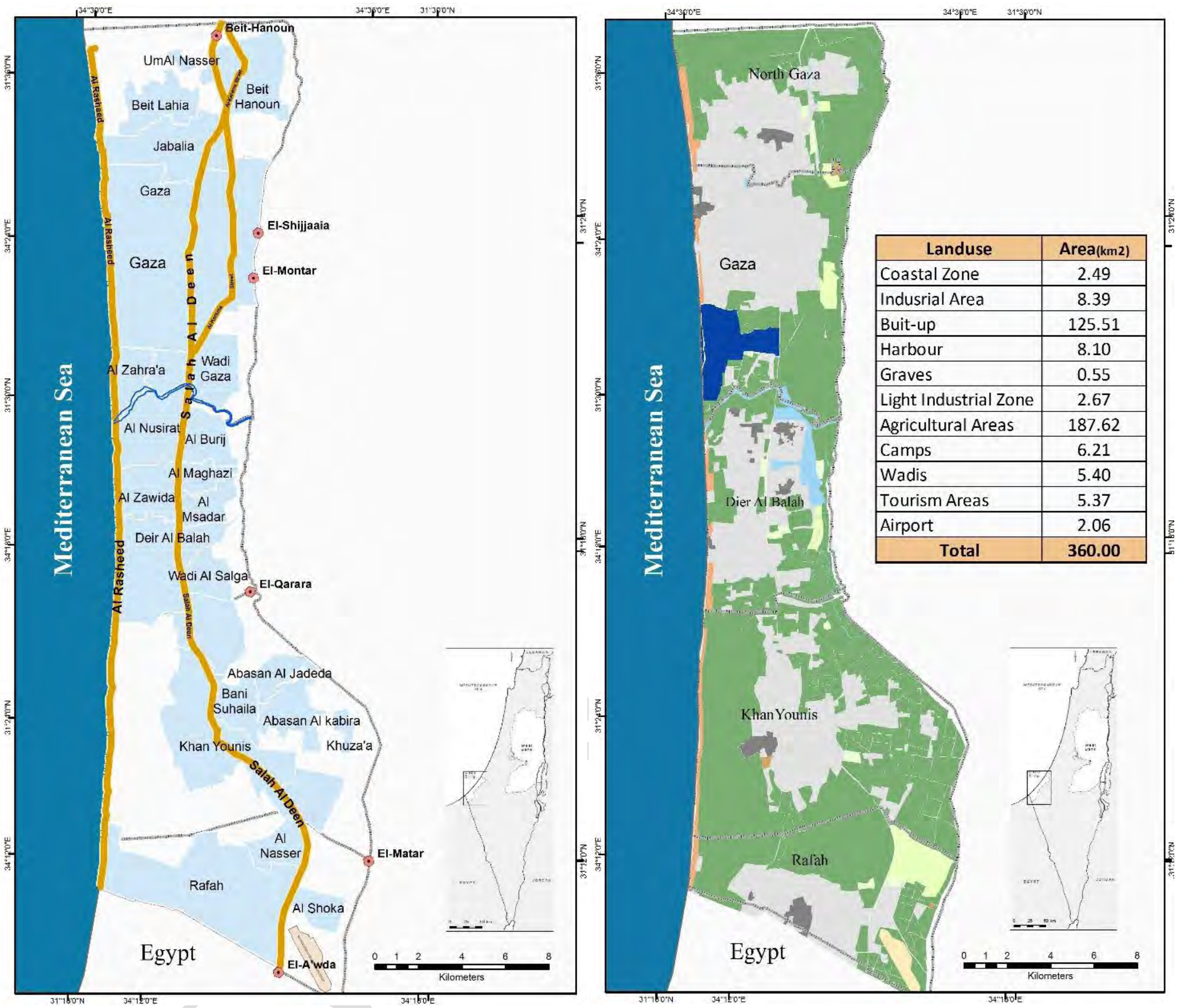
## Population & Catchment Areas

Another essential piece of information is the Gaza Strip population data per neighborhood. Our team contacted the Palestinian Central Bureau of Statistics (PCBS) and acquired the population data from their website for all the neighborhoods in the Gaza Strip. This was important as to be able to calculate the incidence rates of diseases in each neighborhood, as well as, be able to calculate the total population served in each clinic (UNRWA and MOH). PCBS's latest statistics for the population of the Gaza Strip was conducted in 2007, and they have been applying a population growth rate for each governorate based on the recorded births and deaths in those areas. The average growth rate in the Gaza Strip since 2007 is about 3.5% per year. Table (2) below summarizes the Gaza Strip's population per governorate/locality from 2009 to 2013.

*Table (2): Gaza Strip Population per Locality 2009-2013, PCBS (2014)*

| Governorate | Locality Name | Year | | | | |
|---|---|---|---|---|---|---|
| | | 2009 | 2010 | 2011 | 2012 | 2013 |
| North Gaza | Um AlNasr (Village) | 2,977 | 3,092 | 3,219 | 3,351 | 3,487 |
| | Beit Lahia | 68,273 | 70,902 | 73,804 | 76,831 | 79,962 |
| | Beit Hanoon | 40,300 | 41,851 | 43,564 | 45,351 | 47,199 |
| | Jabalia Camp | 44,416 | 46,126 | 48,014 | 49,983 | 52,020 |
| | Jabalia | 130,280 | 135,297 | 140,834 | 146,609 | 152,585 |
| Gaza | Ash Shati' Camp | 36,227 | 37,311 | 38,516 | 39,764 | 41,043 |
| | Gaza | 469,687 | 483,742 | 499,374 | 515,556 | 532,132 |
| | Madinat Ezahra | 3,226 | 3,322 | 3,429 | 3,541 | 3,654 |
| | Al Mughraqa | 6,835 | 7,039 | 7,267 | 7,502 | 7,744 |
| | Juhor ad Dik | 3,053 | 3,144 | 3,246 | 3,351 | 3,459 |
| Deir El Balah | An Nuseirat Camp | 29,497 | 30,462 | 31,531 | 32,641 | 33,781 |
| | An Nuseirat | 38,499 | 39,758 | 41,153 | 42,601 | 44,090 |
| | Al Bureij Camp | 25,207 | 26,031 | 26,945 | 27,893 | 28,868 |
| | Al Bureij | 10,340 | 10,678 | 11,053 | 11,442 | 11,842 |
| | Az Zawayda | 17,786 | 18,367 | 19,012 | 19,681 | 20,369 |
| | Deir al Balah Camp | 6,760 | 6,981 | 7,226 | 7,480 | 7,742 |
| | Al Maghazi Camp | 16,877 | 17,429 | 18,041 | 18,676 | 19,329 |
| | Al Maghazi | 6,865 | 7,089 | 7,338 | 7,596 | 7,862 |
| | Deir al Balah | 57,160 | 59,029 | 61,101 | 63,252 | 65,461 |
| | Al Musaddar | 1,967 | 2,031 | 2,102 | 2,176 | 2,252 |
| | Wadi as Salqa | 4,851 | 5,010 | 5,185 | 5,368 | 5,555 |
| Khan Yunis | Al Qarara | 20,667 | 21,283 | 21,969 | 22,679 | 23,406 |
| | Khan Yunis Camp | 39,417 | 40,593 | 41,901 | 43,255 | 44,642 |
| | Khan Yunis | 149,115 | 153,564 | 158,512 | 163,634 | 168,880 |
| | Bani Suheila | 33,143 | 34,132 | 35,231 | 36,370 | 37,536 |
| | 'Abasan al Jadida | 6,341 | 6,531 | 6,741 | 6,959 | 7,182 |
| | 'Abasan al Kabira | 19,249 | 19,824 | 20,462 | 21,123 | 21,801 |
| | Khuza'a | 9,562 | 9,848 | 10,165 | 10,493 | 10,830 |
| | Al Fukhkhari | 5,791 | 5,963 | 6,155 | 6,354 | 6,558 |
| Rafah | Rafah | 128,150 | 132,533 | 137,385 | 142,427 | 147,618 |
| | Rafah Camp | 36,367 | 37,611 | 38,988 | 40,419 | 41,892 |
| | Al-Naser | 6,638 | 6,865 | 7,117 | 7,378 | 7,647 |
| | Shokat as Sufi | 11,294 | 11,680 | 12,108 | 12,552 | 13,010 |
| TOTAL | | **1,486,817** | **1,535,118** | **1,588,688** | **1,644,288** | **1,701,438** |

*Figure (1): Gaza Strip Base & Land-use Map, UG, 2015*




| Landuse | Area(km2) |
|---|---|
| Coastal Zone | 2.49 |
| Indusrial Area | 8.39 |
| Buit-up | 125.51 |
| Harbour | 8.10 |
| Graves | 0.55 |
| Light Industrial Zone | 2.67 |
| Agricultural Areas | 187.62 |
| Camps | 6.21 |
| Wadis | 5.40 |
| Tourism Areas | 5.37 |
| Airport | 2.06 |
| **Total** | **360.00** |

The population data was not only collected on the neighborhood level, we also needed to collect the population data for the MOH and UNRWA catchment areas. These areas are the areas which each respective clinic serves, along with the total population they serve. UNRWA supplied us with a catchment area profile for all their 21 clinics for 2014, and we adjusted by 3.5% for the population values across the years as noted by PCBS. MOH, however, didn't have this information, hence, our team went out to meeting with an administrative representative from each of the 54 MOH clinics to acquire the geographic boundaries of each clinic, and its respective service population (Catchment area maps shown in ANNEX 3). These numbers are were important to find the incidence rates of the diseases in their respective catchment areas, and they were cross-checked with neighborhood population data acquired from PCBS.

*Table (3): UNRWA Clinics Catchment Areas Population for 2014, UNRWA, 2014*

| Health Center | Details of areas served | Population of each Area | Actual Number of each area using the HC |
|---|---|---|---|
| **Beit Hanon** | Beit hanoun City | 38000 | 36500 |
| | Ezbiet B. Hanoun | 8500 | 2800 |
| | Al-Awda& Al-Nada Towers | 5500 | 560 |
| | Al-Farata | 1844 | 800 |
| | Industrial Zone/Erez/Abu Ghazal(Bedouin) + El Nazaza | 2900 | 500 |
| | **Total** | 56744 | 41160 |
| **N Gaza (Saftawi)** | AbuSkandar and abu almeeen | 25000 | 23000 |
| | Al Jalaa And Al Nafaq | 7000 | 6000 |
| | El Sheikh Redwan third street | 3000 | 3000 |
| | Saftawi area | 15000 | 15000 |
| | Al Mukhabrat, Al Maqousi, Al Ammoudi, Al Karama, El Twam, Abu Sahreik quarter | 22500 | 21000 |
| | Beir al Naaja, El Etesalat | 5000 | 3000 |
| | **Total** | 77500 | 71000 |
| **Sheikh Redwan** | Sheikh Redwan | 52000 | 35000 |
| | **Total** | 52000 | 35000 |
| **Rimal** | Rimal ( North & South) | 60000 | 50000 |
| | Westren Naser/ Wehda/Port | 15000 | 13000 |
| | **Total** | 75000 | 63000 |
| **Beach** | Beach + Christian camp | 81000 | 80000 |
| | Port/ Wehda /Westren Naser | 15000 | 2000 |
| | **Total** | 96000 | 82000 |
| **Jabalia** | Jabalia camp | 107000 | 107000 |
| | Tel Azater | 15000 | 14000 |
| | B Lahia project | 20000 | 18000 |
| | B Lahia city | 3000 | 3000 |
| | Um Nasser | 3500 | 2000 |
| | Saftawy& Amer project | 20000 | 10000 |
| | Ezba | 7000 | 3500 |
| | Towers Al-Nada& Al awda | 10000 | 7000 |
| | el shekh Zayed | 7500 | 5300 |
| | Others | 24000 | 24700 |
| | **Total** | 217000 | 194500 |
| **Maghazi** | Maghazi Camp | 28000 | 24000 |
| | Abu-Alajeen | 500 | 150 |
| | Mahata/ Musader/ Al salga | 6000 | 700 |
| | Zawaydah | 12000 | 1800 |
| | **Total** | 46500 | 26650 |
| **West Nuseirat** | Western Camp | 10000 | 10000 |
| | Mughraga | 2000 | 1500 |
| | Al-Zahra | 2000 | 1500 |
| | **Total** | 14000 | 13000 |
| **Nusierat** | Nusierat Camp | 60000 | 50000 |
| | Hasayna/Sawarha/Khawlda | 5000 | 4000 |
| | Zawayda | 12000 | 3000 |

| | | | |
|---|---|---|---|
| | **Total** | 77000 | 57000 |
| **Sabra** | Zayton | 30000 | 20000 |
| | Sabra | 20000 | 15000 |
| | Shjaea | 20000 | 18000 |
| | Tel Al-Hawa | 15000 | 2000 |
| | Gaza Valley& Mughraga | 10000 | 1000 |
| | **Total** | 95000 | 56000 |
| **Gaza Town** | Shijaea | 48000 | 20000 |
| | Tofah | 49000 | 40000 |
| | Daraj | 35000 | 30000 |
| | **Total** | 132000 | 90000 |
| **Shaboura** | Shabora | 25000 | 22000 |
| | **Total** | 25000 | 22000 |
| **Rafah** | Down Town( Ybna , block O, Block G) | 45000 | 37000 |
| | Brazil/ Salam / Junina | 40000 | 33000 |
| | **Total** | 85000 | 70000 |
| **Tel Sultan** | Tel Sultan | 18000 | 12000 |
| | Canada ( Tel sultan) | 5000 | 4000 |
| | Bader | 5000 | 4000 |
| | Mawasi | 3000 | 1000 |
| | Shout ( Block G) | 6000 | 4000 |
| | **Total** | 37000 | 25000 |
| **Shokah** | Middle Skokah | 8000 | 3500 |
| | Northen Shokah | 4000 | 1500 |
| | Crossing Area | 3000 | 500 |
| | **Total** | 15000 | 5500 |
| **Nasser** | Nasser Village | 12000 | 9500 |
| | Alamor&Sofa | 4000 | 2500 |
| | European | 4000 | 2000 |
| | **Total** | 20000 | 14000 |
| **Japanese** | Al- Amal | 35000 | 18000 |
| | Kateba | 15000 | 8000 |
| | Qarara | 20000 | 8000 |
| | **Total** | 70000 | 34000 |
| **Khan Younis** | Kh Younis Camp | 60000 | 50000 |
| | Eastern Villages | 20000 | 8000 |
| | Down Town ( Sheikh Nasser , Bayok, Najar) | 12000 | 7000 |
| | Mawasi ( Coast) | 3000 | 2000 |
| | **Total** | 95000 | 67000 |
| **Ma'en** | Ma'en | 20000 | 15725 |
| | Estern Khanyounis (Najar Seka- Sheikh Nasser) | 28000 | 25160 |
| | Estern Villages | 30000 | 28304 |
| | Abu Etema | 2000 | 1572 |
| | European hospital | 19000 | 7861 |
| | **Total** | 99000 | 78622 |
| **Burij** | Burij Camp | 50000 | 45000 |
| | Jouhr Adeek/ Gaza Vally | 5453 | 3653 |
| | **Total** | 55453 | 48653 |
| **Der Al Balah** | Der Balah Camp | 20000 | 20000 |
| | D. balah Town hiker berka | 42000 | 38000 |

| | | | |
|---|---|---|---|
| | Zawaydah | 12000 | 3000 |
| | Wadi Salga/ Musader | 6000 | 2000 |
| | **Total** | 80000 | 63000 |
| | **GRAND TOTAL** | 1520197 | 1157085 |

*Figure (2): UNRWA Clinics Catchment Areas*

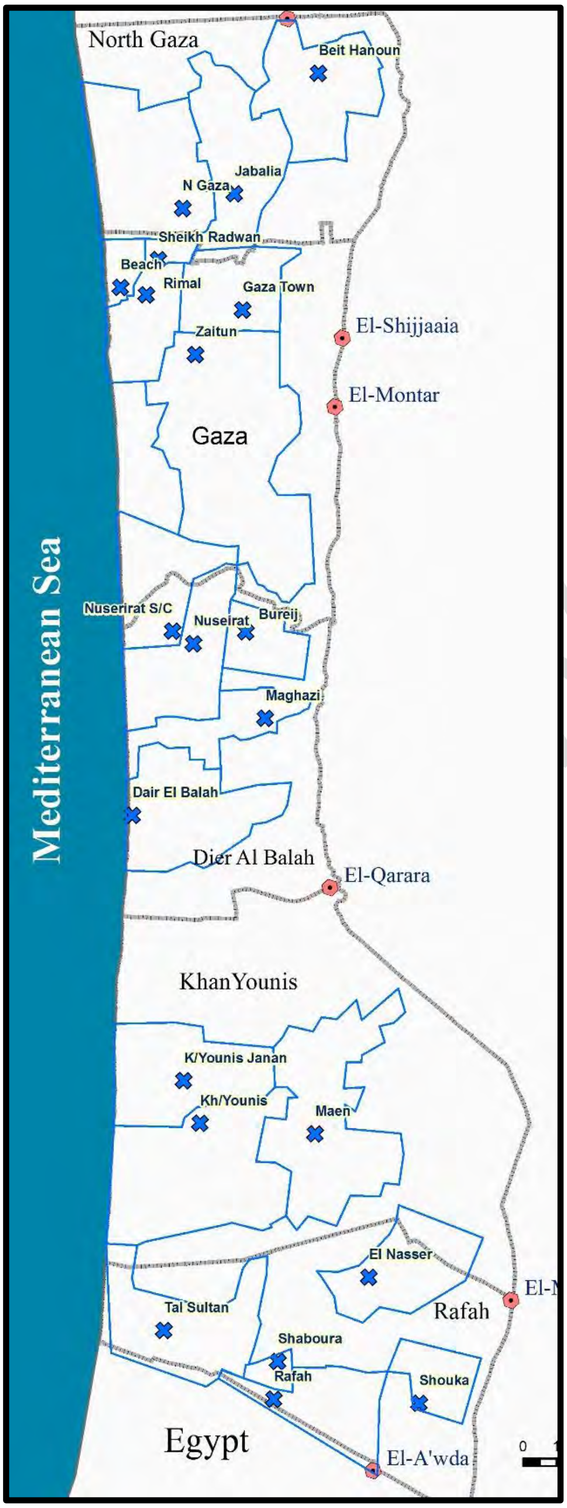



*Figure (3): MOH Clinics Catchment Areas*

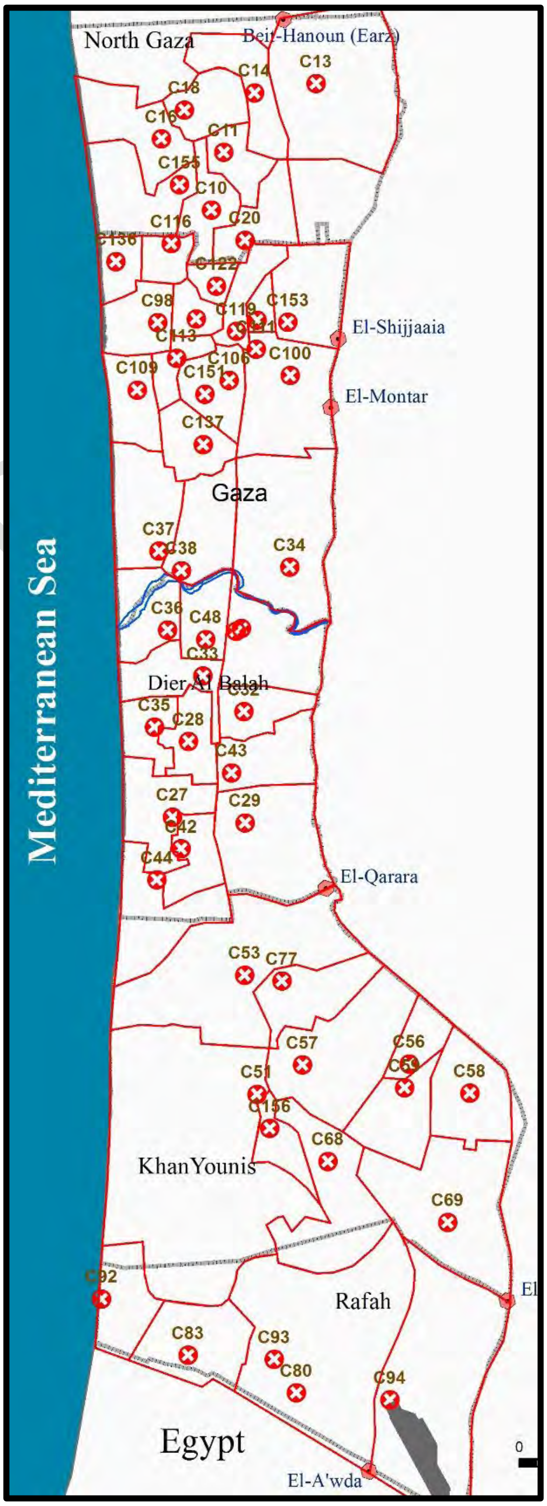


*Table (4): MOH Clinics Catchment Areas Populations, UG, 2015*

| Clinic Name | Clinic Catchment Area Population | | | | |
|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 |
| **North** | **285,990** | **297,001** | **309,158** | **321,837** | **334,953** |
| Shuhada Bait Hanoun Center | 31524 | 32738 | 34078 | 35475 | 36921 |
| Ezbet Bait Hanoun Clinic | 15381 | 15973 | 16627 | 17309 | 18014 |
| Bait Lahya Project | 52555 | 54578 | 56812 | 59142 | 61552 |
| Jabalia Martyrs Center | 92712 | 96282 | 100223 | 104333 | 108585 |
| Abu Shobak | 24477 | 25419 | 26460 | 27545 | 28668 |
| Jamila ElAshi | 33635 | 34930 | 36359 | 37851 | 39393 |
| Atatra & Saifa | 18313 | 19018 | 19797 | 20609 | 21449 |
| Bait Lahya Martyrs (Shimaa) | 17393 | 18063 | 18802 | 19573 | 20371 |
| **Gaza** | **513,971** | **529,349** | **546,456** | **564,163** | **582,301** |
| Shati' Martyrs | 63778 | 65686 | 67809 | 70006 | 72257 |
| Shiekh Ridwan | 67007 | 69012 | 71242 | 73550 | 75915 |
| Rimal | 50324 | 51830 | 53505 | 55239 | 57015 |
| Alfalahh | 27448 | 28269 | 29183 | 30128 | 31097 |
| Zahra Clinic | 7850 | 8085 | 8347 | 8617 | 8894 |
| Mughraga | 10088 | 10390 | 10726 | 11073 | 11429 |
| Hala Alshawa | 6642 | 6841 | 7062 | 7291 | 7525 |
| Zaitoon Martyrs | 33211 | 34205 | 35310 | 36455 | 37627 |
| Alsalam | 35336 | 36393 | 37569 | 38786 | 40033 |
| Aldaraj Martyrs | 35805 | 36877 | 38068 | 39302 | 40565 |
| Huriya Clinic | 25518 | 26281 | 27131 | 28010 | 28910 |
| Soorani | 40532 | 41745 | 43094 | 44490 | 45920 |
| Atta Habib Public Clinic | 48601 | 50055 | 51672 | 53347 | 55062 |
| Sabha Alharazeen | 19481 | 20064 | 20712 | 21383 | 22071 |
| Algoba | 38161 | 39302 | 40572 | 41887 | 43234 |
| Alrahma | 2013 | 2073 | 2140 | 2210 | 2281 |
| Johr Aldeek | 2176 | 2241 | 2314 | 2389 | 2466 |
| **Middle** | **219,719** | **226,903** | **234,867** | **243,134** | **251,630** |
| Alburaij | 24631 | 25436 | 26329 | 27256 | 28208 |
| New Alburaih | 10556 | 10902 | 11284 | 11681 | 12090 |
| Almaghazi | 23545 | 24315 | 25168 | 26054 | 26964 |
| Almasadar | 2025 | 2091 | 2165 | 2241 | 2319 |
| Wadi Alsalga | 25688 | 26528 | 27459 | 28426 | 29419 |
| Baraka Center | 7848 | 8105 | 8389 | 8685 | 8988 |
| Hikir Aljamaa | 9757 | 10076 | 10430 | 10797 | 11174 |
| Dier Elbalah | 27713 | 28619 | 29624 | 30666 | 31738 |
| Alzawaida | 8786 | 9073 | 9392 | 9722 | 10062 |
| Zawaida West | 7029 | 7259 | 7513 | 7778 | 8050 |
| Old Nusairat | 38891 | 40162 | 41572 | 43035 | 44539 |
| Nusairat Martyrs | 14650 | 15129 | 15660 | 16211 | 16778 |

| | | | | | |
|---|---|---|---|---|---|
| Nusairat West | 18600 | 19208 | 19882 | 20582 | 21301 |
| **Khan Younis** | **280,633** | **289,005** | **298,316** | **307,957** | **317,830** |
| Algarara | 24795 | 25534 | 26357 | 27209 | 28081 |
| Alzana | 12122 | 12484 | 12886 | 13303 | 13729 |
| Bandar Khan Younis | 130936 | 134843 | 139186 | 143684 | 148291 |
| Bani Sehela | 36934 | 38036 | 39261 | 40530 | 41829 |
| Small Abasan | 7660 | 7889 | 8143 | 8406 | 8676 |
| Large Abasan | 11491 | 11833 | 12215 | 12609 | 13014 |
| Khuzaa | 9517 | 9801 | 10117 | 10444 | 10779 |
| Khaldiya Alagha | 17319 | 17835 | 18410 | 19005 | 19614 |
| Joret Elloot | 21904 | 22558 | 23285 | 24037 | 24808 |
| Alfukhari | 7955 | 8192 | 8456 | 8730 | 9009 |
| **Rafah** | **186,504** | **192,860** | **199,891** | **207,197** | **214,724** |
| Tal Alsultan | 45394 | 46946 | 48665 | 50451 | 52290 |
| Shaboora Clinic | 12421 | 12846 | 13316 | 13805 | 14308 |
| Shoka Clinic | 11265 | 11650 | 12076 | 12520 | 12976 |
| Mawasi Clinic | 1426 | 1475 | 1529 | 1585 | 1642 |
| Central Rafah Clinic | 115998 | 119943 | 124305 | 128836 | 133508 |

It is important to note that while the stated sources of all the data do represent where the data was received from, we have contacted many other institutions and organizations in our effort to obtain the required parameter data. These organizations include, but are not limited to, World Health Organization (WHO), Red Cross, Environment Quality Agency (EQA), Municipalities, UNDP, UNICEF, Joint Service Council for Solid Waste, Hydrogen Group, Islamic University, Oxfam, Alazhar University, and many others.

After collecting all the above mentioned data, in close cooperation and coordination with PWA's G-PCU, we then started developing the GIS database.

## PHYSICAL DESIGN OF THE GIS SYSTEM & DEVELOPMENT

The physical design of the GIS system began with entering all of the collected data into the GIS database. The available information was imported with its spatial attributes using the GIS software as follows:

- Developing and drawing the geo-database information using the ARCGIS diagram software.
- Create GIS layers (with national and UTM coordinates) related to water quality and public health using coordinates for point objects, lines, and polygons, such as :
  - Municipal wells, agricultural wells, main water carriers (feeders), water desalination plants, water vendors supply plant, wastewater pumping stations, wastewater carriers, discharge points, wastewater treatment plants and lagoons, and solid waste dumping sites.
  - Location of MOH and UNRWA primary health clinics with records of the number of serviced patients and types of diseases.
  - Measurements of chemical and biological parameters of water quality.
  - Main streets, municipalities, and population distribution layers.
- Prepare tables and excel sheets to convert into a geo-database by building domains and subtypes for specific fields.
- Create relationships between layers and tables dependent on primary keys.
- Create a network dataset for layers to plan and apply analysis tools such as services area.
- Build documentation files for each process, and specify layers and tables.

## GIS ANALYSIS & INTERPRETATION, IDENTIFYING THE PRESENT SITUATION, & PREDICTING THE FUTURE

After developing the geo-database according to the specifications and standards, we begin analyzing the data.

**Analysis Techniques (Geo-statistical, Spatial Analysis, & Spatial Statistics tools):**

The following was the course of analysis for the water quality data (water sources and water quality overlay maps) and the public health data (raw data and overlay with water quality data).

**Water Quality**

- Municipal Wells:
  - Create geographical distribution maps of municipal wells by governorates.
  - Create trend maps based on trending quality parameters (chemistry) of water for years 2009 to 2013, and compare the current status of the data against the international/local standards.
  - Create maps for wells' service areas using the Kriging method.
- Agricultural Wells:
  - Create geographical distribution maps of agricultural wells by governorates.

    - Create trend maps based on trending quality parameters (chemistry) of water for years 2009 to 2013, and compare the current status of the data against the international/local standards and regulations.
    - Create maps that showcase the differences between the water quality of the municipal wells and the agricultural wells (to try to determine if there are any impacts on each other in overlapping areas).
- Water Desalination Plants (Public & Private)
    - Create geographical distribution maps of the water desalination plants by estimated catchment areas.
    - Create trend maps based on trending quality parameters (chemistry & microbiology) of water for years 2009 to 2013, and compare the current status of the data against the international/local standards and regulations.
- Wastewater (networks, pumping stations, discharge points, treatment plants, lagoons, and carriers), water carriers, and solid waste dumping sites.

The method of data processing and analysis used is as per the following. The dataset of water quality monitoring was imported into ESRI ArcMap software. The ESRI Geographic Information System (GIS) was then used for the construction of the interpolation surfaces of water parameters (Cl, Na, No3, Mg, F, K, Ph, and TDS) concentration through applying the 'Geo-statistical Analyst' extensions of ArcGIS-ArcMap 10.2.1 software package where it provides a variety of interpolation methods for the creation of an optimal interpolated surface from data.

The Kriging model (Ordinary Kriging type) subjected to semivariogram with smoothing factor under exponential and spherical tuning techniques was used in this study to generate a set of predicted values at known locations along the Gaza Strip. The predicted values by each model were generated by systematically removing some of the input data (Calibration data) for water parameters concentration then their values were calculated based on other data (Modeling data). The performance of prediction model was evaluated by the magnitude and distribution of prediction errors when comparing the predicted values with the calibration data (A.Salha, 2010).

The model was then subjected to validation and evaluation. Before producing the final prediction surface of water parameters, validation and cross validation were used for models verification. The choice of the "best fitted" model for each interpolation trial and its corresponding parameters was based on the evaluation of the estimated errors (standardized mean prediction errors near 0, small root-mean-squared prediction errors, average standard error near root-mean-squared prediction errors, and standardized root-mean-squared prediction errors near 1). An example of the interpolation method (Ordinary Kriging) for Chloride concentration with trials parameters to get of the best model for year 2013 is shown in Annex 2.

With regard to predicting the future, the research team has used interpolation methods to predict the future senarios for each parameter, however, due to the fact that the analysis is only performed on a 5 year period, and that all literature points to the requirement that one needs at least 14 points (periods) to be able to predict the future, the predictions are limited and not conclusive. The analyzed period is too short with too little data points, and the variables are numerous and unknown. For example, a new major desalination plant or a wastewater treatment plant will immediately change the public health situation in the Gaza Strip, so will any offensive by the Israeli forces that will destroy the infrastructure. Hence, our assumption for the future considers that the status quo remains.

### Public Health

First, our GIS expert created maps with geographic distributions for all the health facilities (hospitals, MOH clinics, UNRWA clinics, & NGO clinics). We then created the catchment areas maps for each health facility and performed the following:

- Create maps of classification and distribution of diseases for years 2009 to 2013 (unless otherwise noted in the assumptions above)
- Create prediction, quantile, and probability maps of distribution of diseases using the geo-statistical analysis tools.

### Regression

The potential relationship between water quality parameters in the municipal wells and distribution of diseases (cancer, Renal, Diarrheal under 3 year, total Diarrheal, Hepatitis, Meningitis, Parasitic and Typhoid) incidence were examined using statistical analysis methods. To test the hypothesis, a linear regression analysis was conducted. A regression analysis is a method to investigate the impact of one or multiple independent variables on a dependent variable. This statistical analysis technique is also used in studies that investigate the impact of environmental factors on health (Hinwood et al., 1999; Lang et al., 2009; Sloan et al., 2012; Yenugadhati et al., 2009).

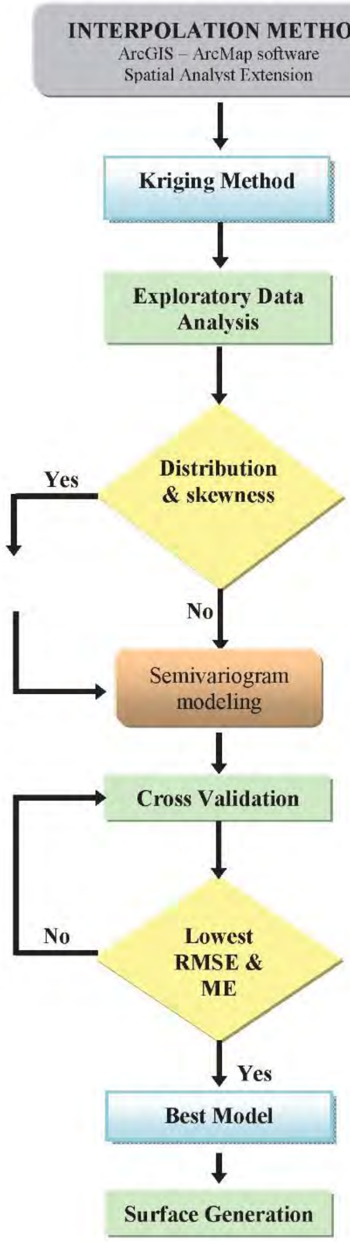



*Figure (4): Kriging method flowchart in selecting the best model.*

# GIS MAPS PRODUCTION, DISCUSSION, AND INTERPRETATION

After building the geo-database and executing all possible GIS analysis operations, we then generated the thematic maps (professional layout maps) for the following:

- **Location Maps** for municipal wells, agricultural wells, main water, water desalination plants, water vendors supply units, wastewater pumping stations, wastewater carriers, wastewater discharge points, wastewater treatment plants and lagoons, and solid waste dumping sites.
- **Disease Maps** for the catchment areas for UNRWA and MOH primary health clinics, spatial of the chosen diseases over the time period between 2009 and 2013, and prediction maps for disease distribution based on previous and current trends.
- **Water Quality Maps** for the chemical and biological parameters related to domestic wells, agricultural wells, and public & private water desalination plants for the time period between 2009 and 2013.

These maps were then analyzed, discussed, interpreted, and included in this final report.

## Overview of Water Quality Data

For the water quality and as illustrated in the literature review and methodology sections, these tests' results for municipal monitoring wells are collected from PWA for years 2009-2013. The data covers only chemical test results for the main elements that are recommended by the brainstorming and consensus building meeting and endorsed by PWA. The analysis used the same number of wells (about 180 wells) for each parameter, geographically distributed across the Gaza Strip, at the five study years to insure consistency and coherent outcomes. In agreement with PWA, where some values for some years where missing, the value was interpolated from the data values of the other years for that specific well. It is important to note that the maps produced are not an accurate representation of the ground water aquifer in the Gaza Strip, it is a representation of the quality of water that is being pumped at the respective wells, and is delivered to the residents of the Gaza Strip for their domestic, agricultural, and industrial use. The biological tests analysis results at the source, network or demand centers were not available in a solid statistical database for the required study period. This is in addition to the lack of comprehensive chain water quality database from water source, piping, storage tanks at house level to the tapping point. The study as per its scope requires presenting the quality of aquifer which forms the majority of water source to Gazans. Vendor supply quality status for "governmental" desalination plants records are also presented according to the available database at CMWU. The infrastructure facilities affecting the water quality condition have been presented and mapped based on available data base form concerned stakeholders. It is worth mentioning that depending on aquifer testing wells database to the level of baseline study can be accepted considering the current complicated water supply intermittent patterns and insufficient quality blending schemes.

The Gaza Strip is known to have serious water problems ranging from quality problems to expected shortage of water supplies not only for agricultural and industrial usage but also for drinking, scarcity, insufficiency, pollution and high salinity. A major reason for this crisis is because the Palestinians lack the control over their water resources. Although there are many plans to improve the situation, it will take time before the situation is significantly improved and current availability of potable water and plans for future improvements do by no means fill estimated needs. Over pumping due to the increased demands of the high population in the Gaza Strip and low recharges from rainwater have limited the quantity of water available and have further contributed to the degradation of the water quality. (Bashir et. al., 2013, PWA 2013, and PNIPH, 2014)

PWA in a recent study for groundwater evaluation (2014) shows that out of 211 wells under monitoring and taking in consideration the combined concentrations of both chloride and nitrate, it's clear that 3.8% of the domestic water is only matching with WHO drinking limit, while the remaining 96.2% is exceeding the limit.

**Chloride**

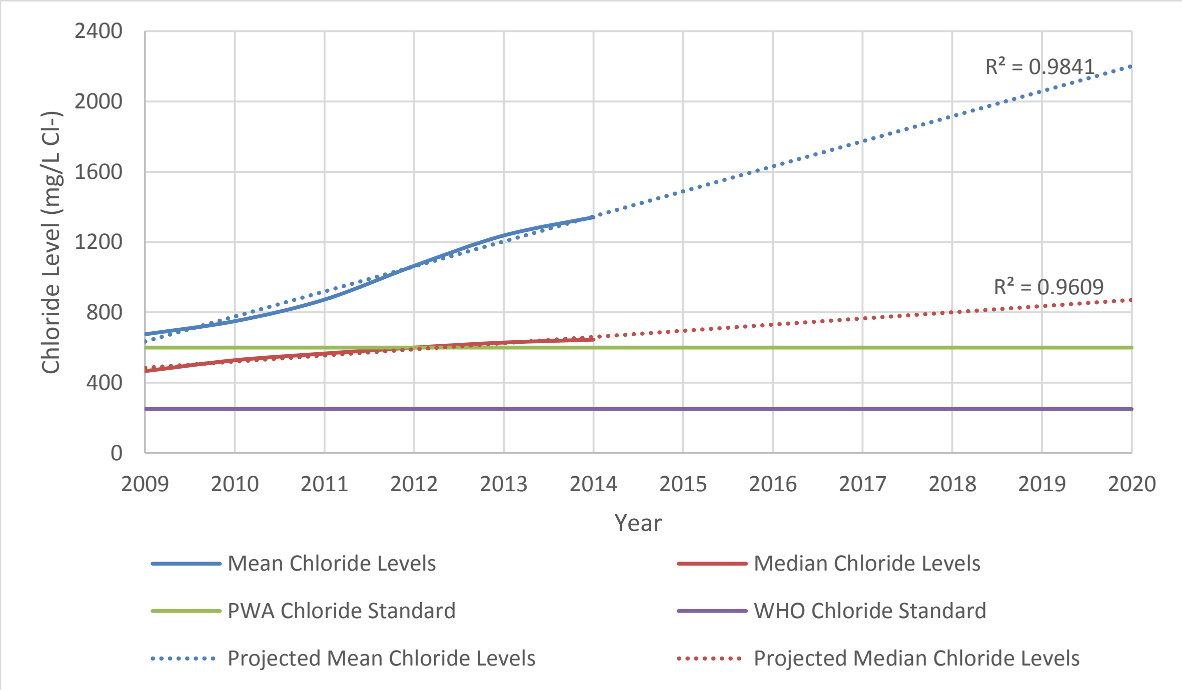
Levels of chloride concentration vastly exceed reasonable limits; internationally accepted safe levels are 250 mg/litre or even the "relaxation" PWA standards of 600 mg/l. The major parts of the Gaza strip aquifer have a Cl concentration ranging between 600-2,000 mg/l, while along the coastal line Cl concentration exceeds 2,000 mg/l and can reach more than 10,000 mg/l at some spots due to effect of the seawater intrusion. PWA (2014) status report stated that 24.6% of them have chloride concentration less than 250 while the remaining (75.4%) exceeds the WHO chloride level.

In evaluation of water quality and based on the result analyses of chloride concentration of the different PWA monitoring wells in Gaza Strip a chloride GIS contour maps have been prepared showing the change of the chloride concentration for five years intervals (2009 to 2013). Mapping is created for the purpose of showing the degradation trend. It is clear that area of fresh water is demolished and /or reduced significantly with time as a result of intensive pumping as well as the deficit in the water balance. Where, the magnitude of fresh groundwater body decreased in the North and southern parts of Gaza Strip which is originally characterized by fresh groundwater (CL < 250 mg/l). In 2009, the chloride concentration a across the Gaza Strip governorates was high and has clear influence at western part of Gaza City and Dir Balah in addition to eastern Gaza strip which can be said that it continues in a same trend. However, since 2012 there is a sharp degradation for chloride concentration in the range of more than 2000mg/l and to about 8000mg/l in some wells along their areas and new one such as Khanyounis and Rafah Governorates. The increasing trend of chloride was applicable for all governorates except northern part of Gaza Strip which is being particularly affected (Figure 5). This is due to the seawater intrusion phenomenon has reached to more than 2 km in land of Gaza aquifer, extensive and unbalanced abstraction and demand increasing.

Based on the water quality graphs magnitude as well as the attitude, taking in consideration the current abstraction status, the abstracted groundwater quality has been predicted up to year 2020 (Figure 5) with average rise at approximately 8.1% per year. Liner extrapolation could be accepted in condition of keeping same situation with no intervention or changing. It is clear that with the absence of alternative water resources (or at least insufficient quality blending schemes due to pure intermittent supply conditions and lack of proper facilities) in the short-term, there will be a real catastrophic water situation in the Gaza Strip.

Findings concluded in this study are congruent with the PWA and CMWU reports which also confirm that there is an increase in the chloride rate (CMWU, 2014 and PWA, 2014). It is worth reminding the reader that a comprehensive water resource management to introduce new resources (as desalination, storm water harvesting, imported water, brackish water treatment, increase irrigation system efficiency and control, and waste water re-use) will improve the aquifer situation. It is advised that areas with specific high rates of chloride needs urgent intervention by PWA as a short term solutions.

*Figure (5): Chloride Levels in the Gaza Strip, Municipal Drinking Wells*

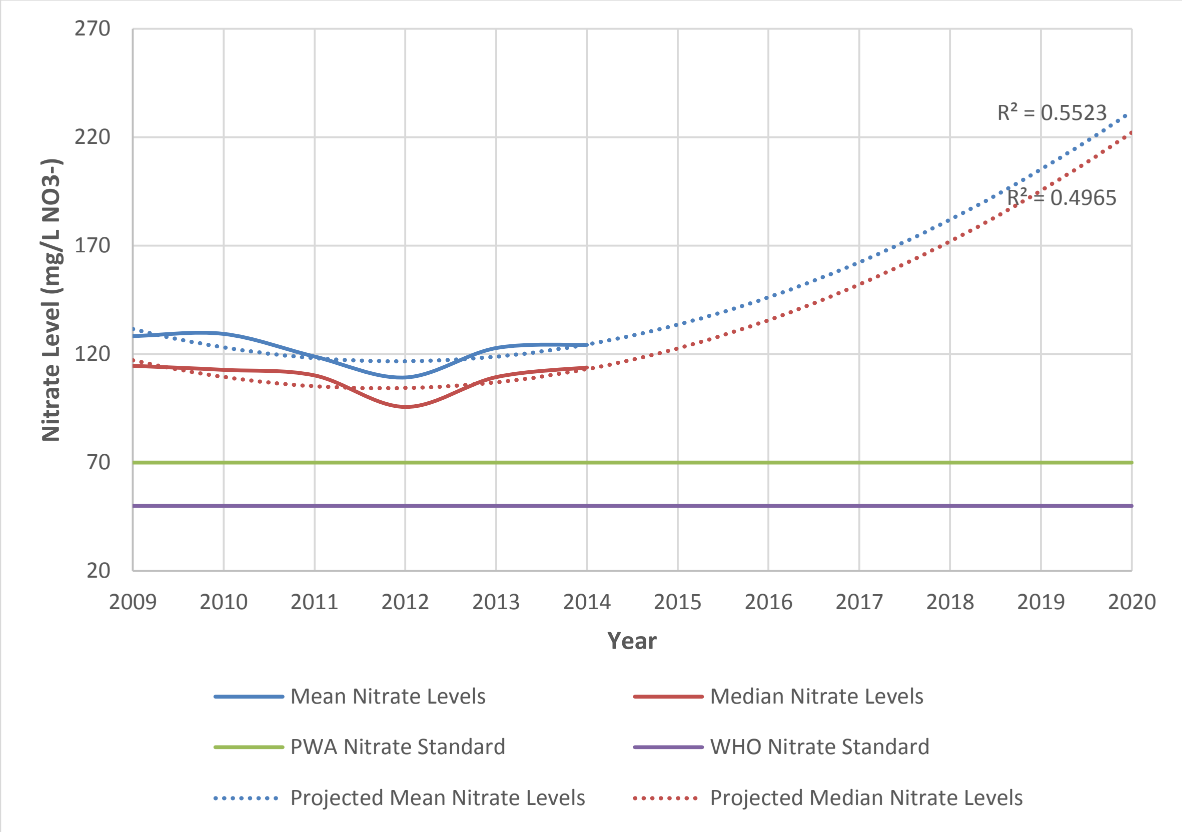



## Nitrate

The generated GIS map of nitrate form the year 2009 to 2013, which is based on quality testing wells results tabulated by PWA, confirms previous findings that almost 90% of the groundwater wells of the Gaza Strip have nitrate concentrations two to eight times higher than the WHO standards. This critical issue is mainly attributed to wastewater, agricultural fertilizers, pesticides and industrial pollutants.

Water Quality evaluation for Gaza strip carried out by PWA (2013) categorized four zones that have the nitrate concentration less than 50 mg/l (WHO & PWA allowable limit), these zones are located in the center of north governorate, Al Zahra and Al Moghraqa areas, east of middle governorate and the southeast of southern governorate, where these areas characterized by limited agricultural activities as well as the sewerage system. The whole urban centers such as Gaza city, refugee Camps in the middle governorate, KhanYounis and Rafah in addition to the agriculturally land used areas such as eastern Khanyounius are recording Nitrate concentrations more than 200 mg/l. This variation per locality could be explained by reasons of leakage from sewerage network as well as the leached wastewater from cesspits in these areas particularly KhanYounis and Rafah. It is worth mentioning that at some areas such as Rafah southeast, the nitrate level shows improvement trend which could be due to new established wastewater treatment plant at Tal Sultan there.

*Figure (6): Nitrate Levels in the Gaza Strip, Municipal Drinking Wells*




Based on the water quality graphs magnitude as well as the attitude, taking in consideration the current abstraction status, the abstracted groundwater quality has been predicted up to year 2020 (Figure 6) with average projected exponential rise at approximately 13.8% per year. However, it is to some level a questionable nitrate prediction accuracy of as it is site specific conditions can vary seasonally. It is clear that with the absence of comprehensive sewage infrastructure improvement program in the short-term, there will be a real catastrophic water situation in the Gaza Strip.

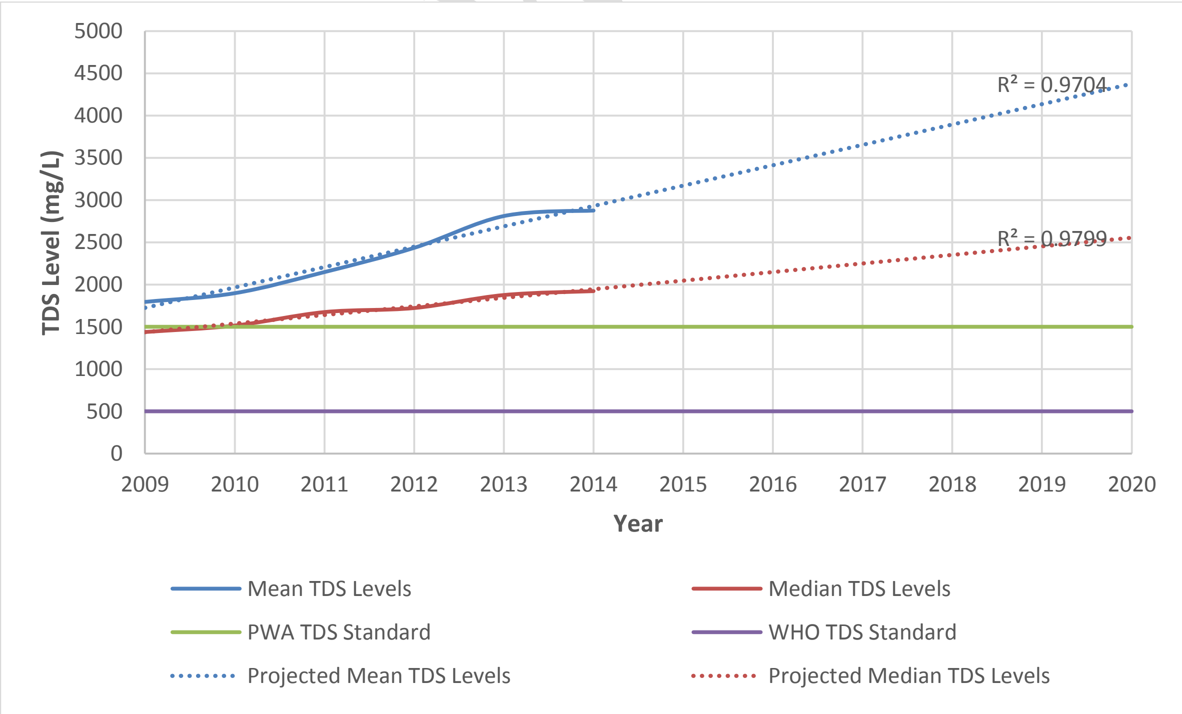
Based on these findings we can conclude that there is a marked increase in the Nitrate concentration which could cause methemoglobinemia in infants. The association of diarrhea and acidosis with methemoglobinemia is more common than previously thought and can produce dangerously high methemoglobin levels. Some researchers reported that diseases resulting from increased nitrate concentrations are mainly blue baby syndrome and cancer. It is worth recommended that areas with specific high rates of nitrate needs critical intervention by PWA as a short term solution to improve the facilities of wastewater network collection, disposal and treatment as well as a strengthening the monitoring of synthetic fertilizers addition to agricultural area. Until the three major WWTP at North, Gaza & Khayounis installed and operated, short term solution become mandatory to protect the public health.

### Total Dissolved Solid

Groundwater in most of the Gaza Strip exceeds the WHO and PWA TDS standard, which is 1000 mg/L. The TDS, Electrical conductivity and Chloride maps show similar patterns as all parameters indicate the concentration of dissolved solids in water. The high TDS value in the eastern parts of Khan Younis (3,000-4,000 mg/L) makes water in the area undrinkable. More than 50% of the groundwater quality database showed TDS of more than 2,000 mg/L. The lowest average values of TDS were measured in the North area, while the highest average value of TDS were estimated in Gaza area, 4,538 mg/L. Possibly, such high records are due to seawater intrusion and over water abstraction in comparing to aquifer balancing.

The GIS mapping for TDS for the study area (2009-2013) is matching to high degree the PWA/CMWU records. Some variation among data in last 5 years in quality records in Al Zahra, and western Khanyounis and Rafah are noted. This could be related to accuracy of measurement taken and seasonal variation due to rainy seasons. Taking in consideration the current abstraction status, and continuing with same conditions without interventions, the abstracted groundwater TDS quality has been predicted up to year 2020 (Figure 7) with average projected exponential rise at approximately 8.3% per year (close to the increasing rate of Chloride). It is advised that areas with specific high rates of TDS needs urgent intervention by PWA as a short term solutions in similar way to Chloride.

*Figure (7): TDS Levels in the Gaza Strip, Municipal Drinking Wells*



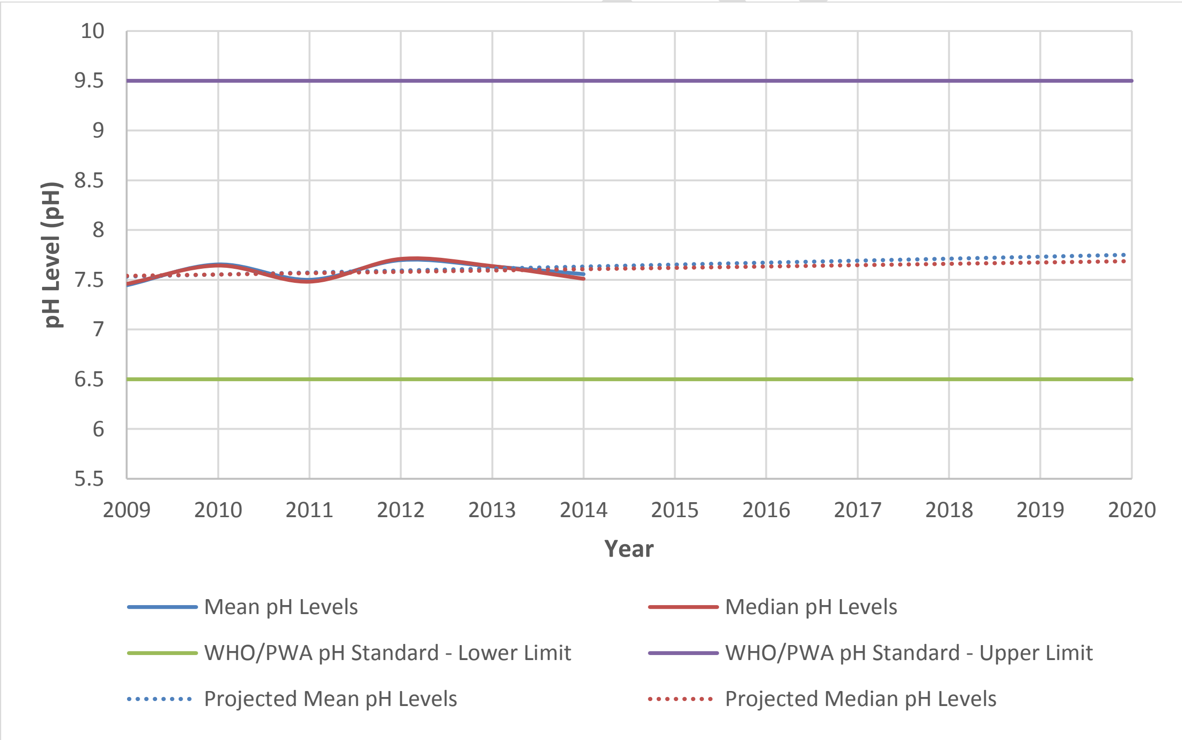
## PH

Power of Hydrogen (PH) is a measure of the hydrogen ion concentration of water. It is recommended to monitor the PH in order to establish baseline water quality in the distribution system. The PH of water in the distribution system is an important factor in nitrification activity. A reduction in PH can be an indication of problematic biofilm growth. For example, a decrease in PH can result from growth of sulfur-reducing bacteria such as Thiobacillus. These bacteria generate hydrogen ions which lowers the PH. Both the WHO and PWA standards range of PH is of 6.5 to 8.5.

Based on the monitoring wells testing results provided by PWA, the PH in Gaza aquifer is matching the WHO and PWA standards. According to produced GIS maps, and considering the accepted range of PH from 6.5 to 8.5, the PH quality records are in good condition. It is worth to mention that the PH level ate eastern Khanyounis and Rafah should be under monitoring in future so that interventions to be taken to avoid any deterioration in its value. Bearing in mind the current abstraction status, and continuing with same conditions without interventions, the abstracted groundwater PH quality has been predicted up to year 2020 (Figure 8) with average pH levels for municipal wells are good and are not expected to change over the next 5 years.



*Figure (8): pH Levels in the Gaza Strip, Municipal Drinking Wells*



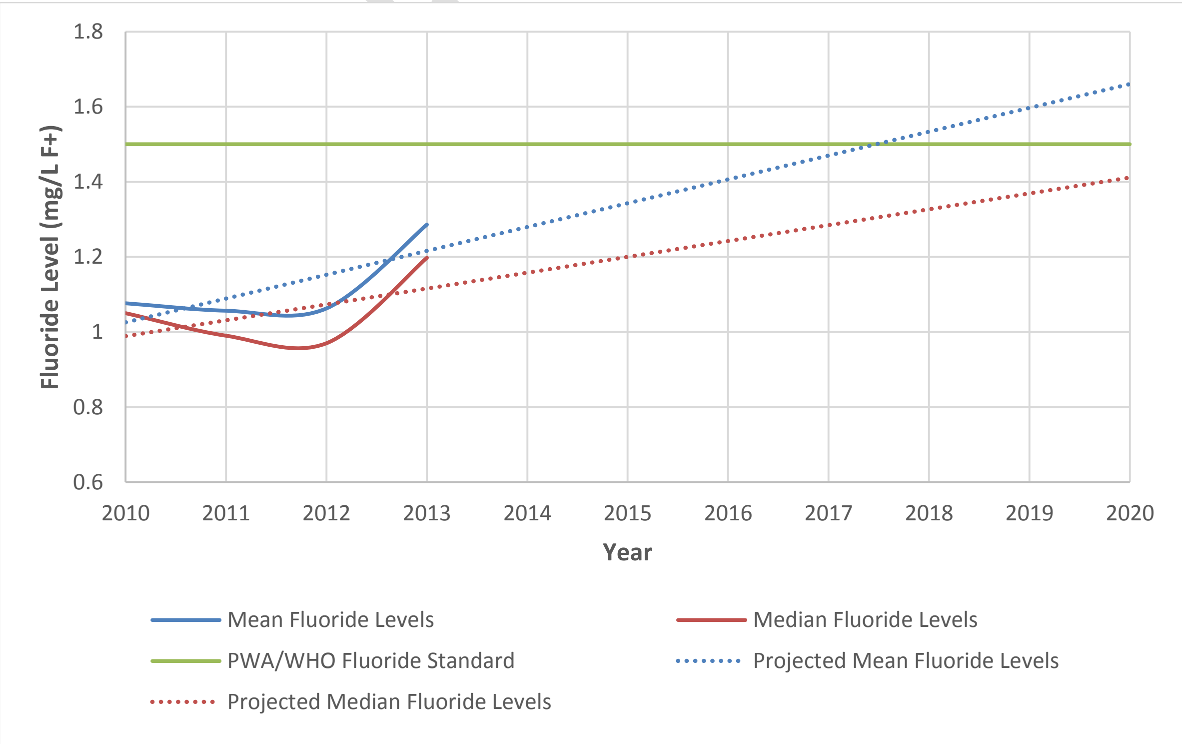
### Fluoride

Increased fluoride pollution above the normal levels of 0.7 – 1.2 ppm causes osteomalacia as well as staining and erosion of teeth, particularly in children. Centre for Health Research, part of Gaza's Department of Health in 2013, found that the level of fluoride in Gaza's drinking water range between 0.8 – 3.8 ppm. It also found that there was an increase in the incidence of fluoride poisoning in areas where increased concentrations of fluoride have been recorded. High doses of fluoride are highly toxic and may result in diseases (Rimawi, 2013).

According to fluoride quality data monitored by PWA for the period 2009-2013, the concentration at majority of Gaza strip is according to WHO and PWA standards except the eastern part of Gaza and segments in eastern Khanyounis and Rafah. Al last two years, the fluoride quality records show increasing in the rate of declination at eastern Khanyounis mainly where values exceed twice the WHO limits. However, the fluoride rate stays stable even in eastern Gaza since 2012. This accidental increase recorded in eastern Khanyounis is in line with PH increase in this area starting also in year 2012. Abu Jabal et., al. (2014) shows a positive coloration between PH and fluoride that could cause increasing the dissolution/solubility of fluoride bearing minerals, leading to fluoride leaching into the groundwater.

The produced GIS maps for fluoride concentration (2009-2013) are matching the PWA/CMWU records. Taking into account the current abstraction status, and continuing with same conditions without interventions, the abstracted groundwater fluoride quality has been predicted up to year 2020 (Figure 9) with average projected exponential rise at approximately 6.0% per year. It is advised that areas with specific high rates of fluoride (mainly at eastern Khanyounis) needs further detailed physicochemical analysis and further intervention by PWA.

*Figure (9): Fluoride Levels in the Gaza Strip, Municipal Drinking Wells*



## Cations

Most of the cations Magnesium ($Mg^{2+}$), Sodium ($Na^+$) and Potassium ($K^+$) show concentrations higher than the WHO standards of 30, 200 and 10 mg/L, respectively. Dissolved magnesium in water is the two most common minerals that make water "hard". Based on the water hardness classification of 0 to 60 mg $CaCO_3$/L as soft, 61 to 120 mg $CaCO_3$/L as moderately hard, 121 to 180 mg $CaCO_3$/L as hard, and more than 180 mg$CaCO_3$/L as very hard, most groundwater in Gaza is hard to very hard. As water hardness is determined primarily by $Ca^{2+}$ and $Mg^{2+}$, not surprisingly, the areas with highest levels of $Ca^{2+}$ and $Mg^{2+}$ also have the hardest water. The average concentration of $Mg^{2+}$ was 48 mg/L. Areas between Gaza and the northern region, a segment in western middle region and western Rafah wells showed the highest levels of $Mg^{2+}$. Same analysis is used for Potassium $K^+$ which shows higher quality records exceeding WGO standards as same location for Magnesium.

The lowest $Na^+$ levels were found in the north and segment in west Khanyounis, and the highest levels were in the areas of eastern Khanyounis, Gaza, Middle and Rafah governorate as well as the western area between Gaza and north governorates. To large extend, $Na^+$ is connected to chloride and TDS bad quality records and deterioration. The only area with accepted $Na^+$ quality record is the north area where water abstraction rate is normal and absence of seawater intrusion could be behind that.

The finding of cations analysis shows that the western area between Gaza and north governorate are suffering of all cations exceeding WHO standards which could be related to seawater intrusion adversely affecting this area.

Based on the water quality graphs magnitude as well as the attitude, taking in consideration the current abstraction status, the abstracted groundwater cations ($Mg^{2+}$), ($Na^+$) and ($K^+$) quality has been predicted up to year 2020 (Figure 10, 11, & 12, respectively), with an average rise at approximately 11.8%, 7.8%, 10.9%, respectively per year. Liner extrapolation could be accepted in condition of keeping same situation with no intervention or changing. Findings accomplished in this study are harmonious with the PWA and CMWU reports which also confirm about the areas suffering from cations' bad quality measurement levels all over Gaza Strip (CMWU, 2014 and PWA, 2014).

*Figure (10): Magnesium Levels in the Gaza Strip, Municipal Drinking Wells*

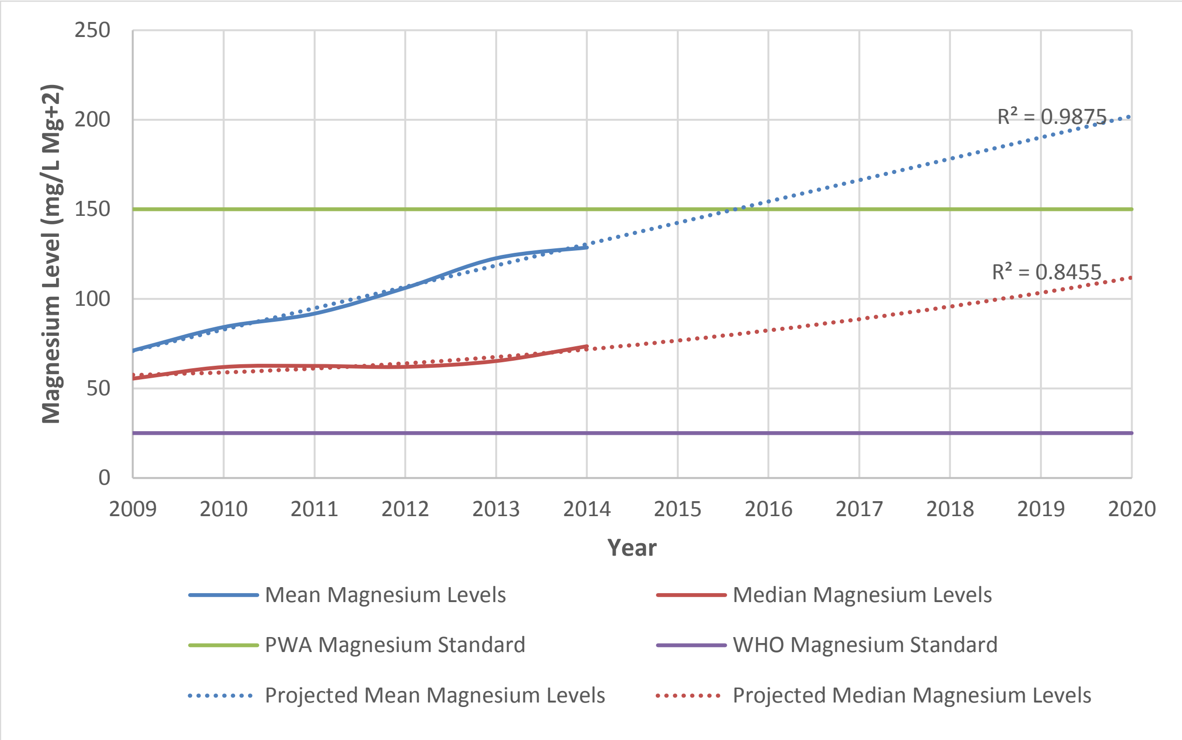



*Figure (11): Sodium Levels in the Gaza Strip, Municipal Drinking Wells*

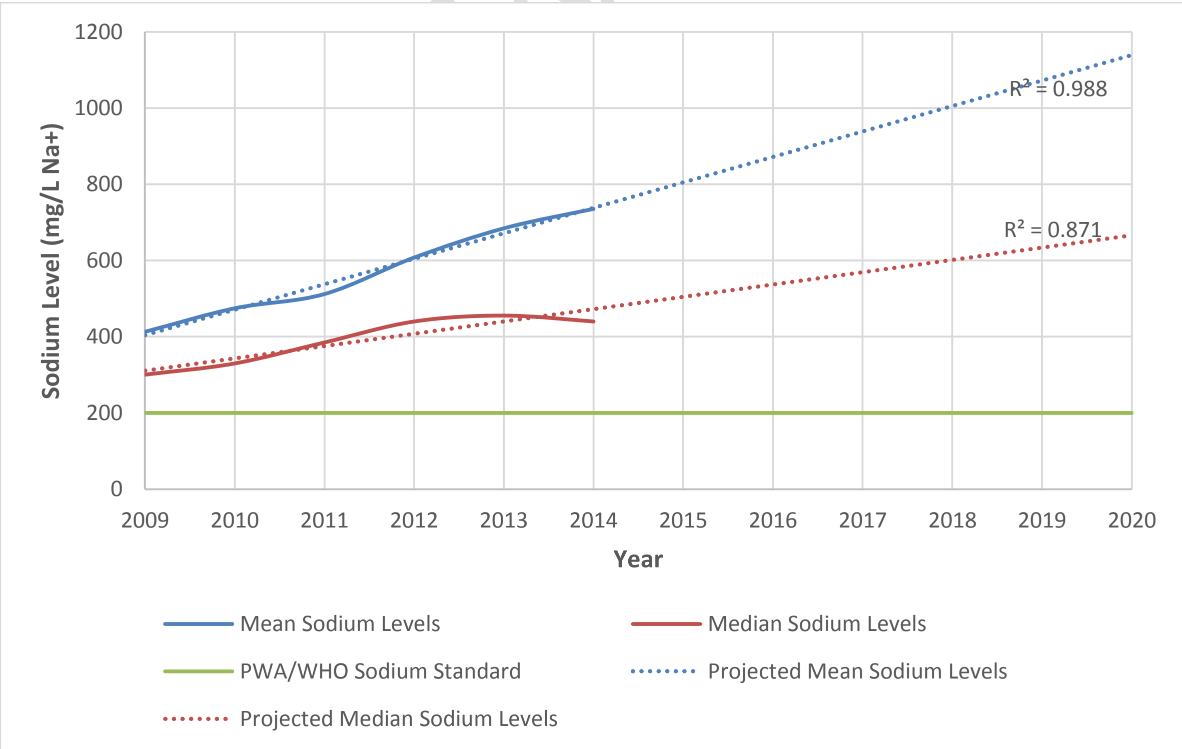
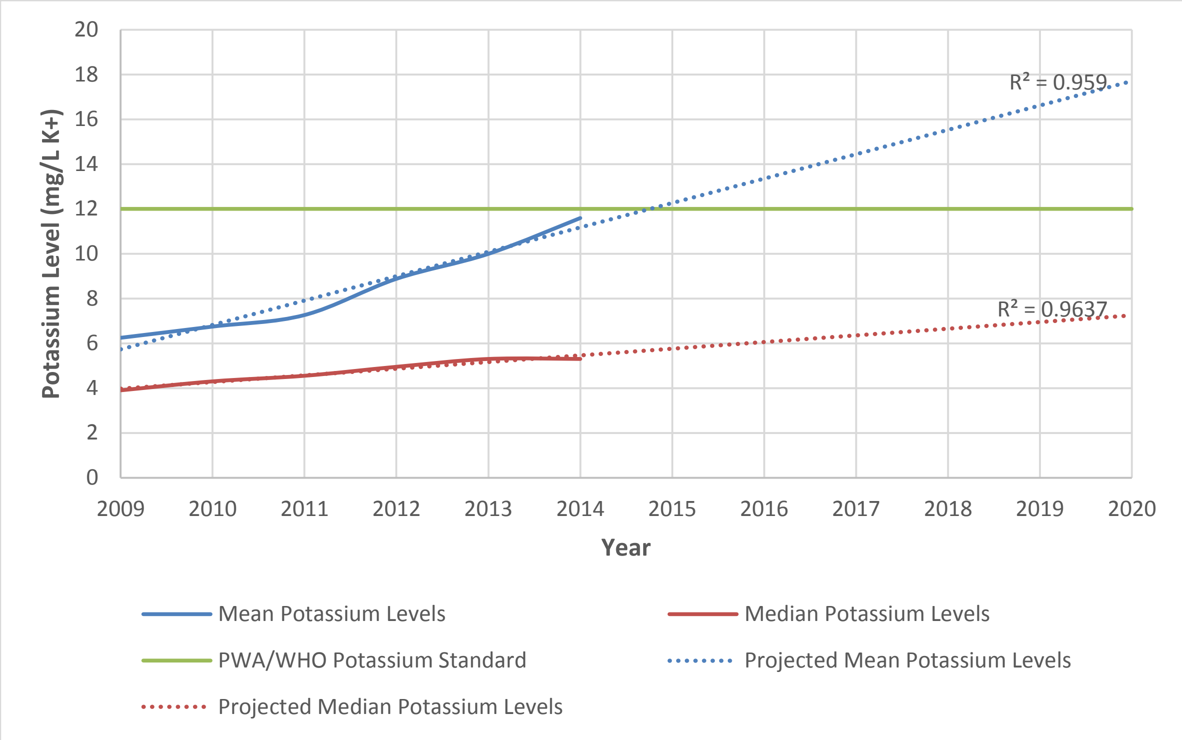


*Figure (12): Potassium Levels in the Gaza Strip, Municipal Drinking Wells*






## Overview of the Public Health Data

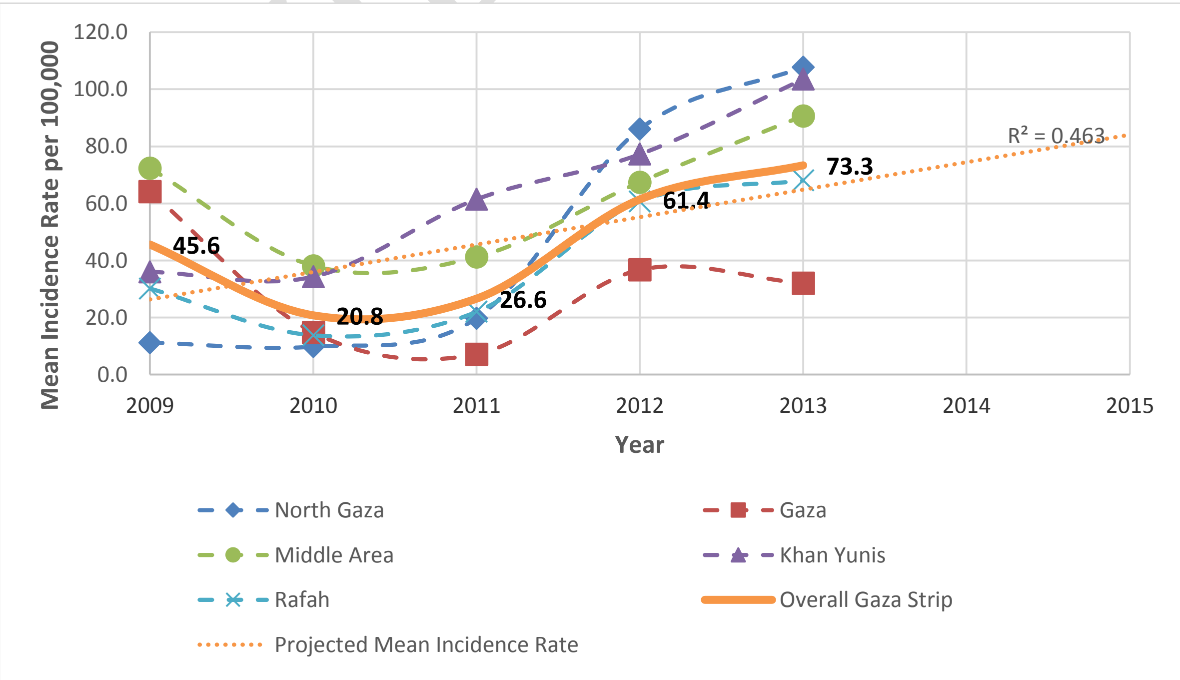
As indicated earlier, because there was great disparities in the reported statistics of the concerned public health diseases across the health care providers, the research team analyzed and mapped the collected data for each of the designated public health disease according to the health care provider and the catchment area served by that provider. For diseases reported by UNRWA and the MOH health facilities; the research team analyzed and mapped each disease independently according to the providers' clinics' catchment areas. Subsequently, the reader can see a map that shows the incidence of the disease according to UNRWA statistics; another one according to MOH statistics as annexed to this report. Then, the data at the governorate level were reported and mapped combined from the different sources and calculated based on the population of the concerned governorate. Wherever possible, data has been analyzed and mapped at the community/neighborhood level such as meningitis, cancer and renal failure. When it was possible to get data disaggregated by gender or age, these variations were also analyzed and disclosed as in case of diarrhea which has been analyzed as a whole and then for children under three years old. It is worth noting that the incidence rates reported by clinics is largely determined by the number of clients who present to these clinics. Clients may be entitled to go for more than one clinic, but finally their decisions are based on many factors including their perceptions about the quality of services, affordability, access, personal preference, and the availability of resources. It is possible that some clients go to clinics other than the nearby ones or to shop around providers and receive services from more than one place, thus double counted. The coming paragraphs, discuss briefly the incidence and trends of the designated diseases at the concerned years, with some illustrations at the governorate and community level, reflecting the incidence reported by the two main providers, MOH & UNRWA.

### Hepatitis A

Viral hepatitis is one of the most serious health problem globally, with some variations from one type to another and from a country to another. In Palestine the most common are hepatitis A, hepatitis B and hepatitis C. Hepatitis A remains a major cause of morbidity among reportable infectious diseases among the refugee population of the Gaza Strip (UNRWA, 2011). It is a highly contagious liver infection caused by the hepatitis A virus that causes inflammation and affects human's livers' ability to function. A person usually contracts hepatitis A from contaminated water (drinking or washing vegetables/fruits) or food or from close contact with someone who's infected. The mode of transmission is usually oral-fecal route; therefore inappropriate sewage disposal and biological water pollution play an important role in the transmission of the disease. It is more common in regions of the world with poor sanitation and not enough safe water (WHO, 2013).

In 2009, the incidence of hepatitis A across the Gaza Strip governorates was high 45.6 per 100,000 population, and then dropped to 20.7 per 100,000 in 2010. However, since 2010 there is a steady increase from 20.7 per 100,000 population to 61.4 per 100,000 in 2012 and 73.3 per 100,000 in 2013-around four times the incident reported in 2010. The increasing trend of hepatitis was applicable for all governorates with Dier Al Balah, the north, and Khanyounis governorates being particularly affected (Figure 13). Possibly, the conflict, siege and the massive destruction of infrastructure including water resources and inappropriate sewage disposal together with the decline in socioeconomic indicators had contributed to the spread of the diseases during that period.

*Figure (13): Distribution of the incidence rate of hepatitis A per governorate (2009-2013)*



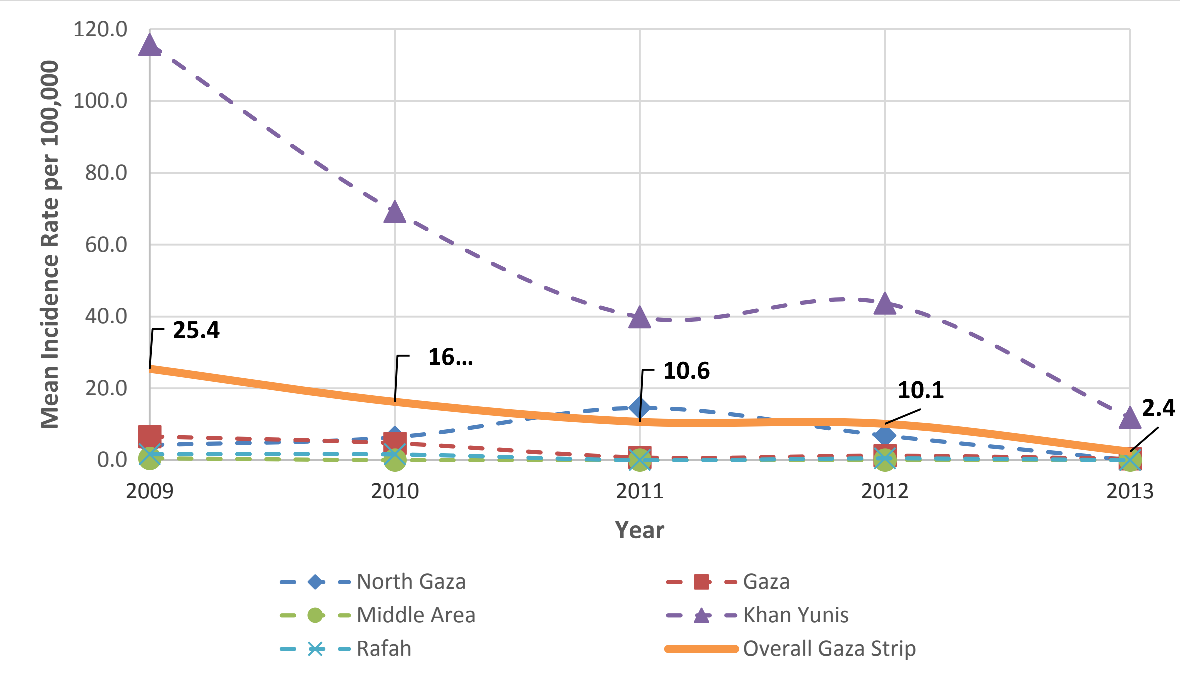
However, at the community level, UNRWA and MOH data show diverse findings regarding the mostly affected areas by Hepatitis A. Data from MOH clinics show that the highest incidence rate per 100.000 population in the year 2013 was reported in the Bet Hanoun (227.5), and Khanyounis (209.0), while the lowest incidence rates were reported in Sheikh Radwan and Al Rimal (6.6 and 7.0, respectively). Also, the catchment area of Khaldah Al Aga Clinic had the highest hepatitis A incidence rates in 2010 and 2011 (123.4 and 152.1, respectively). On the other hand, data derived from UNRWA clinics reflected that the highest reported hepatitis A incidence rates in 2010, 2011 and 2013, were prominent in Khan Younis (186.0, 129.8 and 198.5 respectively); nevertheless, the lowest rate was reported in Jabalia, Rimal and Bet Hanoun (4.0, 1.7 and 19.4 respectively). In 2012, Zaitun had the highest hepatitis (A) incidence rates (166.5), yet the lowest rate has been reported in Elnasser (7.4 per 100,000), all according to data collected from UNRWA clinics. According to the same source, the highest incidence rates in 2009 was reported in Rimal area (428.3) followed by Maghazi (212.0) and the lowest rate had been reported in Bet Hanoun and Rafah (2.8 and 6.6, respectively). This wide variation per locality could be explained by the nature of the disease epidemicity which easily transmits from one person to the other in the same area.

Findings concluded in this study are congruent with the MOH and UNRWA reports which also confirm that there is an increase in the incidence rate in the year 2013 in comparison with previous years (UNRWA, 2014 and MOH, 2014). It is worth reminding the reader that hepatitis A transmits through oral-fecal routes and can be controlled by promoting the WASH components which to high extent limits its transmission. Improving water quality, improving safety of water supply, appropriate sewage disposal and promoting personal hygiene are among the factors that significantly reduce the spread of the disease. It is advised that areas with specific high rates of hepatitis needs further investigation with focus on exploring water contamination with untreated sewage.

**Typhoid**

Typhoid fever, also known simply as typhoid, is a symptomatic bacterial infection caused by Salmonella Typhi (Wain, et al. 2015). Typhoid usually spreads by drinking or eating food or water contaminated with the feces of an infected person (WHO, 2008). Risk factors includes poor sanitation, poor hygiene and hardship conditions (Wain, et al. 2015). Typhoid fever is a septicemic illness that is endemic in Palestine. Assuming that the provided information by MOH and UNRWA are accurate, in the last several years, there is steadily decline in the incidence of the disease. At the governorate level, based on the available data from all sources covering the period 2009 to 2013, the incidence rate of typhoid has significantly decreased from 25.4 per 100,000 population in 2009 to 16.22 in 2010, 10.6 in 2011, 10.1 in 2012 and it reached 2.3, always per 100,000. Also, the geographical distribution by governorates shows that the majority of cases in the years 2009 to 2013 were reported in Khan Younis (11.69, 69.9, 40.2, 44.2, 12.0 per 100,000, respectively) and lowest in the North Gaza, Rafah, Gaza, Rafah and Gaza (0.5, 1.6, 0.7, 0.5, 0.3 per 100,000, respectively). Congruently, data collected from MOH at the clinic level, show that the highest rates per 100,000 population were observed in Khan Younis City from the years 2010 and 2013 (157.2, 86.2, 94.7, 25.6 respectively). In the year 2009, Abasan Al-Kabera reported the highest incidence rate (435.1 per 100,000). Contrarily, the catchment areas of Sohdaa Jabalia center had the lowest rate (428.3 per 100,000 vs. 4.3 per 100,000).

*Figure (14): Distribution of the incidence rate of Typhoid per governorate (2009-2013)*




Data reported by UNRWA clinics clarify that in 2013, Tal Sultan area had the highest incidence rate (120.0 per 100,000), while Nuserirat S/C had the highest rate in 2012 (23.9 per 100,000), and Shouka (17.9 per 100,000) in 2011. It is worth noting that the incidence rate at Tal Sultan area could be overestimated because the clinic at that period served the entire refugee population in Rafah. UNRWA Rafah clinic was under renovation. In 2010, Maghazi reported the highest rate, meanwhile Jabalia has reported the lowest rates (129.4 per 100,000 and 1.1 per 100,000, respectively). In 2009, Maen had the highest typhoid incidence rate followed by Khan Younis (66.0 per 100,000 and 53.4 per 100,000, respectively), while the lowest rate was observed in Rimal and Bureij (1.8 per 100,000 and 2.4 per 100,000, respectively). Findings revealed by this study are consistent with MOH and UNRWA published reports. One of the issues that deserves consideration is the diagnosis and reporting of cases, not always the reported cases are confirmed and also not all the confirmed cases are registered and appropriately reported. Possibly, case diagnosis and lack of study lead to over or under estimation.

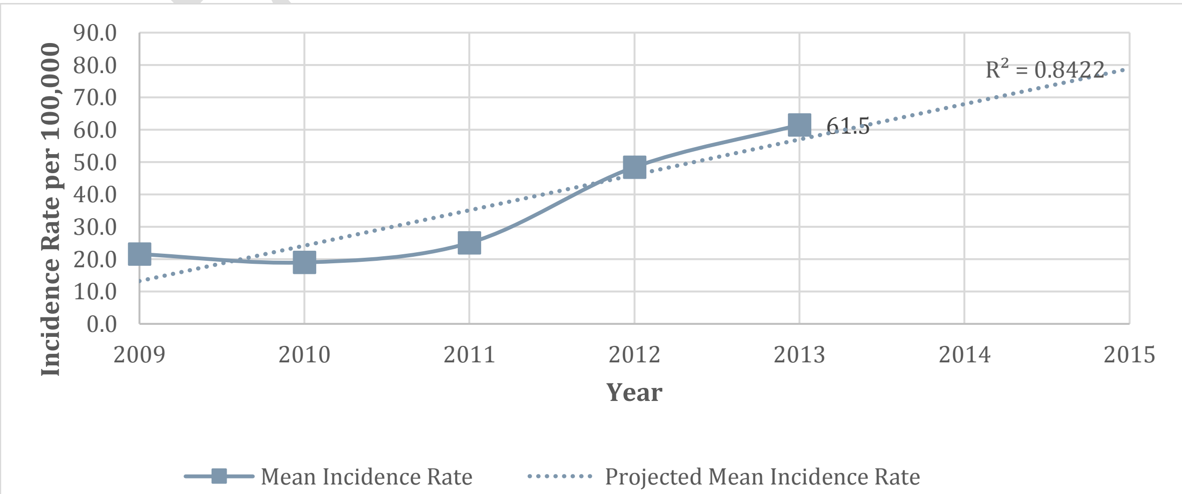
Variations per localities across the different years could be attributed to the change in the sanitary conditions, quality of water, sewage disposal and also the change in access/preference of clients when seeking medical services and the differences in from where client get services. Many of the reasons affecting Typhoid fever are contextual and affected by a politically and socioeconomically unstable environment. It is important to strengthen the surveillance system at health facilities and to conduct epidemiological study of the phenomena with appropriate involvement of the stakeholders.

## Cancer

Cancer is a disease caused by an abnormal growth of cells, also called malignancy. It is a group of 100 different diseases, and is not contagious. In most individual cases of cancer, the exact cause of cancer is unknown. Risk factors may include increased genetic susceptibility, environmental pollution, such as chemical exposure, lifestyle factors, diet, infectious disease; and many more. Globally, there is an increase in the incidence of cancer; in 2012, about 14.1 million new cases of cancer occurred (not including skin cancer other than melanoma) were diagnosed all over the world. In the same year, it caused about 8.2 million deaths or 14.6% of all human deaths (WHO, 2014). As Figure 15 depicts, there has been an increase in cancer cases since 2010 possibly as a result of environment contaminations with toxic materials and heavy metals resulted from bombardments. In 2009 the annual incidence rate was 22 per 100,000 population which has increased to 25 in 2011 and reached to 61.5 per 100,000 in 2013. Should the current trend of increase continue in the same pattern, the rate would be about 80 per 100,000 in 2013. Although the figure below reflects an increasing trend in cancer, it doesn't reflect the real incidence of cancer as the research team wasn't able to recognize the locations of around 3000 cases which represents 30% of cases. The actual ***cancer rate is 30%*** higher than the reported figure in this report which is also congruent with MOH report (2014) which illustrates that the incidence rate in 2011 as 46.2 per 100,000; 73.6 in 2012 and 81.7 in 2013.

Gaza Governorate reported the highest incidence rate of cancer in 2013 69.7 per 100,000 meanwhile North Gaza elicited the lowest rate (45.7%). This is congruent with the findings reported by MOH reports about cancer (MOH, 2011, 2013). In fact, differences between governorates were general small. Further investigations revealed that the higher rates in Gaza is related to an administrative process where in cancer registry office the staff report Gaza when the address is not recorded or not clear. Similar variations between Governorates were observed in Jordan where Amman reported the highest cancer rates. The rates in the capital Amman are twice or triple of other governorates in Jordan (Al Tarawneh, Khatibs and Arqub, 2010). Cairo and Geiza reported more than 50% of cancer cases in Egypt (Egypt National Cancer institute, 2003).

*Figure (15): Distribution of the incidence rate of cancer per governorate and years (2009-2013)*



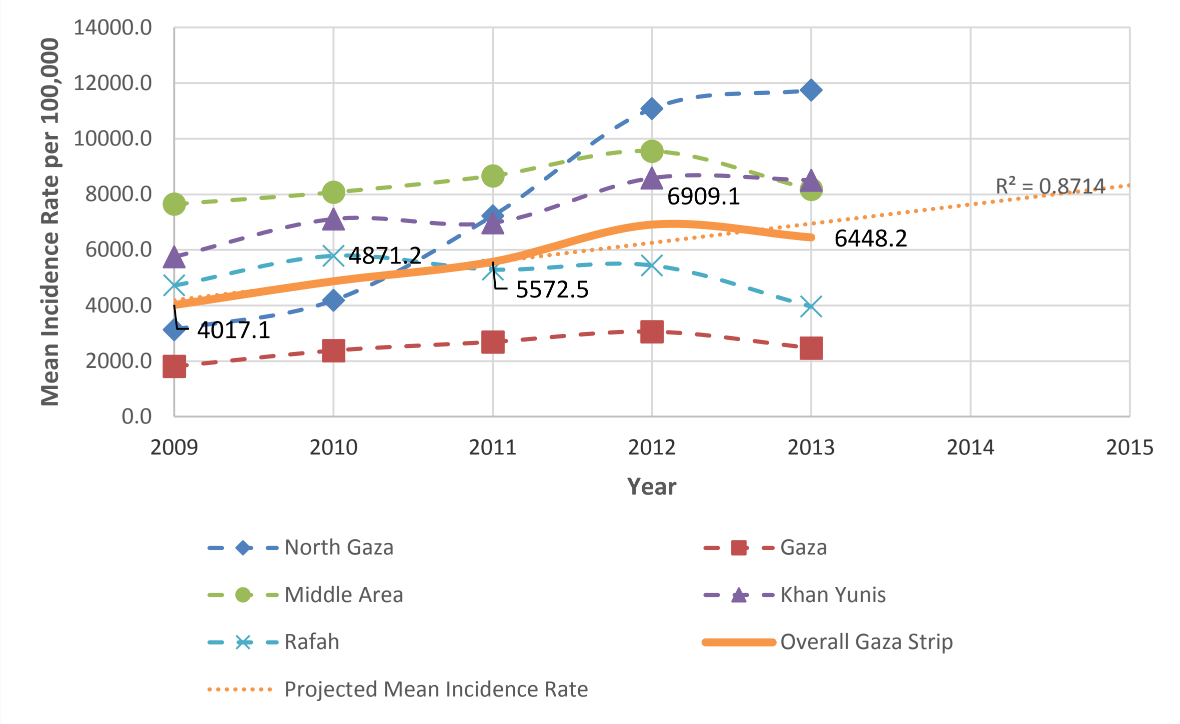
Taking all the cancer cases together through the years 1995 till 2013, Al Remal followed by Jabalia and Jeir Al Balad elicited the highest cancer rates. Highest rates were observed in Dir Al Balah and Abasan Aljadidah in the year 2009 (195.6 per 100,000 and 177.5 per 100,000, respectively), Maspah and Abasan Aljadidah in 2010 (174.2 per 100,000 and 124.5 per 100,000, respectively). In 2011, Heker AL-Jame had the highest cancer incidence rate (267.6 per 100,000) and Abasan Aljadidah in 2012 had the highest (637.9 per 100,000). In 2013, Deir Albalah camp had the highest rate (547.9 per 100,000). Based on these findings we can conclude that there is a marked increase in incidence rates of cancer possibly attributed to several factors including the Israeli aggressions. Possibly, the rate has increased due to improvement in the methods of diagnosis and reporting. This increase can also be real, reflecting long term changes in lifestyle, increased exposure to contaminants together with the increased exposure to stressors with the increase in life expectancy. Further efforts are needed to improve registration of cancer cases and to further investigate the relationship between cancer and the exposure to heavy metals and containments.

### Diarrhea

Diarrhea is the condition of having at least three loose or liquid bowel movements each day. The most common cause is an infection of the intestines due to either a virus, bacteria, or parasite; a condition known as gastroenteritis. These infections are often acquired from water or food that has been contaminated by stool, or directly from another person who is infected (WHO, 2013). Diarrheal disease is a leading cause of child mortality and morbidity in the world. It is a common problem that generally lasts for few days. Globally, about 1.7 to 5 billion cases of diarrhea occur per year (WHO, 2013). It is common in developing countries, where young children get diarrhea on average three times a year (WHO, 2013). Total deaths from diarrhea are estimated at 1.26 million in 2013 (CDC, 2013).

In Gaza Strip, acute diarrhea is one of the most common childhood illnesses and the main cause of outpatient visits and hospitalizations. Diarrheal diseases were the highest self-reported diseases among residents in the Gaza City. Such diseases were more prevalent among people using municipal water than people using desalinated water and water filtered at home for drinking (Yassin, Amr and Al-Najar, 2006). Both UNRWA and MOH reports show a constantly increasing trend in the incidence of diarrhea, possibly attributed to deterioration of water resources and sewage infrastructure. At the Gaza Strip level, it was clear that there is an increasing trend in the incidence of diarrhea during the period between 2009 and 2013. The rate was 4017.1 per 100,000 in 2009 and increased to 6909.1 per 100,000 in 2012. After 2012, a steady decrease was observed in the years 2013 (6448.2 per 100,000). Data per governorate shows Deir Al Balah (in 2009, 2010 and 2011) and the North (in 2012 and 2013) elicited the highest incidence rates of Diarrhea while Gaza reported the least incidence.

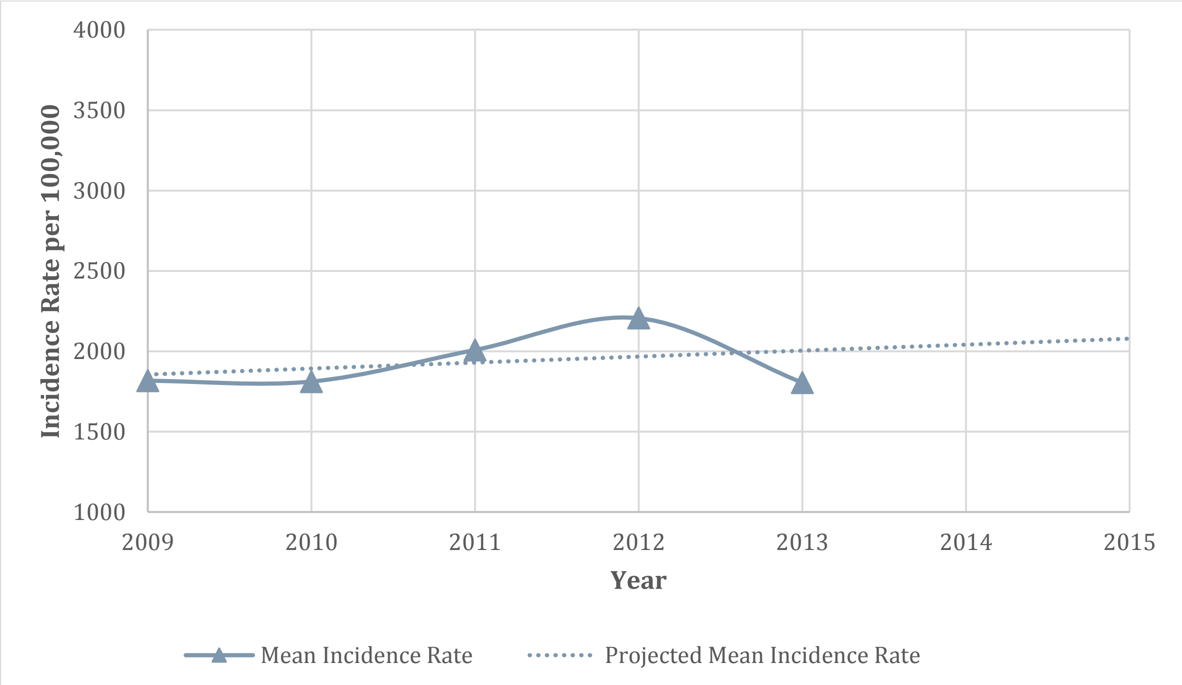
*Figure (16): Distribution of the incidence rate of diarrheal diseases per governorate (2009-2013)*




At the clinic level, MOH clinics report show that the highest diarrheal incidence rates per 100,000 population were observed in Masader in the years from 2009 to 2013 (35580.2, 24868.5, 33856.8, 34582.8 and 34972.0), followed by Abasan Al Kabera in years 2009, 2010, 2012 and 2013 (20590.0, 18152.6, 24038.4 and 22760.1), and Johr Dik in 2011 (22990.5). In contrary, UNRWA available data from 2009- 2013 shows that Tal Sultan had the highest incidence rate in 2012 and 2013 (11954.4 per 100,000 and 12108 per 100,000, respectively). This could be attributed to the fact that many of the refugees from Rafah Camp were treated at Tal Sultan because Rafah clinic was demolished and rebuilt at that period. Also, UNRWA records show that in 2011, Shaboura had the highest rate (11402.4 per 100,000), while Shouka had the highest rate in years 2009 and 2010 (9811.6 per 100,000 and 8160.6 per 100,000 respectively), but the lowest rate was observed in Maen in years from 2009 to 2012 (1328.8, 1607.9, 1624.0 and 1746.4 per 100,000, respectively).

Regarding watery diarrhea among children below 3 years as reported by UNRWA, Tal Sultan had the highest incidence rate in the years 2012 and 2013 (7158.5 per 100,000 and 78112.0 per 100,000 respectively), possibly due to the reasons mentioned earlier. In 2009 and 2011, Shouka had the highest rate (5910.0 and 4840.7 per 100,000 respectively). Lower incidence rate was reported in Maen in the following years 2012, 2011 and 2010 (1119.0, 993.0 and 900.2 per 100,000 respectively). The high incidence of diarrheal disease in some governorates is often linked to contaminated food, poor water quantity and quality and due to bad sanitation and hygiene. Diarrhea among children is a sensitive indicator that reflects the availability and quality of the WASH related component and should therefore be always monitored.

*Figure (17): Distribution of the incidence rate of diarrhea among children less than 3 years and reported at UNRWA centers per years (2009-2013)*




Findings revealed by this study are consistent with UNRWA and MOH statistics which show an increasing trend in the last three years (watery diarrhea) with a fluctuation in the incidence according to the contextual situations (MOH, 2014; UNRWA 2015). UNICEF points that the increasing trend of diarrhea may be due to poor water quality and hygiene practices, 20% of households had at least one child under the age of five who had been infected with severe diarrhea in the four weeks prior to the survey; this ratio can rise up to 38% (UNICEF 2010) in certain areas. In 2011, Abouteir, et al study shows variables that were independently predictive of diarrhea: access to public water, poultry or rabbits at home, and presence of cooker at home. The most effective control measures to prevent diarrhea are maximizing access to sanitation, safe water, safe food supplies, and improving personal hygiene practices. The literature indicates that improving WASH components is associated with significant reduction in the incidence of diarrhea.

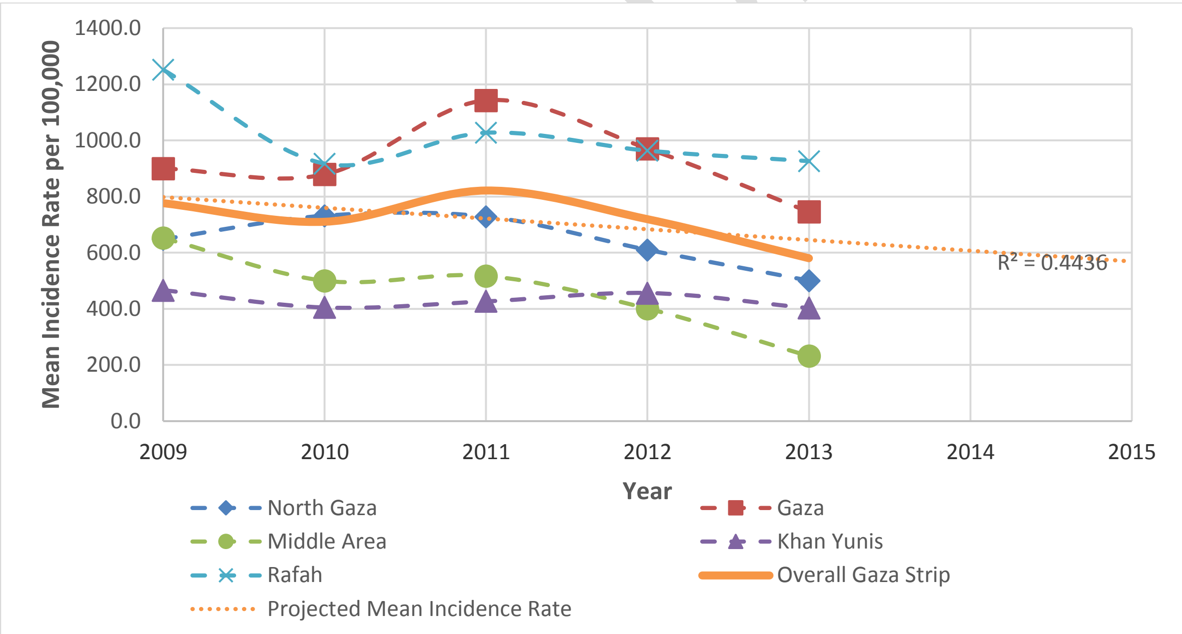
Monitoring the incidence of diarrhea through effective surveillance system and responding to high incidence rates through conducting multi-sectoral epidemiological assessment is a starting point to set corrective strategies. Measures to control diarrhea should be established at both preventive and therapeutic level. Promoting the quality of drinking water, housing conditions and improving sanitations are important strategies. Also, improving documentation practices at health facilities is crucial. It is important to note that the reported incidence rate in this study is based on health facilities. The actual incidence rate is higher as not all the people with diarrhea present to health facilities; others are self-recovered or treated at home. It is recommended to compliment the facility based reported incident rate with household studies.

### Parasitic Infestations

Parasitic infection is an intestinal infection caused by a microscopic parasite that's found in areas with poor sanitation and unsafe water. These parasitic infections can cause long-term effects such as anemia, retarded growth and mental disorders. The disease is endemic in the Gaza Strip; in the last five years (2009–2013), a total of 57191 cases were reported as parasitic infestations with a fluctuation trend. The incidence rates shows some declining trends in the last years (in 2009, 776 per 100,000, in 2013 580). In more details, since 2009, the incidence has decreased, from 776.2 per 100,000 population in 2009 to 710.2 per 100,000 in 2010. After 2010 a marked increase was observed in the years 2011 (821.2 per 100,000). The incidence has decreased significantly to reach 719.2 per 100,000 in 2012 and 580.5 per 100,000 in the years 2013.

Parasitic infestations were reported in all the Gaza Strip governorates; however, the incidence rate was the highest in the Rafah in the years 2009, 2010 and 2013 (1224.6, 897.5 and 906.7 per 100,000, respectively) followed by Gaza in 2009 and 2010 (909.2 per 100,000 and 887.9 per 100,000, respectively). While the lowest rate was reported in Khan Younis in 2009, 2010, 2011 (470.4, 409.0 and 430.8 per 100,000, respectively).

*Figure (18): Distribution of the incidence rate of parasitic infestation (2009-2013)*




Data collected from UNRWA clinics depicts that in 2013 El-Maghazi reported the highest rate (2908.1 per 100,000) followed by El Nasser (2450.0 per 100,000), and lowest rate was reported in Gaza town (314.4 per 100,000) followed by Khan Younis (331.3 per 100,000). In 2011 and 2012, Shouka and El Nasser had the highest incidence rate in the Gaza Strip, while Khan Younis had the lowest rate in 2011 and Maen in 2012. In 2010, El Nasser had the highest rate followed by Nuseirat (4188.9 per 100,000 and 2588.7 per 100,000, respectively), but Dair El Balah and Jabalia had the lowest rate (365.6 per 100,000 and 715.2 per 100,000, respectively). In 2009, Nuseirat had the highest incidence rate followed by Shouka (2601.7 per 100,000 and 2508.1 per

100,000, respectively), while the lowest rate was observed in Khan Younis Japanes and Jabalia (427.4 per 100,000 and 544.9 per 100,000, respectively). Findings of this study are congruent with the literature (ELRamlawi and Hararah, 2013, MOH 2014, UNRWA 2014) and flag the relationships between water quality and parasitic infestation as detailed later.

Intestinal parasitic infection in the Gaza Strip is still a Public Health problem, due to gaps in sanitation, water, bad hygienic habits, and inadequate community awareness (Al Hindi and El Kichaoi, 2008). Measures to control parasitic infection should be established at the preventive level. Promoting the quality of drinking water, improving sanitation and appropriate sewage disposal are important strategies.

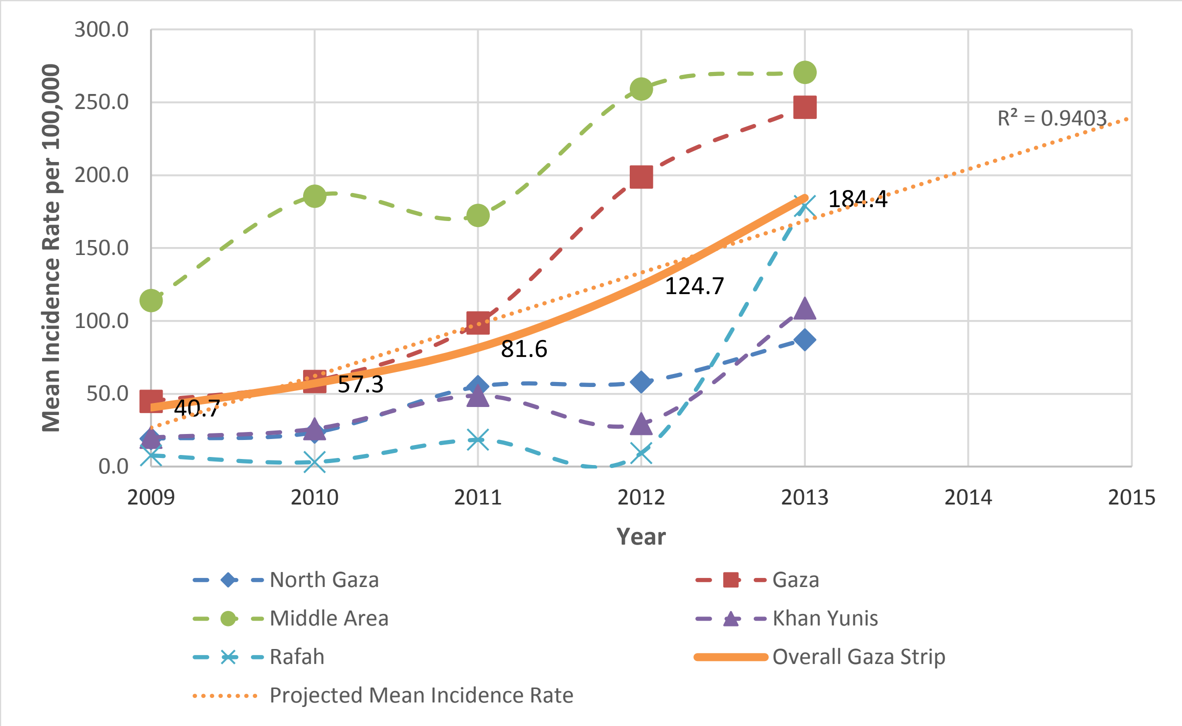
**Meningitis**

Meningitis is an infection that involves the membranes overlying the brain and spinal cord (meningitis) and the causative agents vary greatly among the different age groups. There are several different causes of meningitis like bacteria, virus or fungus infection. Meningitis is also a serious infectious disease related to sanitary and housing conditions. It has a high prevalence in developing countries, with associated mortality and risk of severe residual neurological problems.

The available data from all sources show that the incidence rate of meningitis in the Gaza Strip is constantly increasing. Through 2009 to 2013, 7967 cases of meningitis were reported in the Gaza Strip. Meningitis related diseases are endemic in Gaza with seasonal and governorate variations. Based on the available data, the yearly incidence of meningitis in the years 2009-2013 has increased from 40.7 to 184.4" per 100.000 population; especially in the last two years. In all years, Dier Al Balah has reported the highest incidence among all other governorates followed by Gaza governorate.

The geographical distribution at the community level as reported by MOH hospitals, it is observed in the year 2013 that the highest incidence rate per 100,000 population was observed in Khan Younis (2802.8), followed by Mawasi (1427.6), and the lowest incidence rate has been reported in Abasan Kabera (9.2). However, in the 2009, Al Tofah showed the highest meningitis incidence rates (180.2), followed by Gizan Al-Najar (150.2) and the lowest incidence rate had reported in Tal Sultan (2.9).

*Figure (19): Distribution of the incidence rate of meningitis per governorate (2009-2013)*




## Renal Failure

Renal failure (also kidney failure or renal insufficiency) is a medical condition in which the kidneys fail to adequately filter waste products from the blood. When the kidneys fail, the body retains fluid. Harmful wastes build up. The two main forms are acute kidney injury, which is often reversible with adequate treatment, and chronic kidney disease, which is often not reversible. In both cases, there is usually an underlying cause. We collected data about chronic renal failure from kidney dialysis units pertaining to the year 2013 including the deaths in that year. A person with ESRD needs treatment to replace the work of the failed kidneys.

The research team was able to identify the residency place of 580 clients undergoing kidney dialysis or died in that year from kidney failure. MOH reports indicate that the number of cases with kidney failure is increasing (MOH, 2014); it was 369 in 2009 and increased significantly afterwards. The highest number of kidney failure was reported in Gaza (234) followed by the north (119). Gaza obtained around 40% of cases and the north obtained 20.5% of cases slightly higher than the population concentration in these areas. The lowest reported cases were found in khanyounis. Analysis according to the community level showed that Jabalia camp obtained the highest number of the reported cases (97), followed by Dier Al Balah (67) and Al Rimal (63). Kidney failure is a multifactorial diseases and the increase in the cases requires further in-depth investigation.

## GIS Overlay Analysis of Water Quality and Public Health

When exploring variables over space it is often found that spatial autocorrelation exists. Regression analysis allows to model, examine, and explore spatial relationships, and can help explain the factors behind observed spatial patterns. Regression analysis is also used for prediction. Ordinary linear regression (OLS) is the best known of all regression techniques. It is also the proper starting point for all spatial regression analyses. It provides a global model of the variable or process you are trying to understand or predict; it creates a single regression equation to represent that process. Geographically Weighted Regression (GWR) is one of several spatial regression techniques, increasingly used in geography and other disciplines. It is a powerful tool for exploring spatial heterogeneity. GWR provides a local model of the variable or process you are trying to understand/predict by fitting a regression equation to every feature in the dataset, in this study (LOS) used to find any possible correlation between water quality and public health because (GWR) it is need more than (160 feature class) to use it and all features of catchment areas of study area not exceed 50 features.

The feature class which used in (LOS) analysis contains of diseases incidence rate per 100,000 and water parameters measurements created with the spatial queries and overly tools (select and spatial join) in ArcGIS toolbox. A statistical evaluation of the relationship between the chemical analysis of municipal wells and the diseases incidence rate were conducted via linear ordinary regression (LOS) from ArcGIS geo-statistical analyst toolbox. In this analysis, the dependent variable was diseases incidence, and 8 independent variables of water parameter measurements (Cl, No3, Mg, Na, TDS, F, K, pH) through period of study (2009 -2013).

ArcGIS Model was built to spatial select of water parameters measurements which exceed on acceptability standards of PWA and spatial join with public health layers for each year, then used OLS from spatial statistics tools to create regression and find any correlation between public health and water quality layers.

**Analyzing Patterns**

Identifying geographic patterns is important for understanding how geographic phenomena behave. The Spatial Autocorrelation (Global Moran's I) tool from ArcGIS spatial statistics tools measures spatial autocorrelation based on both feature locations and feature values simultaneously. Given a set of features and an associated attribute, it evaluates whether the pattern expressed is clustered, dispersed, or random.

# RESULTS

## CORRELATIONS EVALUATION

As explained earlier, the research team conducted multiple regression using the 'Geo-statistical Analyst' extensions of ArcGIS-ArcMap 10.2.1 software package. The Kriging model (Ordinary Kriging type) was used to generate a set of predicted values at known locations along the Gaza Strip. The predicted values by each model were generated by systematically removing some of the input data (Calibration data) for water parameters concentration then their values were calculated based on other data (Modeling data). The performance of prediction model was evaluated by the magnitude and distribution of prediction errors when comparing the predicted values with the calibration data.

However, the potential relationships between water quality parameters and the distribution of diseases (cancer, Renal, diarrheal among children under 3 year, diarrhea, hepatitis, meningitis, parasitic and typhoid) incidence rates were examined using statistical linear regression analysis. Annex 3 shows the results of the correlation between the dependent variables (public health diseases) and the independent variables (water quality parameters). Correlation results indicate that there were statistically significant associations between water quality parameters and the occurrence of public health diseases in certain years regarding certain variables as detailed below.

There were strong positive statistically significant associations between nitrate level and the occurrence of parasitic infection (Adjusted r-squared=4, P value=0.0002) in the reported data from UNRWA clinics in 2011. It is worthy indicating that R-square is the proportion of variability in a data set that is accounted for by a statistical model. Adjusted R-square is a modification of R-square that adjusts for the number of terms in a model. It increases only if the new term improves the model more than would be expected by chance. Based on the statistical analysis in the year 2011, it could be concluded that high nitrates level in water is more associated with parasitic infestations. This could be related to seawater intrusion into the wells which is accompanied by higher level of nitrates, chloride and TDS. Also, nitrate contamination usually results from runoff of agricultural fertilizers or from human or animal wastes. The nitrate levels in Gaza is far over the limits recommended by the WHO and PWA Guidelines, the WHO guidelines for nitrate levels recommend a maximum of 50 mg/L, compared to the PWA Guidelines, which recommend a maximum of 70 mg/L. The average nitrate levels observed in Gaza wells ranges from 8 mg/L to 528 mg/L, also over the recommended limits by both guidelines. This calls for initiating a strategy to improve the quality of water as this contributes to reduction of diseases. Areas with high nitrate level should be further assessed and adequate interventions such as screening of community should be done.

Also, data pertaining to the year 2012 show similar positive association between nitrate level and parasites with strong statistically significant associations (P value 0.002). In the same year, there were also statistically significant associations between the incidence of hepatitis and nitrate level in the year 2012. In other words, the high level of nitrate in the water, increases the possibilities of developing hepatitis. As explained earlier, hepatitis is usually transmitted through oral-fecal route and is associated with water and food contamination (Adjusted R-square 0.134 and p value 0.043). Clearly the study flags the risks associated with high level of nitrates which is by itself a manifestation of pollution and contamination that should be urgently addressed. Areas with high nitrates should be scrutinized and further investigations related to the underlying cause of high nitrate level as well as the consequences of this be subjected for further investigation.

*Table (5): Water Quality Parameters & Public Health Diseases Correlation Results, UG, 2015*

| Correlation Between water quality and public health | | | |
|---|---|---|---|
| Diseases | Water parameter | Summary of OLS Results | |
| | | Adjusted R-squared | P value |
| **Year** | **2009** | | |
| **Cancer** | No3 | 0.015 | 0.87 |
| **Diarrheal < 3Y** | No3 | 0.065 | 0.418 |
| **Total Diarrheal** | Cl | 0.013 | 0.29 |
| | TDS | 0.008 | 0.319 |
| | No3 | -0.004 | 0.64 |
| **Hepatitis A** | Cl | -0.075 | 0.603 |
| | TDS | -0.07 | 0.619 |
| | No3 | 0.068 | 0.37 |
| **Meningitis** | TDS | -0.38 | 0.7 |
| | No3 | -0.26 | 0.41 |
| **Parasitic Infection** | No3 | 0.168 | 0.484 |
| **Typhoid** | No3 | -0.058 | 0.855 |
| **Year** | **2010** | | |
| **Cancer** | No3 | -0.018 | 0.32 |
| **Diarrheal < 3Y** | No3 | 0.065 | 0.418 |
| **Total Diarrheal** | TDS | -0.006 | 0.67 |
| | No3 | 0.052 | 0.87 |
| **Hepatitis A** | TDS | 0.0008 | 0.56 |
| | No3 | -0.065 | 0.52 |
| **Meningitis** | TDS | -0.049 | 0.45 |
| | No3 | -0.016 | 0.34 |
| **Parasitic Infection** | No3 | 0.061 | 0.07 |
| **Typhoid** | No3 | -0.08 | 0.55 |
| **Year** | **2011** | | |
| **Cancer** | No3 | 0.147 | 0.8 |
| **Diarrheal < 3Y** | No3 | 0.129 | 0.065 |
| **Total Diarrheal** | Cl | -0.003 | 0.566 |
| | TDS | -0.019 | 0.64 |
| | No3 | 0.076 | 0.027 |
| **Hepatitis A** | TDS | -0.059 | 0.84 |
| | No3 | -0.061 | 0.73 |

| | | | |
|---|---|---|---|
| **Meningitis** | TDS | -0.08 | 0.5 |
| | No3 | -0.04 | 0.45 |
| **Parasitic Infection** | No3 | 0.4 | 0.0002 |
| | TDS | -0.06 | 0.61 |
| | Cl | -0.06 | 0.63 |
| **Typhoid** | No3 | 0.008 | 0.048 |
| **Year** | **2012** | | |
| **Cancer** | No3 | -0.006 | 0.56 |
| **Diarrheal < 3Y** | No3 | -0.023 | 0.6 |
| **Total Diarrheal** | Cl | 0.0097 | 0.64 |
| | TDS | 0.002 | 0.617 |
| | No3 | -0.02 | 0.75 |
| **Hepatitis A** | TDS | -0.049 | 0.409 |
| | No3 | 0.136 | 0.043 |
| **Meningitis** | TDS | -0.02 | 0.506 |
| | No3 | -0.038 | 0.33 |
| **Parasitic Infection** | No3 | 0.258 | 0.002 |
| | TDS | -0.05 | 0.74 |
| | Cl | -0.065 | 0.63 |
| **Typhoid** | No3 | 0.005 | 0.409 |
| **Year** | **2013** | | |
| **Cancer** | No3 | 0.04 | 0.72 |
| **Diarrheal < 3Y** | No3 | 0.0041 | 0.48 |
| **Total Diarrheal** | Cl | -0.014 | 0.68 |
| | Mg | -0.02 | 0.639 |
| | Na | 0.0097 | 0.49 |
| | TDS | -0.003 | 0.644 |
| | No3 | -0.0007 | 0.56 |
| **Hepatitis A** | TDS | -0.027 | 0.5 |
| | No3 | -0.023 | 0.21 |
| **Meningitis** | TDS | -0.049 | 0.66 |
| | No3 | -0.043 | 0.34 |
| **Parasitic Infection** | No3 | 0.056 | 0.92 |
| **Typhoid** | No3 | -0.09 | 0.44 |
| **Renal** | Cl | -0.02 | 0.68 |
| | No3 | 0.011 | 0.23 |

Denotes statistical significance

Other none statistically significant associations between water quality parameters and public health diseases can't be rolled out completely. The research team assumes that there could be more factual associations but didn't appear simply because of the inaccuracy of data at both the water quality parameters side or the public health side or both. It could be claimed that adequate measures to improve data management processes might reveal more solid conclusions about the possible associations and links between water quality parameters and public health diseases. During the data collection and analysis, it was clearly noticed that there are serious gaps in case definition of diseases, documentation, reporting, and data management as detailed below.

*Figure (20): Correlation between Parasitic Infestation incidence rate (UNRWA) and Average Nitrate Concentration for year 2011, UG, 2015*

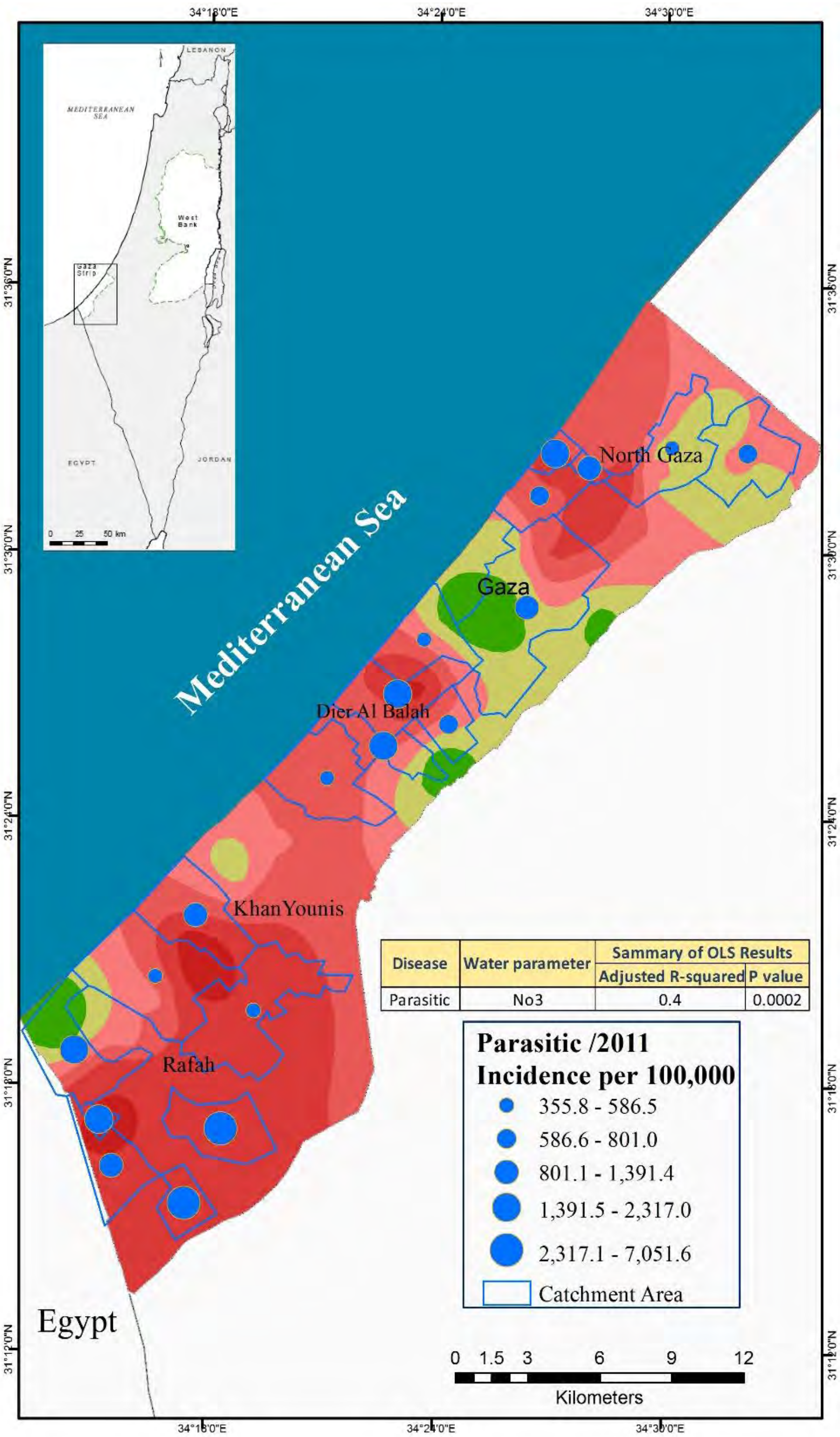
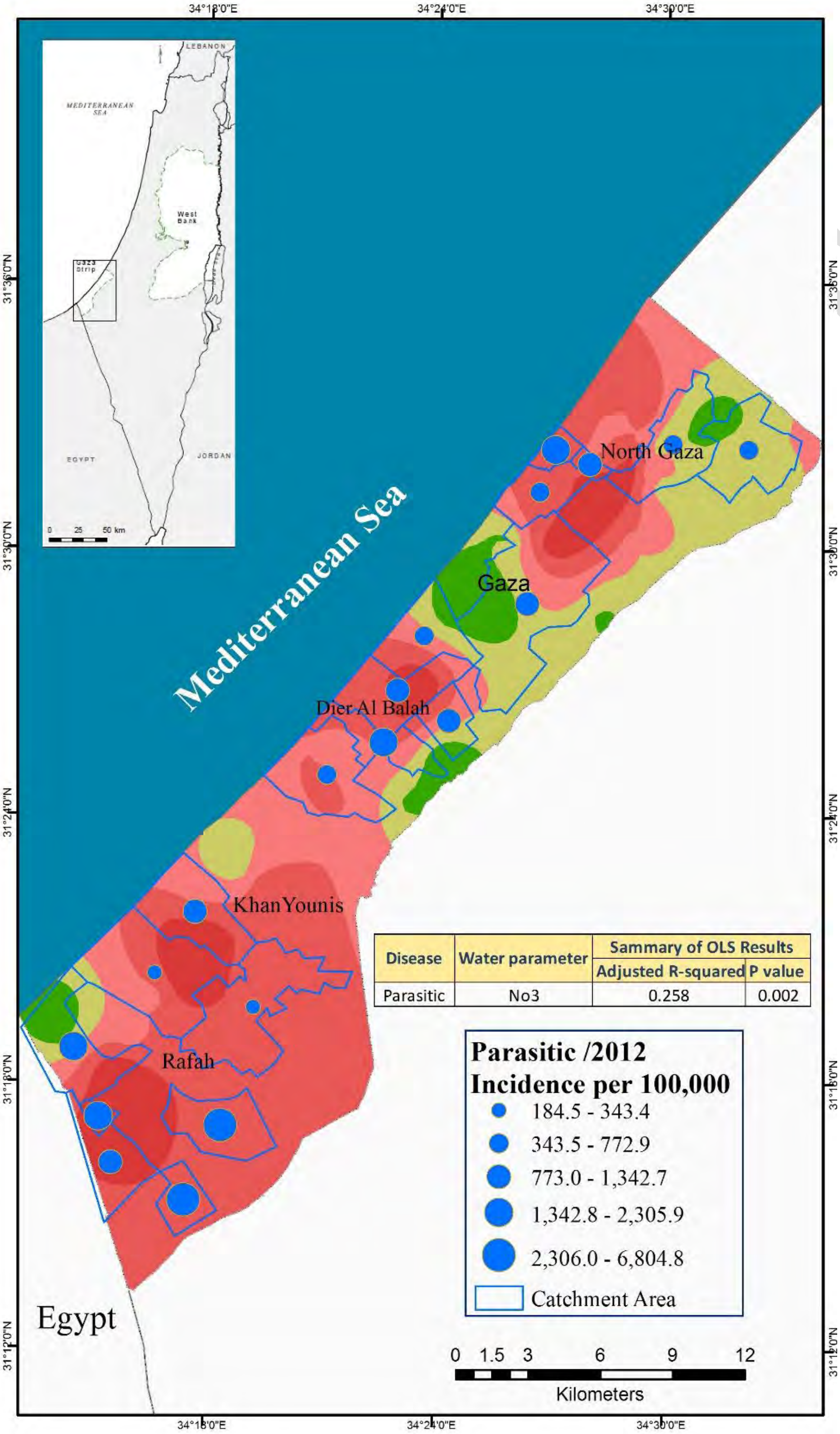
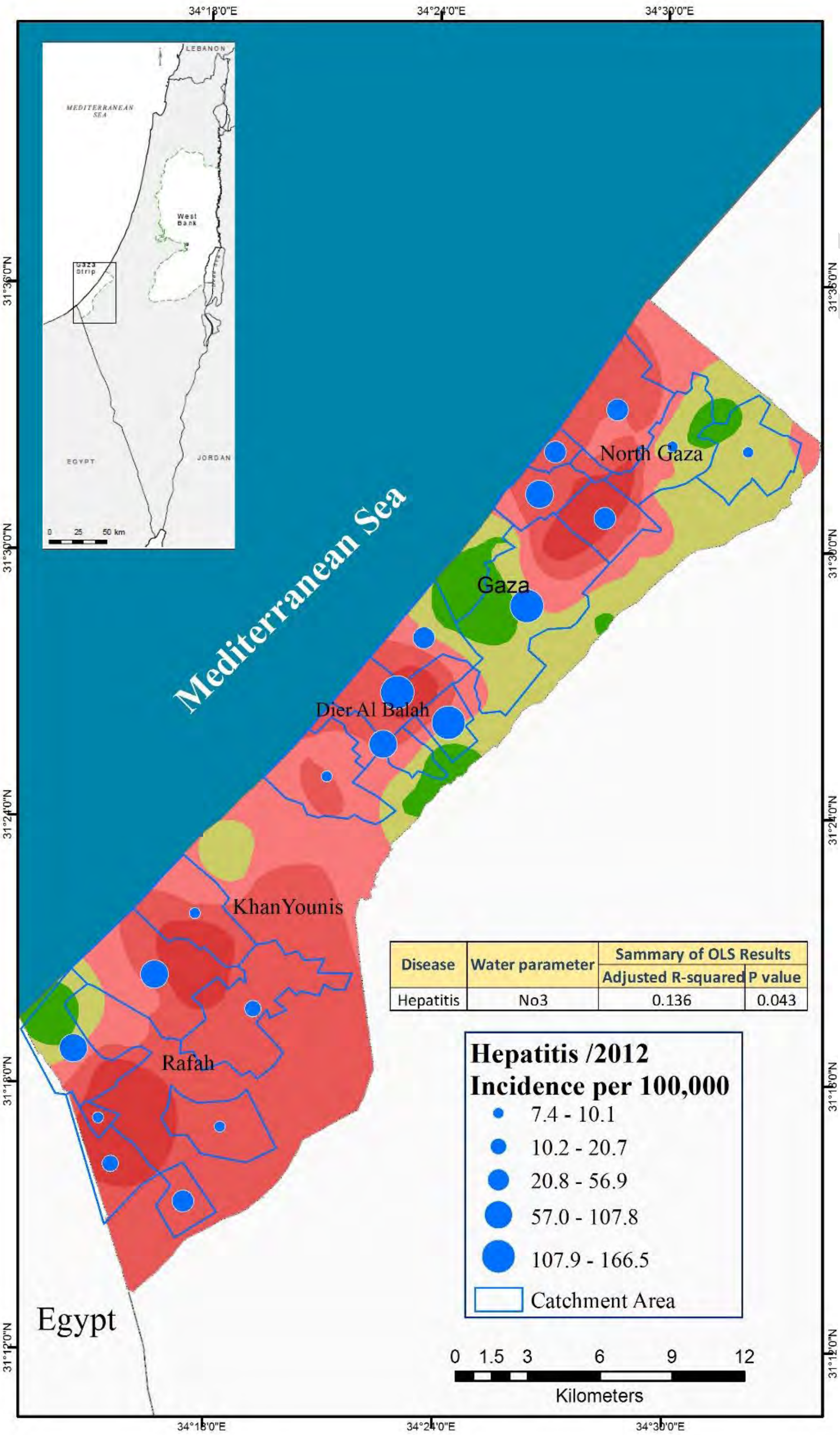


*Figure (22): Correlation between Parasitic Infestation incidence rate (UNRWA) and Average Nitrate Concentration for year 2012, UG, 2015*




| Disease | Water parameter | Sammary of OLS Results | |
|---|---|---|---|
| | | Adjusted R-squared | P value |
| Parasitic | No3 | 0.258 | 0.002 |

*Figure (22): Correlation between Hepatitis A incidence rate (UNRWA) and Average Nitrate Concentration for year 2012, UG, 2015*



## RESERVATIONS

This study enabled the research team to flag some important gaps related to the availability of credible information about water quality and its links to public health diseases. Mostly, the available research studies had focused on certain districts/areas that were selected based on researchers' convenience, interests or research samples. Very few studies were conducted at the Gaza Strip or at the national level. It was noticed that the few available large scale studies are donors-led and funded; conducted on ad hoc basis; not routinely done or done based on a national long term strategy.

Data available at the concerned organizations such as MOH are usually reported as aggregated data; at the governorate level. No data is reported at the community or neighborhood level which hinders the policy makers and programs designers to address the specific vulnerabilities at specific areas. In other words, there are gaps in obtaining consistent information from neighborhoods and districts. However, the availability of electronic databases open new horizon to obtain data disaggregated at the community level. It is suggested to develop the electronic databases at health facilities to generate data disaggregated by gender, locality, neighborhood and the disease/s.

Diseases, parameters and indicators are ill-defined in Gaza. Organizations widely vary in how they interpret and define these important parameters. Of the necessary steps that stakeholders should contribute to is developing a consensus about basic parameters, indicators and their definitions, data collection methods and sources, data processing, storage and use. This would enable the better use of information for decision making. For example, it was noticed that although the selection of water quality and public health diseases at the consensus building meeting was based on criteria which included the availability of data, no valid information were found about dental caries, anemia, malnutrition and skin diseases. In addition, although water biological contamination is a corner stone in investigating the links between water use and diseases; no data were available about the biological status of water that is used in drinking especially at the consumers' ends. One of the lessons learned from this exercise is to initiate a national dialogue among stakeholders about water quality parameters and public health diseases and to finally agree on a list of these parameters and to establish mechanisms to collect credible data about these parameters.

Much work is required to improve the processes that ensure better quality of routine information system particularly data management processes. In Gaza, the process of data management (collection, processing and analysis) requires improvement. There are no national data management procedures document that guides the process across the different organizations. No assessment of data quality (on the basis of the Data Quality Assessment Framework) has been conducted so far. There is also a need to work on standardization of data and improving the inter-operability between the various information systems. This entails the necessity of using data dictionary, development of a metadata dictionary and the identification of a minimum data set which all stakeholders can report on.

Coordination among the information holders is weak. Promoting coordination among the various stakeholders for purposes of data collection, analysis and information sharing is crucial to guarantee the provision of relevant, accurate and timely information for decision making. The authors of this report noticed a wide diversity in data, a reluctance of organization to share information and too much unnecessarily bureaucracy. Therefore, it is essential to support a culture to disseminate, share and use information as a tool for decision making and to stimulate evidence-based practice. Information units need further technical, financial and managerial support.

Incidence rates in this study were calculated based on the number of people who presented to health facilities during their illnesses; not at the household level which is more inclusive. This raises concerns related to the following;

- Not all people with infectious diseases seek services at MOH and UNRWA facilities; other may decide not to seek services at all or to seek private providers
- There are no clear boundaries which identify the catchment areas of different health facilities which may contaminate data and distort findings
- Some patient may seek services from several providers therefore double counted

Also it was noticed that the documentation practices at health facilities are poor. For example, addresses are not documented in many dangerous diseases such as cancer and in certain data nearly 30% of the documented IDs are wrong although it could be easily to build up quality control checks to reduce errors in IDs automatically.

Areas that require further focus include identifying the national prevalence and incidence of water quality related parameters and diseases associated with water use. Because mostly routine health information system reports about those who present to health facilities; still many masked cases could be available at households who require a community survey to uncover. Still gaps in information related to water sources, water for drinking and the contribution of the water sources to the water use do exist. For instance, there is a gap in knowledge related to desalination at houses, bottled water, use of agriculture wells for drinking and the associated risks of using these water sources. National studies with adequate samples about risk factors for possibly water related diseases which constitute public health problem such as anemia, malnutrition, hepatitis, meningitis and cancer are needed. It is also important to gather data about the availability of light and heavy metals in water. There is dearth of information about diseases related to the recreational use of water. Studies tackling the links between public health diseases and water use should be given a priority. Operational and action research related to water use constitute a priority as these can't be imported and are usually country specific. Concisely the following gaps could be documented about the concerned public health diseases, along with suggesting recommendations.

*Table (6): Limitations on the Chosen Diseases' Data & Improvement Suggestions, UG, 2015*

| Disease | Source of information | Limitations | Suggestion |
|---|---|---|---|
| **Diarrhea** | MOH and PHC centers | Not all clients with diarrhea go to health facility- some regard it as a minor illness others provide home remedies<br>Possible duplication and double counting of cases<br>Seeking private health providers and pharmacies<br>Lack of clear case definition-operational definition<br>Reporting sometimes is based on health care provider memory (recall bias)<br>Lack of clearly identified catchment areas<br>Inappropriate documentation<br>Lack of information about biological contamination at household level | Compliment with household survey |
| **Hepatitis** | MOH and PHC centers | Same as above<br>Gaps in diagnosis; some cases might be missed<br>Reliance on clinical diagnosis<br>Differential diagnosis | Improving standardization and clinical diagnosis |
| **Meningitis** | Mainly MOH hospitals and PHCs | Data reported at both clinic and hospital level, possible double recording at Hospitals and Clinics<br>Problems in diagnosis<br>Availability of many types of meningitis<br>Poor use of ICD 10 at hospitals<br>Inadequate tracing and follow up of cases at PC after referrals<br>Some reported cases at PHC are not confirmed | Improving surveillance system |
| **Typhoid** | MOH and UNRWA PHC centers | Differential diagnosis<br>Case confirmation is a problematic and is not standardized<br>Some cases might be missed or not confirmed | Improving standardization and clinical diagnosis |
| **Oncology** | MOH cancer registry | Not documenting addresses of patients<br>Wrong IDs of many cases<br>Availability of more than 100 type of cancer<br>Poor documentation at the cancer registry | Promoting cancer registry |
| **Parasites** | PHC centers at UNRWA lab | Not all clients with parasites infection go to health facility<br>Possible duplication and double counting<br>Seeking private providers and private labs<br>Lack of clearly identified catchment areas<br>Weak documentation of cases at PHC<br>Some doctors prescribe medications without conducting lab investigations<br>Lack of consistent data at MOH | Enhance registration and case diagnosis |

# CONCLUSION

This report summarizes the main conclusions of a comprehensive Baseline Study on Water Quality and Public Health in the Gaza Strip, which is conducted to document the present public health status in relation to the existing water quality, showcased on GIS-based mapping. The study aims at establishing baseline information that link water quality to the public health and to explore the health impacts attributed to the existing poor quality of water in the Gaza Strip in order to suggest corrective strategies that decrease mortalities and morbidities attributed to water use. The comprehensive baseline study will be the copestone for a public health and water quality monitoring program. The review process heavily relied on the analysis of the secondary literature and elapsed approximately two months.

The research team organized a brain storming session which resulted in drawing a schematic map reflecting water sources in the Gaza Strip and identified possible contaminations associated with each source. In addition, through a consensus building process, experts in water and public health identified 9 water quality parameters and 11 public health diseases possibly associated with the water use (Table 1). The identified parameters were endorsed by stakeholders and constituted a frame for the literature analysis. The research team conducted thorough literature study in order to inform stakeholders including the researchers about the status of water quality and the prevailing public health issues. The literature review process aims at finding the possible relationships that link water quality and public health diseases in the Gaza Strip.

The contextual factors have an important stake on water and public health diseases. Exacerbating the problem is the decrepit state of Gaza's sanitation services. Due to the blockade imposed on the Gaza Strip for several years, many essential water, sanitation, and hygiene materials and equipment are facing continuous entry delays or preventing the entire entry of some materials, which have further complicated the situation and pushed Gaza's water and wastewater systems to the edge of collapse, and also delay the construction of major projects which can assist in facing the aquifer deterioration. Findings from the literature indicate there are many contextually-related barriers that negatively affects the availability and consumption of quality water for the human use including lack of electricity, modesty of experience, scarcity of economic resources, and supplies of essential materials such as cement, pipes, spare parts and special electro-mechanical treatment equipment, in addition to the significant tension between Israel and the Palestinians over the ownership of water rights and adherence to agreements and over water management. These factors have rendered the water and wastewater services unreliable and hazardous, which poses a formidable challenge for the population to obtain adequate clean water.

Municipal water in the Gaza is considered un-fit for domestic consumption due to high and rising levels of chlorides and nitrates; as high as six times the World Health Organization (WHO) standard levels. Moreover, fluorides can have toxic effects in both excess and deficiency as well. The level of fluoride in Gaza's drinking water ranges between 0.8–6.45 ppm. The salinity of water wells in Gaza increases in general as a result of continuous over-pumping of the aquifer's water and sea water intrusion resulted from that; however, some improvement has been noticed in certain areas over the past two years due to reasonably intense rainfall showers. The trend of increase in salinity varies from well to well based on the well location, abstraction rate, soil type, and pumping durations.

Although, nearly ninety eight percent of Gazans are connected to the municipal water network but supply is in complicated intermittent schemes and the quality is deteriorating, making its drinkability is questionable. Currently, most households do not use municipal water supplies for drinking which limited the possibility to link the analysis of municipal water to diseases. Simply, people use purified and filtered water for drinking. It is advised to intensify research investigations on the quality of water that is actually used for drinking at the household level-at the users' outlets.

It is needless to say that sewage is the biggest reason for groundwater biological and chemical contamination in the Gaza Strip. Only about 40% of the sewage generated in the Gaza Strip is properly treated. The percentage of population served by sewerage systems has increased in the last two decades and currently reached around 80%, leaving nearly half a million people unconnected to the sewage network and dependent on alternative means for excreta disposal. Reports show that 19% of groundwater, 27% of desalinated water and 20% of water network samples are microbiologically contaminated by total Coliform while 13%, 14% and 12%, respectively, are contaminated by fecal coliform bacteria.

The water situation in Gaza is dire. The Coastal Aquifer, Gaza's sole fresh water resource, is polluted by the infiltration of raw sewage from cesspits and sewage collection ponds and by the infiltration of seawater (itself also contaminated by raw sewage discharged daily into the sea near the coast) and has been degraded by over-extraction. The water quality will be worse in the next few years and the aquifer will not be able to cover the people water needs, where the water quality will not able to be used for any purposes (domestic, agriculture,…).

Taking in consideration the combined concentrations of both chloride and nitrate, it's clear that 3.8% of the domestic water is only matching with WHO drinking limit, while the remaining 96.2% is out of limit. Even for other elements as cations , TDS and fluoride, analysis shows that many areas in Gaza strip are suffering from degradation of these elements' quality level.

It can be said that the chemical water quality database given by PWA is solid, well organized and useful to develop a water quality baseline GIS mapping. However, the biological water quality records are not detailed to the level used for analysis for potential public health correlation.

Produced GIS mapping for water quality shows to high percentage a consistency with the PWA and CMWU maps. The Produced GIS maps are created using a fix number of monitoring wells to insure integrity and uniformity of data presented.

Tentative predilection, to a hypothetical level of assuming no change scenario in resource and infrastructure while keeping same demanding trend, shows that the majority of main water quality parameters will continue in degrading to year 2020 in a yearly rate from 6 to 12%. Except for PH which is expected to continue being between the accepted limits.

Due to absence of national data warehouse, there was great disparities in the reported statistics of the concerned public health diseases across the health care providers, therefore the research team analyzed and mapped the collected data for each of the designated public health diseases according to the health care provider and the catchment area served by that provider. Unfortunately, data are not available disaggregated by neighborhood for most of the agreed public health diseases. However, findings indicate that the incidence of diarrhea as reported by health clinics is constantly increasing over the past five years; almost doubled in five years. Also, hepatitis incidence rate is at the increasing trend (20.7 per 100,000 population to 73.3 per 100,000 in 2013). Fortunately, based on the available data from all sources covering the period 2009 to 2013, the incidence rate of typhoid has significantly decreased. The increase in the annual cancer incidence rate as concluded from data collected at the hospital level is striking since 2010 possibly as a result of environment contaminations with toxic materials and heavy metals resulted from bombardments, better discovery of cases and improvement in reporting. Parasitic infection is endemic in the Gaza Strip with a fluctuation trend in the past five years as reported by health facilities. The available data from all sources especially hospitals show that the incidence rate of meningitis in the Gaza Strip is constantly increasing especially in the last two years. It wasn't possible to find consistent data from all localities in relation to anemia, malnutrition, skin diseases and dental decay. Assuming that there is a consensus about a possible link between these diseases and water quality; it is important to agree on a valid national approach to collect data about these diseases. The availability of electronic database at health facilities opens a new horizon for extracting information about these diseases.

Possibly, the conflict, siege and the massive destruction of infrastructure including water resources and inappropriate sewage disposal together with the decline in socioeconomic indicators had contributed to the spread of the above mentioned diseases during that period.

Epidemiological studies into the relationships between the quality of water supply and human health in the Gaza Strip are limited, and when available, vary widely, as there are severe methodological difficulties involved in undertaking such studies. Nevertheless, there is sufficient international evidence to support the conclusion that improving water supply and sanitation can have a significant impact on human health. Serious information gaps are revealed through this review including lack of standardized definitions of diseases, limited national studies with adequate samples, and absence of data at a neighborhood level.

The study concluded that there is strong positive association between the nitrate level and the occurrence of parasitic infestations (adjusted r-squared =4 P value 0.0002) in the UNRWA clinics reported data in 2011. Accordingly, it could be concluded that the higher nitrates level in water, is more associated with parasitic infestations. This could be related to seawater intrusion into the wells which is accompanied by higher level of nitrates, chloride and TDS levels. Also, nitrate contamination usually results from agriculture and human or animal wastes. Similarly, data pertaining to the year 2012 show similar positive association between nitrate level and parasites with strong statistically significant association (P value 0.002); also according to data obtained from UNRWA clinics. In the same year, there was also statistically significant association between the incidence of hepatitis and nitrate level in the year. Hepatitis is usually transmitted through oral-fecal route and is associated with water and food contamination (Adjusted R-square 0.134 and p value 0.043).

Having said that, other non-significant correlations can't be rolled out completely. The research team assumes that there could be more logical associations but didn't reveal simply because of certain limitations in data accuracy and consistency. Assuming that adequate measures will be implemented to improve data management processes at various levels, would reveal more credible information about the possible associations and links between water quality parameters and public health diseases. It is noticed and reported as well that there are serious problems in case definition, data documentation, analysis and reporting as well.

To tackle the multi-faceted challenges pertaining to water, there is a pressing need to design an integrated overall strategy for water in the Gaza Strip. The international trends clarifies that there is a need to improve water resources. Interventions to improve health status and reduce burden of diseases need to tackle water quality related issues. Improving the quality of water requires multidisciplinary interventions at health, municipal, water sector and the population levels.

# RECOMMENDATIONS

In the studied literature, the recommendations proposed predominantly stressed the overall need for improved water resources. Many studies presented specific recommendations that could be of interest at the political level, including negotiating water rights with neighboring countries. Other recommendations were more technical and were appropriate for the service delivery level, such as the selection of sites for treatment, management of effluent and leachate, and strategies for monitoring water quality. Several documents stressed the need for construction and/or maintenance of the water delivery and sanitation infrastructure, including pipelines. Recommendations for the population level frequently addressed the need for increased awareness regarding water quality, and hygiene and sanitation practices, including the regular cleaning of rooftop tanks.

With regard to this final report, and concerning the tasks performed herein, our main recommendations encompass proper data collection, commissioning targeted prioritized needs-based national level studies, unifying the operational definitions of the parameters, increase in data reporting and access efficiency, accuracy, and timeliness of the collected data. Public health decisions, as well as, water improvement projects, can only be formulated correctly if the input information is accurate and readily available. The actual methods of analysis do not need improvement, however, the direction the analysis and the studies undertake can use some improvements by means of well-aware, well-informed, and prioritized thinking.

The following specific recommendations are based on the outcomes of this report and can be summarized as follows:

## WATER QUALITY DATA

1) It is important to strengthen cooperation between all parties that are working in the water sector in Palestine, such as the Palestinian Water Authority, Coastal Municipalities Water Utility, Environmental Quality Authority, Ministry of Health, Ministry of Agriculture, Municipalities, and the water legislation research institution " the water research center ". Also local and international NGO's working in water field should be subject to close monitoring and regulation.
2) Data collection methods need to be improved and a standard needs to be developed for the parameters which need to be tested for in all sources of the water. A national plan, using the schematic diagram for all water sources, needs to be setup to collect all the required chemical, physical, and biological data required for the future decision making process. These tests should include both the heavy metals and biology parameters, which are generally neglected. A reporting program needs to be setup, agreed to by all relevant stakeholders, and start immediately collected all necessary data into a central, easily accessible database, and construct programs for data collection where required.
3) The PWAs should regulate water quality from private suppliers and encourage good water storage practices in households and schools/health centers. The PWA should also set appropriate standards where none exist. Child-friendly water and sanitation facilities should be developed and promoted, particularly in schools and youth centers.
4) Wells, which are located in seawater intrusion zones, should be decommissioned and stop pumping to reduce the deterioration in these zones and prevent the expansion of the phenomenon of seawater intrusion and high chloride, TDS, and nitrate levels.
5) The Gaza Strip cannot continue depending on the groundwater as the only source to cover their water needs for all purposes where new water resources such as seawater desalination and reclaim of wastewater use.
6) Detailed study on water quality modeling schemes for each supply center (wells zone) via locality/municipality is needed to have more comprehensive analysis on water quality relation with public health. Such quality scheme should consider the current intermittent supply condition and should be based on clear water supply and hydraulic zones.
7) Water quality production models with various water resources and infrastructure improvement cross scenarios are essential for better decision making. The study highlight the crucially to have such tool available as a dynamic features.
8) Water quality chain records as household survey in the critical water quality regions are needed to clarify the reasons and propose mitigating and interventions to response for such situation. This baseline study show up such areas with water quality degradation.
9) Efforts to be focus on developing a biological quality measurement database at various water network stations (source, pipe, storage and tapping). This will improve in identification of possible correlation between water quality and public health.
10) Action to be taken to investigate regularly on heavy metal concentration in aquifer becomes an important factor though providing needed testing facilities. This assist in explaining the sudden quality degradation at many areas such as eastern Khanyounis.

## PRIVATE DESALINATION PLANTS

1) A safety and monitoring program for the private desalination plants and its delivery units (tankers and distribution points) including chemical and microbiological analysis should be developed, enhanced, and intensified for the evaluation of the product and distributed water in order to pursue the compliance of these desalination plants to conditions and terms of water quality. Close coordination between all parties involved in water issues is needed to confirm the implementation of this program in Gaza Strip
2) Low content of minerals concern may be applicable for Gaza. This requires to consider the guidelines for desalination water treatment, specifying the minimum content of the relevant elements such as calcium, magnesium and TDS.
3) Disinfection of desalinated tank water and advice on mitigation of risks associated with home storage of water should be considered in a public campaign
4) A strategy should be adopted to control the location of the small scale desalination plants' construction according to the groundwater quality to manage salinity problems in the Gaza Strip.
5) Short term solution and large seawater desalination plants should be established in order to decrease pumping water in the Gaza Strip aquifer.

## BOTTLED WATER

1) As the microbiological quality of water bottled distributed and consumed in Gaza is currently unclear, better monitoring is needed to ensure the compliance of this water source should be conducted

## PUBLIC HEALTH DATA COLLECTION, AVAILABILITY, AND USAGE

1) Perhaps most importantly, we recommend a substantial improvement to the data collection and accessibility process. Data at the health sector should be collected accurately and in a timely fashion at community and neighborhood levels, and proper records should be filed for easy access to facilitate the ability of programs to address specific vulnerabilities in the future. To make well-informed decisions, readily available, easily obtained, and accurate data are crucial. This will require reform in the way health organizations carry out its duties on a daily basis, and the decision should involve the relevant stakeholders.
2) We need to advise the stakeholders to start commissioning targeted prioritized needs-based national level studies that address the concerns and needs of the local population, and that aim at finding practical, tangible, and measurable solutions.
3) We also need to standardize the operational definitions of the parameters and indicators at the national level in accordance with the international guidelines. Organizations can no long afford to vary in how they interpret and define these important parameters. Of the necessary steps that stakeholders should contribute to is developing a consensus about basic parameters, indicators and their definitions, data collection methods and sources, data processing, storage and use. This would enable the better use of information for decision making.

4) Further investigation needs to be performed for areas with high incidence rates of the listed diseases in order to identify the underlying cause, and introduce mitigation measures.
5) Cooperation must be encouraged between the different sectors in the public health as to avoid the duplication of data and ease the introduction of a centralized data bank. Using ID as an identifier prevents duplication and double counting of cases by the different providers.
6) Better utilization of the currently evolving electronic health information systems at the health sector which can generate data at the community and household level
7) Data collection methods need to be setup for nutritional diseases, anemia, and skin disease. This will aid in the future analysis.
8) The data surveillance system at the health sector needs major improvement particularly for monitoring infectious diseases such as diarrhea, typhoid, hepatitis A, and meningitis. Epidemiological departments at the health organizations should be supported by extra staff and the needed resources and logistics to be able to better supervise data collection, processes and management at the operational and managerial.
9) Hospitals documentation practices and cancer registry need to be improved, and accurate data must always by recorded about the patients, especially addresses and ID numbers. Built in quality control measures should be developed to eradicate data entry problem possibly through linking databases with the Civil Registry and the Palestinian Centre Bureau of Statistics
10) It is essential that catchment areas for health facilities are clearly defined and appropriately communicated to the communities.
11) To capture people with illness who don't present to health facilities, it is essential to conduct periodic surveys at the household level in order to compliment and verify the data reported routinely by HIS.



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http://resources.arcgis.com/en/help/main/10.1/index.html#//005p0000000n000000

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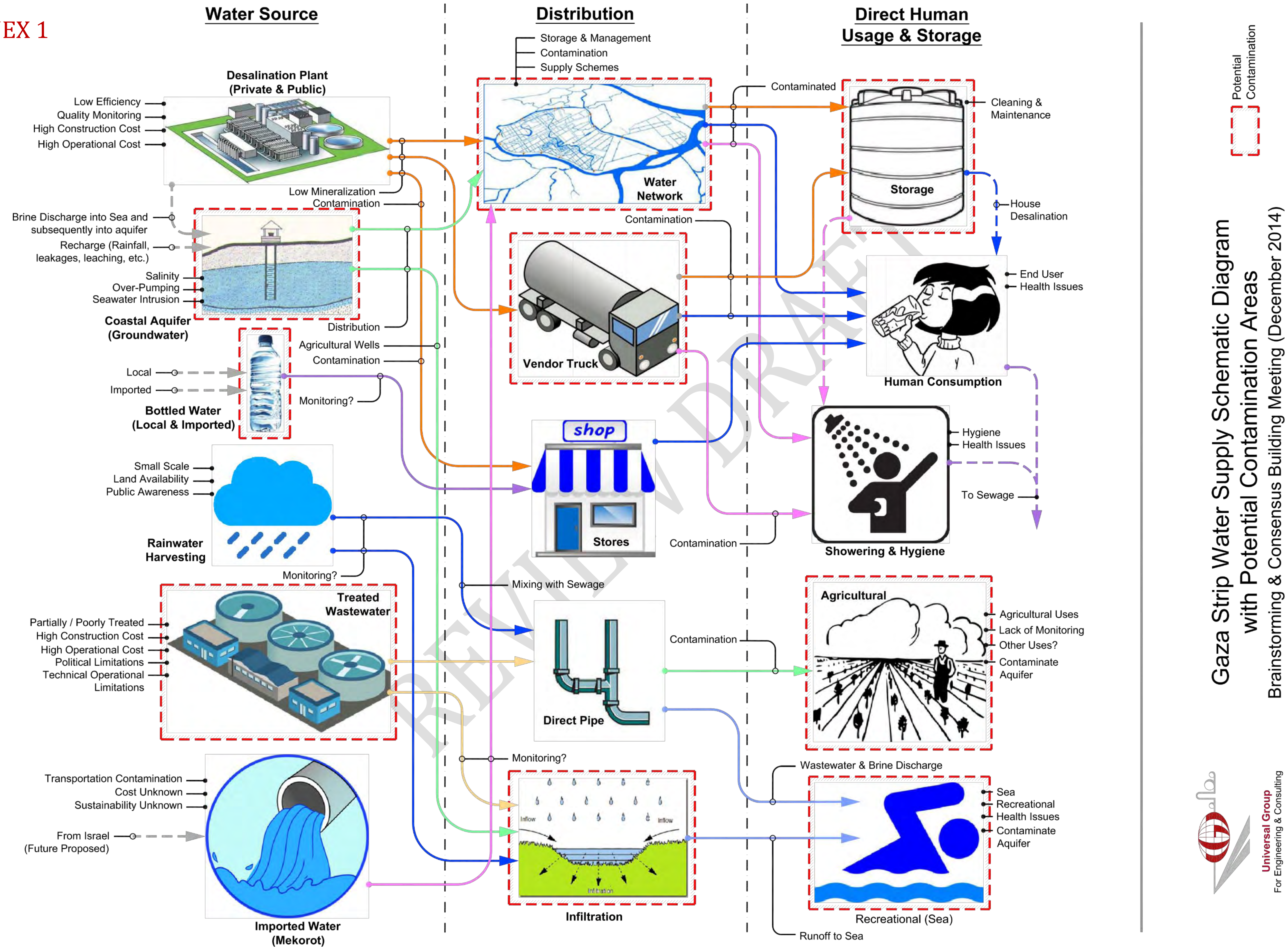
http://www.cdc.gov/cancer/dcpc/data/state.htm

ANNEX 1


Water Source
Distribution
Direct Human Usage & Storage
Desalination Plant (Private & Public)
Low Efficiency
Quality Monitoring
High Construction Cost
High Operational Cost
Low Mineralization
Contamination
Storage & Management
Contamination
Supply Schemes
Water Network
Contaminated
Storage
Cleaning & Maintenance
House Desalination
Brine Discharge into Sea and subsequently into aquifer
Recharge (Rainfall, leakages, leaching, etc.)
Salinity
Over-Pumping
Seawater Intrusion
Coastal Aquifer (Groundwater)
Distribution
Agricultural Wells
Contamination
Contamination
Vendor Truck
End User
Health Issues
Human Consumption
Local
Imported
Bottled Water (Local & Imported)
Monitoring?
shop
Stores
Hygiene
Health Issues
To Sewage
Showering & Hygiene
Small Scale
Land Availability
Public Awareness
Rainwater Harvesting
Monitoring?
Contamination
Mixing with Sewage
Treated Wastewater
Partially / Poorly Treated
High Construction Cost
High Operational Cost
Political Limitations
Technical Operational Limitations
Direct Pipe
Contamination
Agricultural
Agricultural Uses
Lack of Monitoring
Other Uses?
Contaminate Aquifer
Monitoring?
Transportation Contamination
Cost Unknown
Sustainability Unknown
From Israel (Future Proposed)
Imported Water (Mekorot)
Inflow
Inflow
Infiltration
Infiltration
Wastewater & Brine Discharge
Sea
Recreational
Health Issues
Contaminate Aquifer
Recreational (Sea)
Runoff to Sea
REVIEW DRAFT
Potential Contamination
Gaza Strip Water Supply Schematic Diagram with Potential Contamination Areas
Brainstorming & Consensus Building Meeting (December 2014)
Universal Group
For Engineering & Consulting

# ANNEX 2

## Water Parameters Validation and Modeling

### Sample Validation Trials and Results for Chlorides in year 2013

**Method** Kriging/Ordinary
**Geostatistical Method/Output** Prediction Map
**Transformation** log

| **Semivariogram parameters** | **Spherical** | **Expo.** | | | | | |
|---|---|---|---|---|---|---|---|
| Partial sill | 1.333 | 1.581 | 1.699 | 1.294 | 1.558 | 1.054 | 0.969 |
| Nugget | 0.170 | 0.190 | 0 | 0.189 | 0.19 | 0.271 | 0.282 |
| Lag Size | 492.4 | 492.4 | 800 | 1000 | 500 | 1500 | 2300 |
| Smooth | 1 | 1 | 1 | 1 | 0.5 | 1 | 1 |
| **Cross Validation statistics** | | | | | | | |
| Mean (ME): | 80.457 | 89.502 | 64.958 | 81.813 | 94.68 | 75.026 | 75.33 |
| Root-Mean-Square (RMSE): | 1213.353 | 1236.612 | 1341.876 | 1227.96 | 1232.29 | 1218.85 | 1220.05 |
| Root-Mean-Square Standardized | 1.001 | 1.209 | 1.990 | 1.126 | 1.1767 | 0.9956 | 0.973 |
| | **OK** | | | | | | |

# ANNEX 3

## GIS Maps

# BaseMap in Gaza Strip for year 2014

Baseline Study on Water Quality and Public Health - April, 2015


سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

- Crossing Point
- Wadi_Gaza
- Regional Road
- sea
- Airport
- Municipalities
- Governorate

**Source:**
**- SilverMap.ps**

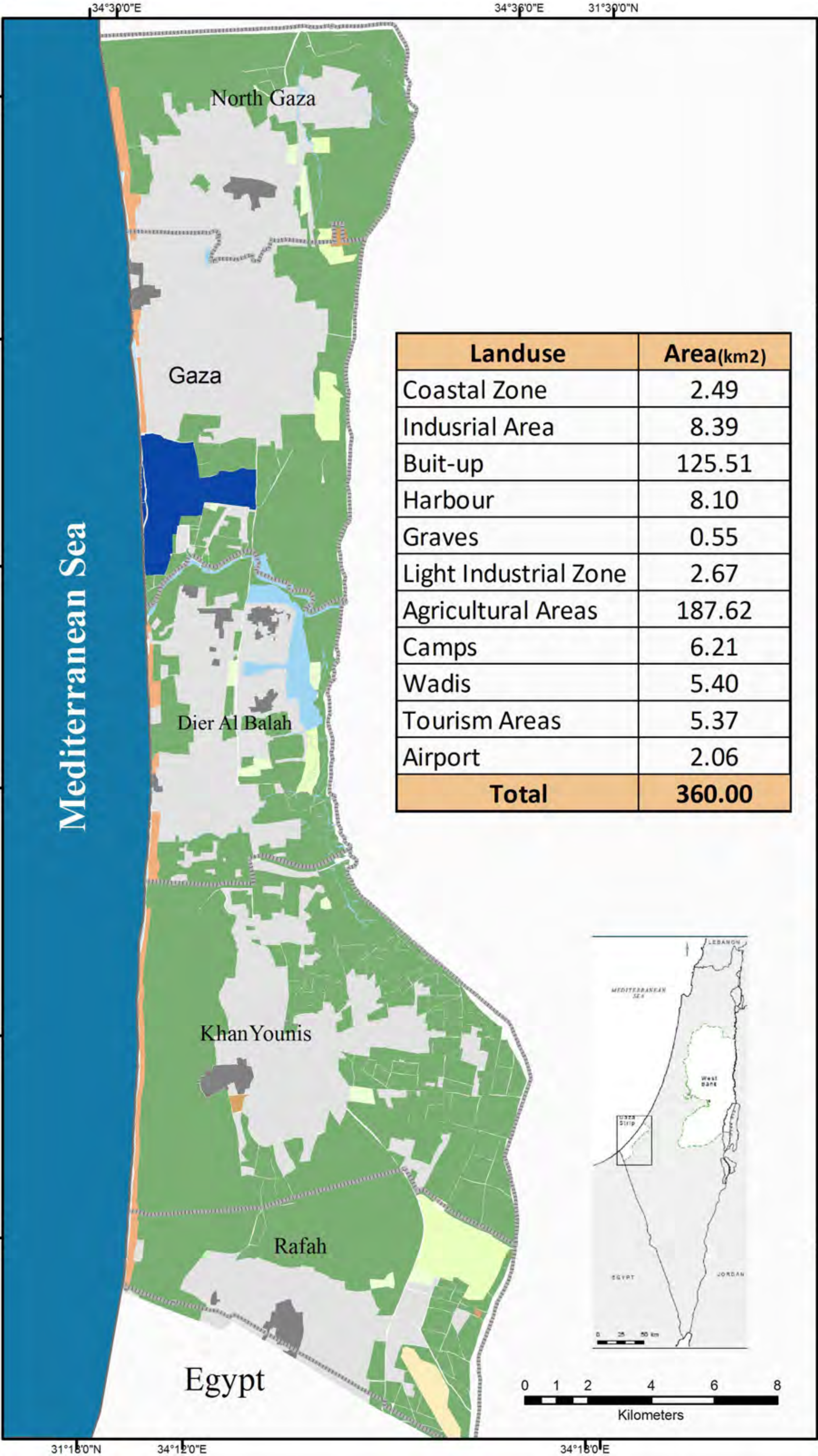
Coordinate System: Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Landuse of Gaza Strip -2014

Baseline Study on Water Quality and Public Health - April, 2015




| Landuse | Area(km2) |
|---|---|
| Coastal Zone | 2.49 |
| Indusrial Area | 8.39 |
| Buit-up | 125.51 |
| Harbour | 8.10 |
| Graves | 0.55 |
| Light Industrial Zone | 2.67 |
| Agricultural Areas | 187.62 |
| Camps | 6.21 |
| Wadis | 5.40 |
| Tourism Areas | 5.37 |
| Airport | 2.06 |
| **Total** | **360.00** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

## Legend

- Agricultural Areas
- Airport
- Buit-up
- Camps
- Coastal Zone
- Graves
- Harbour
- Indusrial Area
- Light Industrial Zone
- Tourism Areas
- Wadis
- Sea
- Governorate

**Source:**
- Ministry of Local Government

Coordinate System:
Palestine 1923 Palestine Grid
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Units: Meter

**Date: 4/22/2015**

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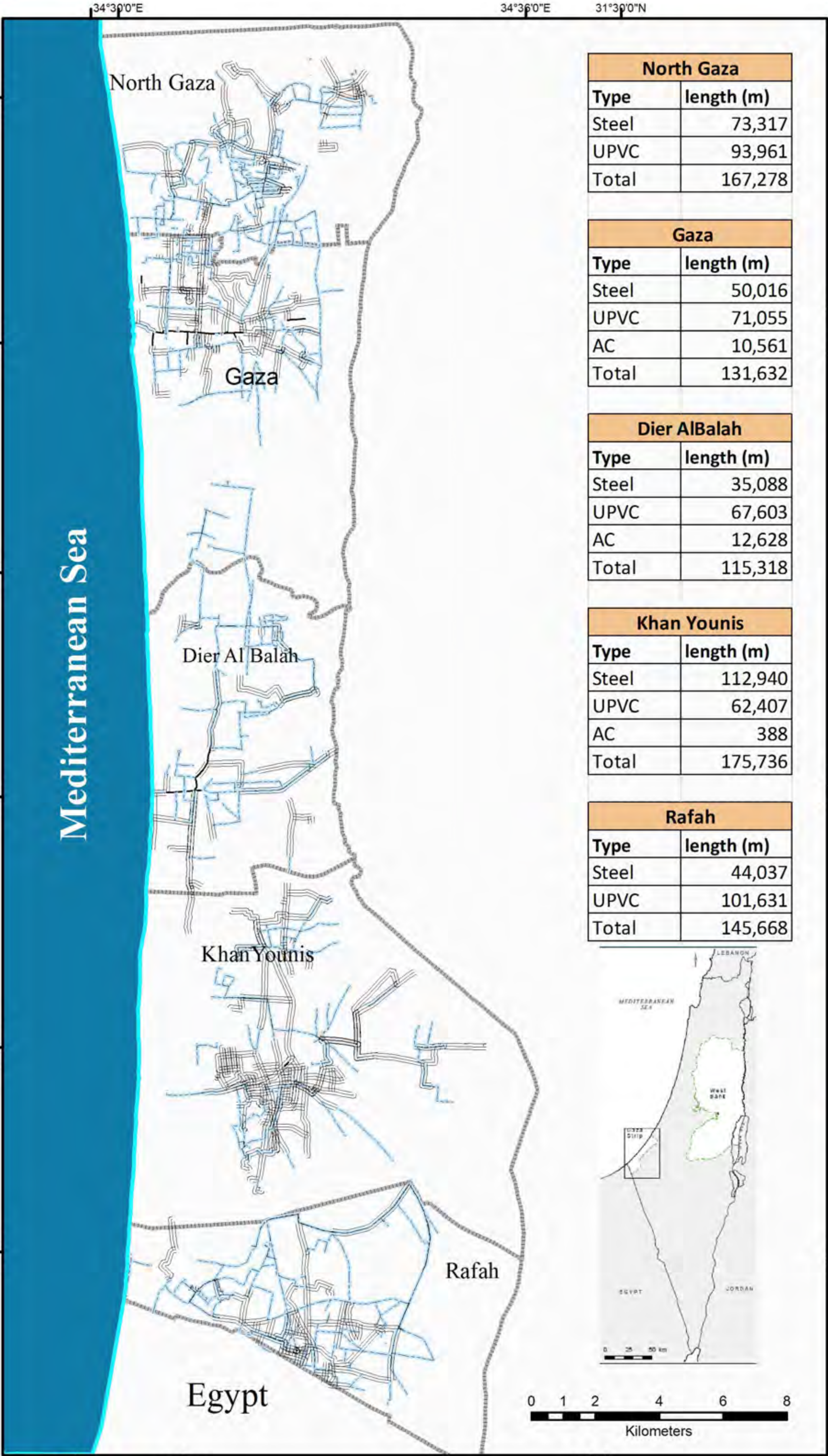
# Water Network in Gaza Strip for Year 2014

Baseline Study on Water Quality and Public Health - April, 2015




| North Gaza | |
|---|---|
| Type | length (m) |
| Steel | 73,317 |
| UPVC | 93,961 |
| Total | 167,278 |

| Gaza | |
|---|---|
| Type | length (m) |
| Steel | 50,016 |
| UPVC | 71,055 |
| AC | 10,561 |
| Total | 131,632 |

| Dier AlBalah | |
|---|---|
| Type | length (m) |
| Steel | 35,088 |
| UPVC | 67,603 |
| AC | 12,628 |
| Total | 115,318 |

| Khan Younis | |
|---|---|
| Type | length (m) |
| Steel | 112,940 |
| UPVC | 62,407 |
| AC | 388 |
| Total | 175,736 |

| Rafah | |
|---|---|
| Type | length (m) |
| Steel | 44,037 |
| UPVC | 101,631 |
| Total | 145,668 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

N E W S

## Legend

- UPVC
- Steel
- AC
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

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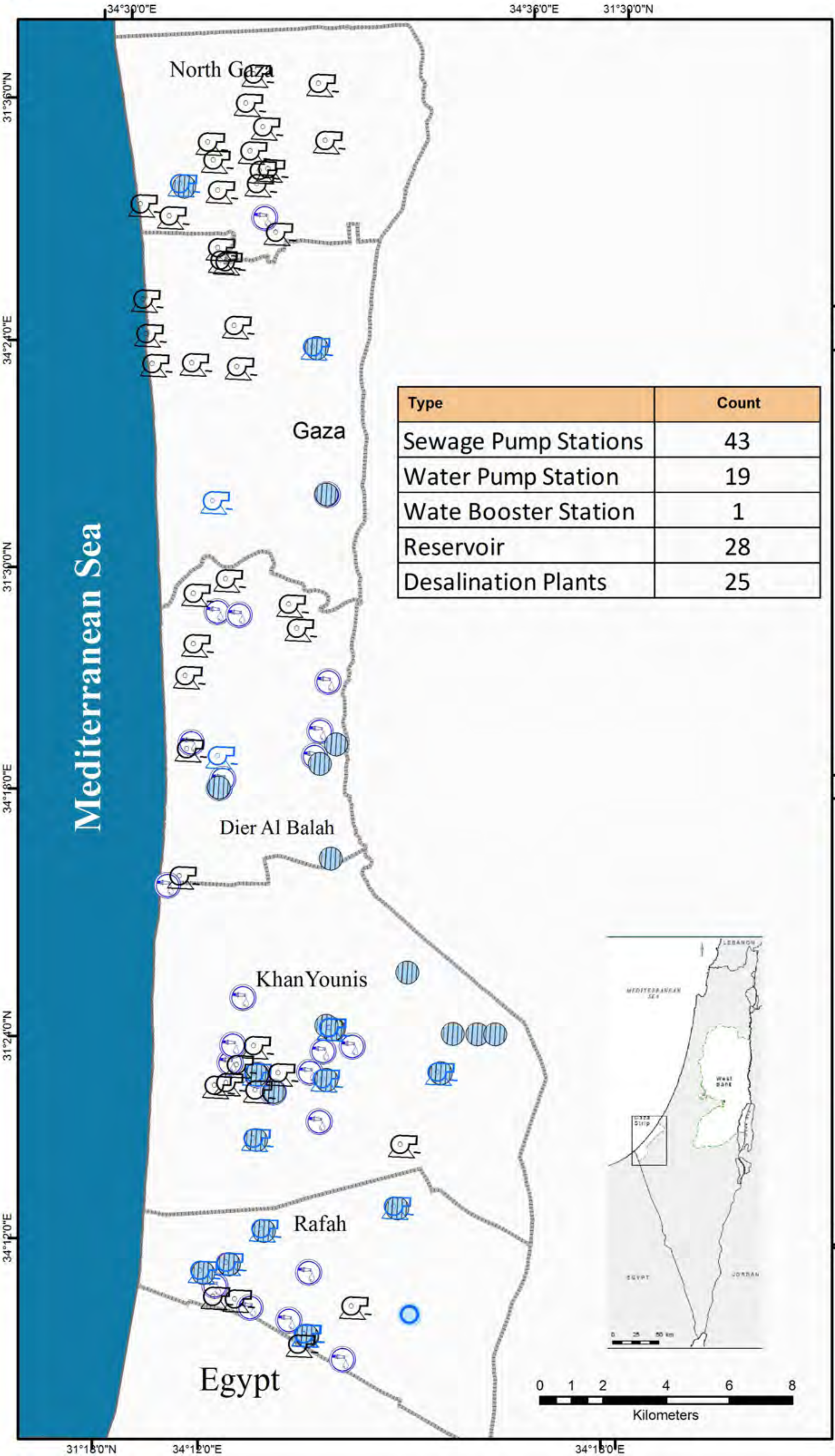
# Water Facilities Point in Gaza Strip for Year 2014

Baseline Study on Water Quality and Public Health - April, 2015




| Type | Count |
|---|---|
| Sewage Pump Stations | 43 |
| Water Pump Station | 19 |
| Wate Booster Station | 1 |
| Reservoir | 28 |
| Desalination Plants | 25 |

## Legend

- Sewage Pump Station
- Water Pump Station
- Water Booster Station
- Reservoir
- Desalination Plants
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
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Datum: Palestine 1923
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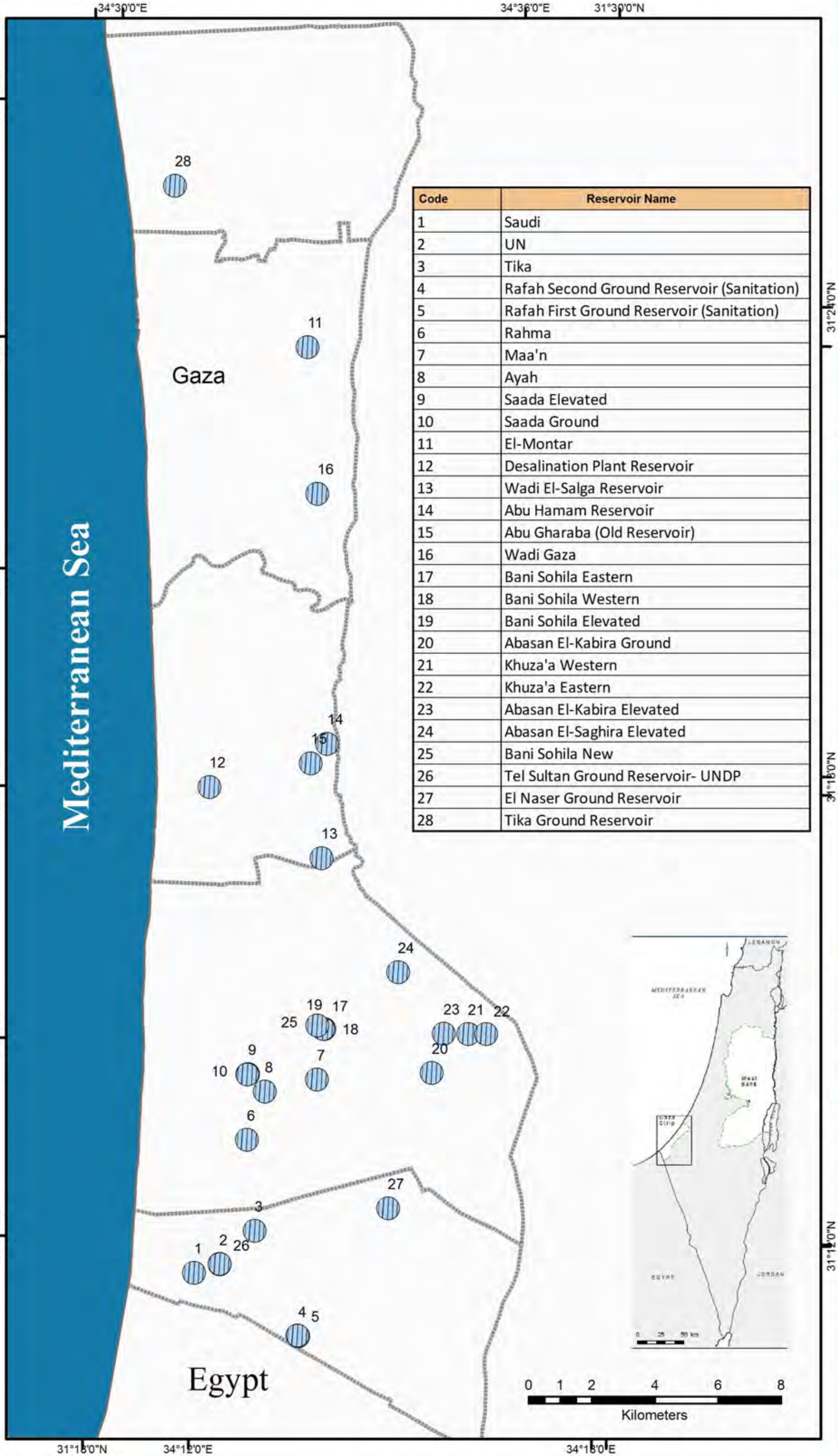
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Reservoir in Gaza Strip -2014

Baseline Study on Water Quality and Public Health - April, 2015




| Code | Reservoir Name |
|---|---|
| 1 | Saudi |
| 2 | UN |
| 3 | Tika |
| 4 | Rafah Second Ground Reservoir (Sanitation) |
| 5 | Rafah First Ground Reservoir (Sanitation) |
| 6 | Rahma |
| 7 | Maa'n |
| 8 | Ayah |
| 9 | Saada Elevated |
| 10 | Saada Ground |
| 11 | El-Montar |
| 12 | Desalination Plant Reservoir |
| 13 | Wadi El-Salga Reservoir |
| 14 | Abu Hamam Reservoir |
| 15 | Abu Gharaba (Old Reservoir) |
| 16 | Wadi Gaza |
| 17 | Bani Sohila Eastern |
| 18 | Bani Sohila Western |
| 19 | Bani Sohila Elevated |
| 20 | Abasan El-Kabira Ground |
| 21 | Khuza'a Western |
| 22 | Khuza'a Eastern |
| 23 | Abasan El-Kabira Elevated |
| 24 | Abasan El-Saghira Elevated |
| 25 | Bani Sohila New |
| 26 | Tel Sultan Ground Reservoir- UNDP |
| 27 | El Naser Ground Reservoir |
| 28 | Tika Ground Reservoir |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

## Legend

- Reservoir
- Sea
- Goernorate

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

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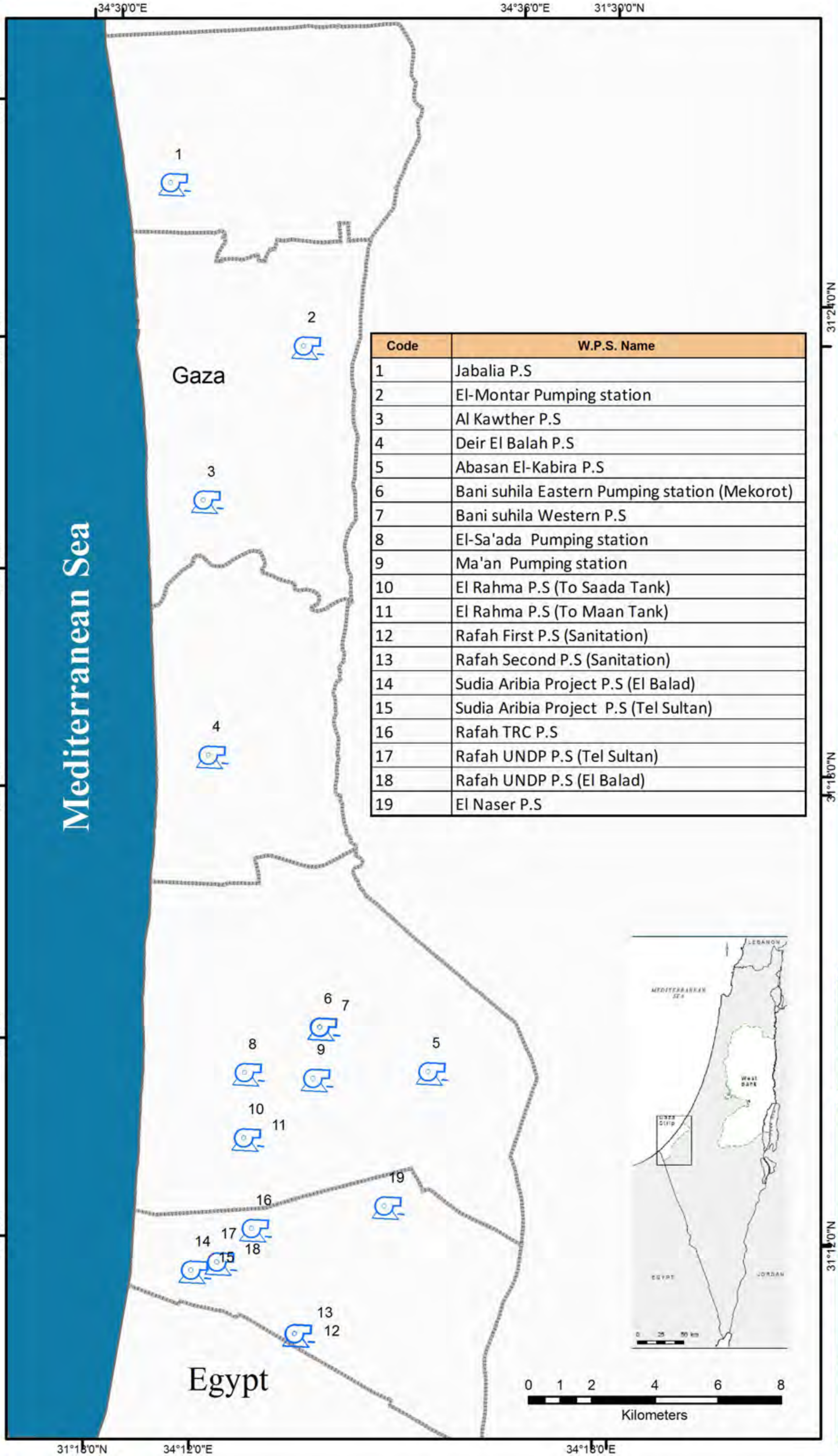
**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Water Pump Stations in Gaza Strip -2014

Baseline Study on Water Quality and Public Health - April, 2015




| Code | W.P.S. Name |
|---|---|
| 1 | Jabalia P.S |
| 2 | El-Montar Pumping station |
| 3 | Al Kawther P.S |
| 4 | Deir El Balah P.S |
| 5 | Abasan El-Kabira P.S |
| 6 | Bani suhila Eastern Pumping station (Mekorot) |
| 7 | Bani suhila Western P.S |
| 8 | El-Sa'ada Pumping station |
| 9 | Ma'an Pumping station |
| 10 | El Rahma P.S (To Saada Tank) |
| 11 | El Rahma P.S (To Maan Tank) |
| 12 | Rafah First P.S (Sanitation) |
| 13 | Rafah Second P.S (Sanitation) |
| 14 | Sudia Aribia Project P.S (El Balad) |
| 15 | Sudia Aribia Project P.S (Tel Sultan) |
| 16 | Rafah TRC P.S |
| 17 | Rafah UNDP P.S (Tel Sultan) |
| 18 | Rafah UNDP P.S (El Balad) |
| 19 | El Naser P.S |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

Water Pump Station
Sea
Governorate

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

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Datum: Palestine 1923
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latitude of origin: 31.7341
Units: Meter

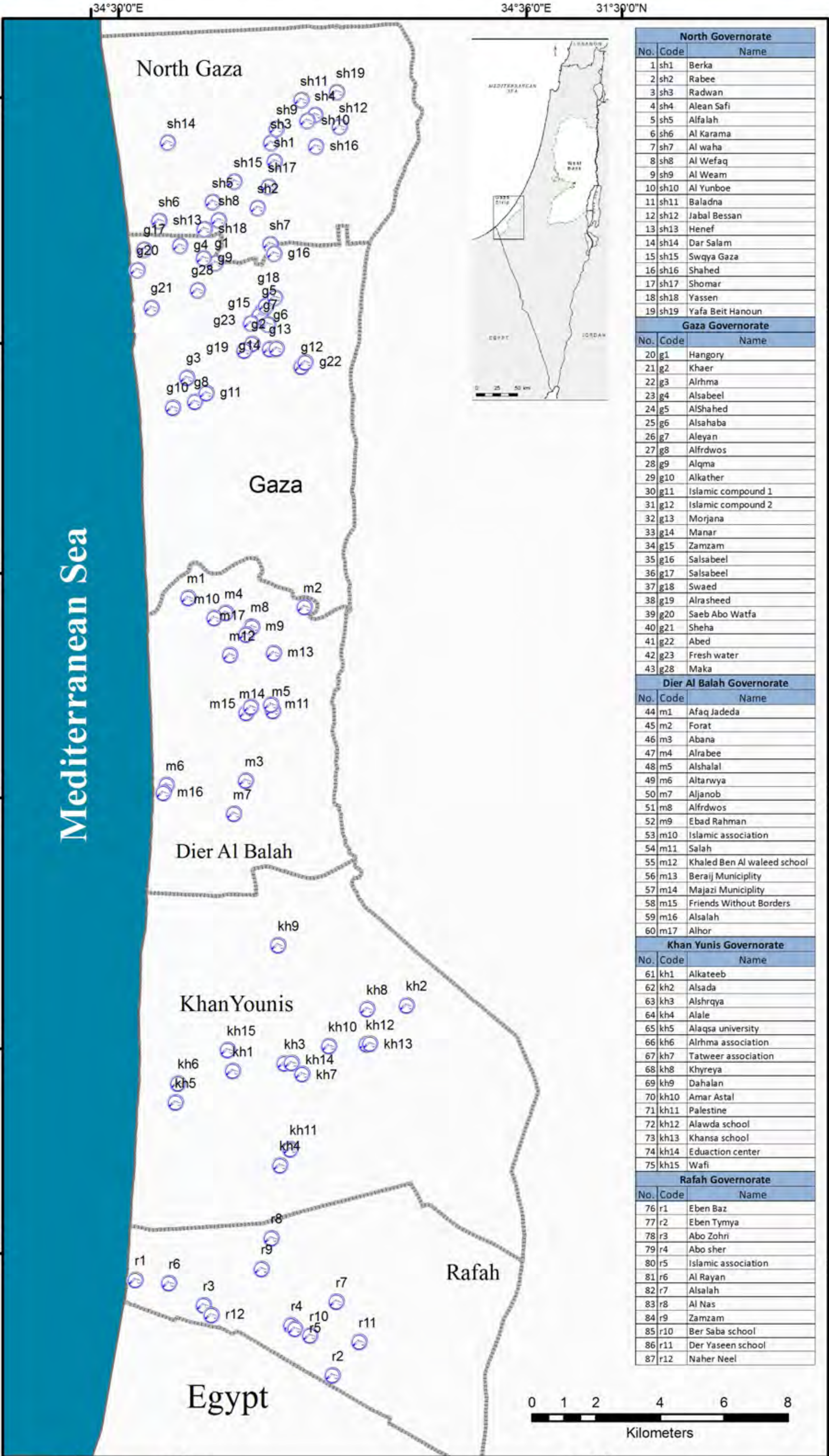
**Date: 4/22/2015**


**Funded by:**

Austrian Development Agency

# Private Desalination Plants in Gaza Strip - 2014

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name |
|---|---|---|
| **North Governorate** | | |
| 1 | sh1 | Berka |
| 2 | sh2 | Rabee |
| 3 | sh3 | Radwan |
| 4 | sh4 | Alean Safi |
| 5 | sh5 | Alfalah |
| 6 | sh6 | Al Karama |
| 7 | sh7 | Al waha |
| 8 | sh8 | Al Wefaq |
| 9 | sh9 | Al Weam |
| 10 | sh10 | Al Yunboe |
| 11 | sh11 | Baladna |
| 12 | sh12 | Jabal Bessan |
| 13 | sh13 | Henef |
| 14 | sh14 | Dar Salam |
| 15 | sh15 | Swqya Gaza |
| 16 | sh16 | Shahed |
| 17 | sh17 | Shomar |
| 18 | sh18 | Yassen |
| 19 | sh19 | Yafa Beit Hanoun |
| **Gaza Governorate** | | |
| 20 | g1 | Hangory |
| 21 | g2 | Khaer |
| 22 | g3 | Alrhma |
| 23 | g4 | Alsabeel |
| 24 | g5 | AlShahed |
| 25 | g6 | Alsahaba |
| 26 | g7 | Aleyan |
| 27 | g8 | Alfrdwos |
| 28 | g9 | Alqma |
| 29 | g10 | Alkather |
| 30 | g11 | Islamic compound 1 |
| 31 | g12 | Islamic compound 2 |
| 32 | g13 | Morjana |
| 33 | g14 | Manar |
| 34 | g15 | Zamzam |
| 35 | g16 | Salsabeel |
| 36 | g17 | Salsabeel |
| 37 | g18 | Swaed |
| 38 | g19 | Alrasheed |
| 39 | g20 | Saeb Abo Watfa |
| 40 | g21 | Sheha |
| 41 | g22 | Abed |
| 42 | g23 | Fresh water |
| 43 | g28 | Maka |
| **Dier Al Balah Governorate** | | |
| 44 | m1 | Afaq Jadeda |
| 45 | m2 | Forat |
| 46 | m3 | Abana |
| 47 | m4 | Alrabee |
| 48 | m5 | Alshalal |
| 49 | m6 | Altarwya |
| 50 | m7 | Aljanob |
| 51 | m8 | Alfrdwos |
| 52 | m9 | Ebad Rahman |
| 53 | m10 | Islamic association |
| 54 | m11 | Salah |
| 55 | m12 | Khaled Ben Al waleed school |
| 56 | m13 | Beraij Municiplity |
| 57 | m14 | Majazi Municiplity |
| 58 | m15 | Friends Without Borders |
| 59 | m16 | Alsalah |
| 60 | m17 | Alhor |
| **Khan Yunis Governorate** | | |
| 61 | kh1 | Alkateeb |
| 62 | kh2 | Alsada |
| 63 | kh3 | Alshrqya |
| 64 | kh4 | Alale |
| 65 | kh5 | Alaqsa university |
| 66 | kh6 | Alrhma association |
| 67 | kh7 | Tatweer association |
| 68 | kh8 | Khyreya |
| 69 | kh9 | Dahalan |
| 70 | kh10 | Amar Astal |
| 71 | kh11 | Palestine |
| 72 | kh12 | Alawda school |
| 73 | kh13 | Khansa school |
| 74 | kh14 | Eduaction center |
| 75 | kh15 | Wafi |
| **Rafah Governorate** | | |
| 76 | r1 | Eben Baz |
| 77 | r2 | Eben Tymya |
| 78 | r3 | Abo Zohri |
| 79 | r4 | Abo sher |
| 80 | r5 | Islamic association |
| 81 | r6 | Al Rayan |
| 82 | r7 | Alsalah |
| 83 | r8 | Al Nas |
| 84 | r9 | Zamzam |
| 85 | r10 | Ber Saba school |
| 86 | r11 | Der Yaseen school |
| 87 | r12 | Naher Neel |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

Private Vendor
Governorate
Sea

Source:
Palestinian Ministry of Health
Date of Data : 2014

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
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**Date: 4/22/2015**

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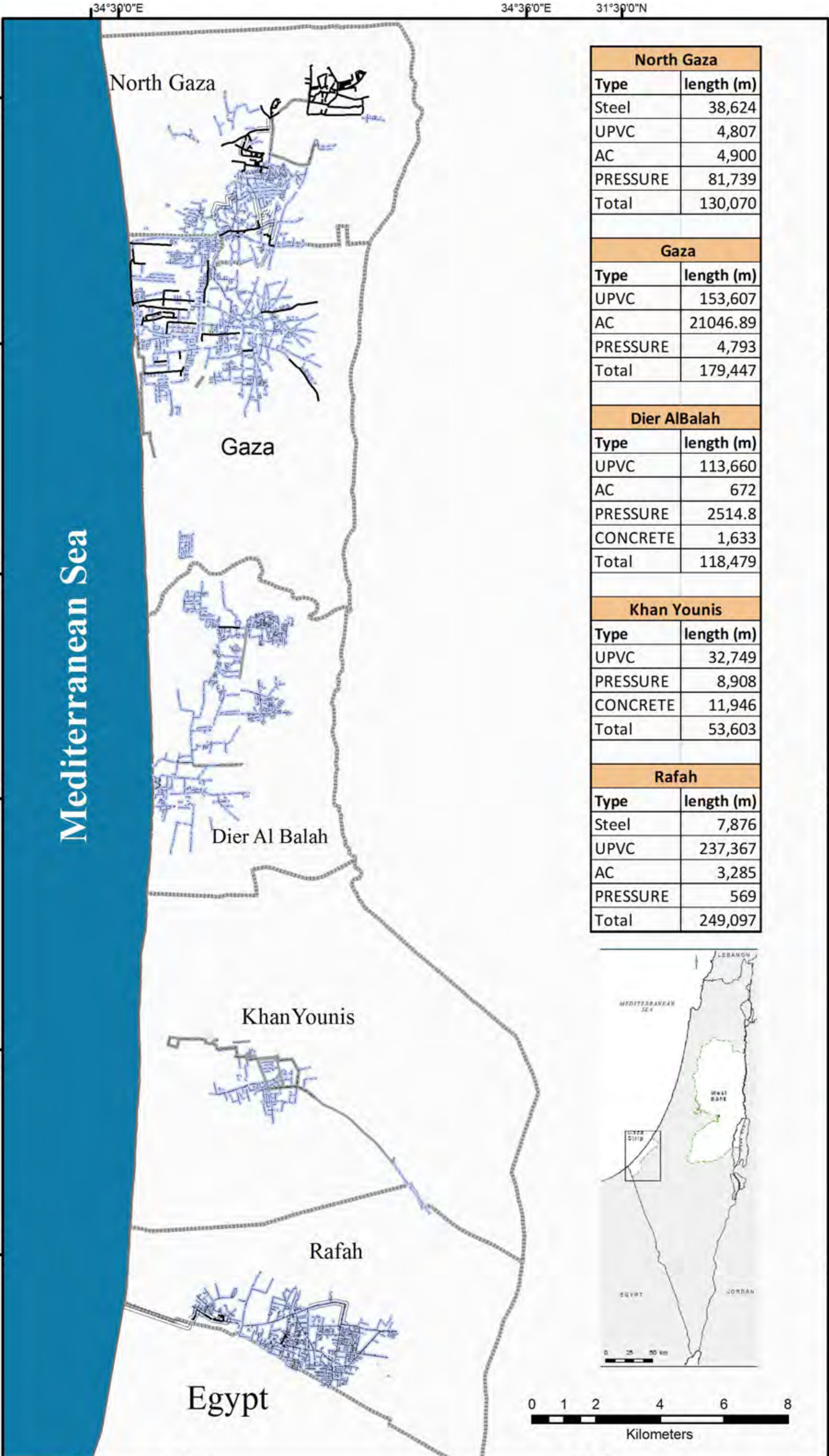
# Waste Water Network in Gaza Strip for Year 2014

Baseline Study on Water Quality and Public Health - April, 2015




| North Gaza | |
|---|---|
| Type | length (m) |
| Steel | 38,624 |
| UPVC | 4,807 |
| AC | 4,900 |
| PRESSURE | 81,739 |
| Total | 130,070 |

| Gaza | |
|---|---|
| Type | length (m) |
| UPVC | 153,607 |
| AC | 21046.89 |
| PRESSURE | 4,793 |
| Total | 179,447 |

| Dier AlBalah | |
|---|---|
| Type | length (m) |
| UPVC | 113,660 |
| AC | 672 |
| PRESSURE | 2514.8 |
| CONCRETE | 1,633 |
| Total | 118,479 |

| Khan Younis | |
|---|---|
| Type | length (m) |
| UPVC | 32,749 |
| PRESSURE | 8,908 |
| CONCRETE | 11,946 |
| Total | 53,603 |

| Rafah | |
|---|---|
| Type | length (m) |
| Steel | 7,876 |
| UPVC | 237,367 |
| AC | 3,285 |
| PRESSURE | 569 |
| Total | 249,097 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Waste Water Network**

**type**

- AC
- CONCRETE
- PRESSURE
- STEEL
- UPVC
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
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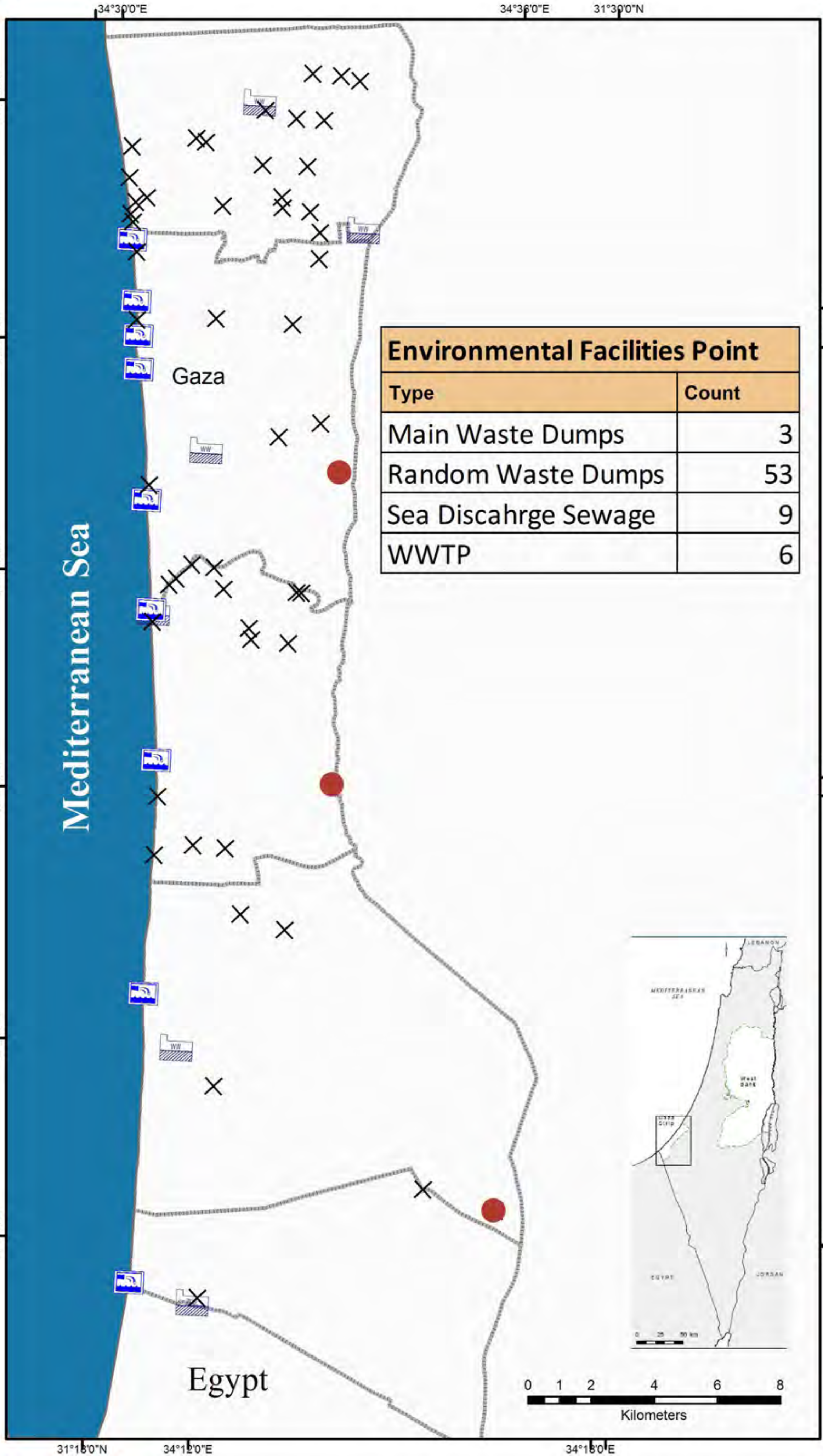
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Environmental Facilities Points in Gaza Strip 2014

Baseline Study on Water Quality and Public Health - April, 2015




| Environmental Facilities Point | |
|---|---|
| Type | Count |
| Main Waste Dumps | 3 |
| Random Waste Dumps | 53 |
| Sea Discahrge Sewage | 9 |
| WWTP | 6 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

## Legend

- Main Waste Dumps
- Random Waste Dumps
- Sea Discharge Sewage
- WWTP
- Sea
- Governorate

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
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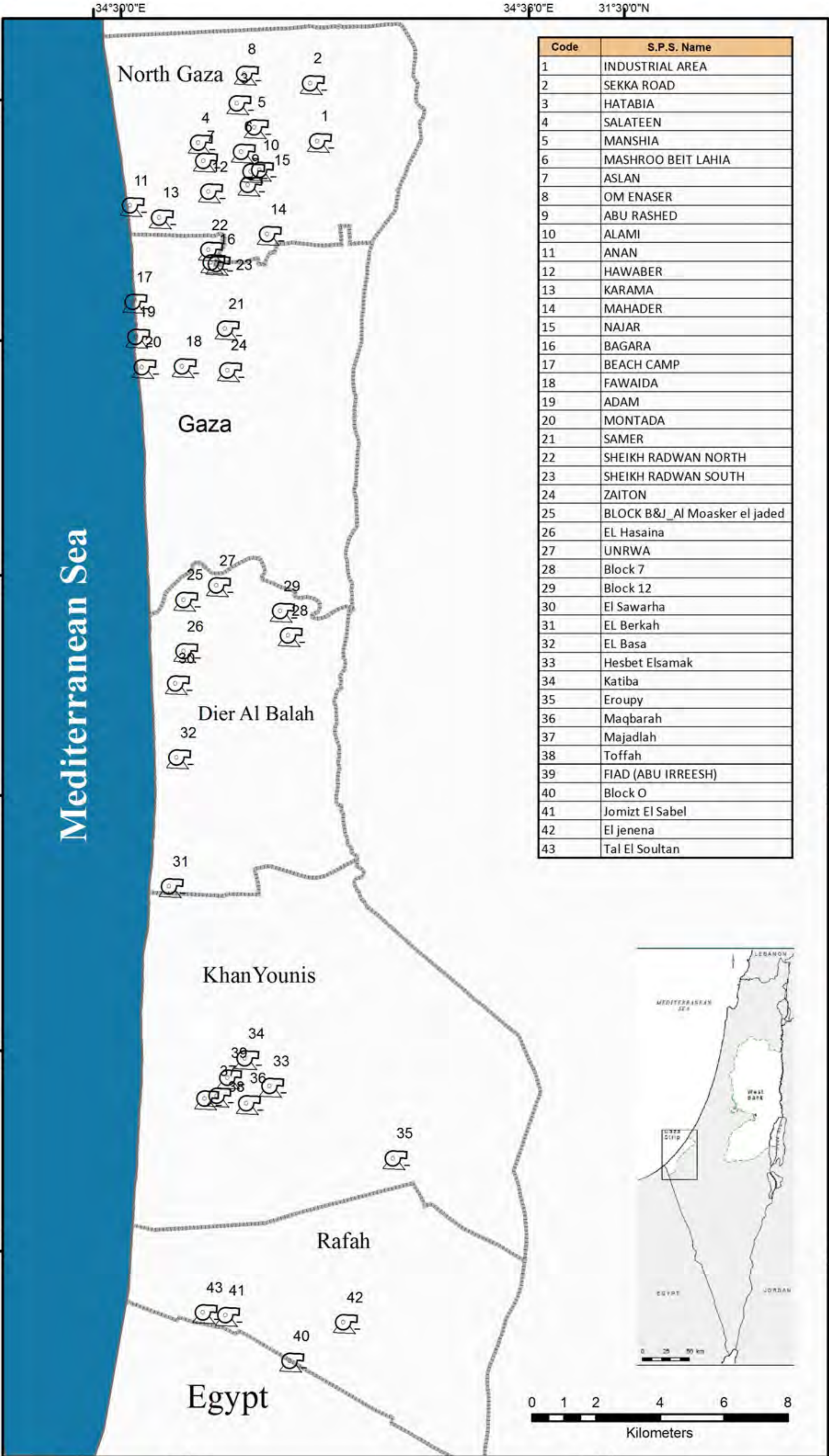
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Sewage Pump Stations in Gaza Strip -2014

Baseline Study on Water Quality and Public Health - April, 2015




| Code | S.P.S. Name |
|---|---|
| 1 | INDUSTRIAL AREA |
| 2 | SEKKA ROAD |
| 3 | HATABIA |
| 4 | SALATEEN |
| 5 | MANSHIA |
| 6 | MASHROO BEIT LAHIA |
| 7 | ASLAN |
| 8 | OM ENASER |
| 9 | ABU RASHED |
| 10 | ALAMI |
| 11 | ANAN |
| 12 | HAWABER |
| 13 | KARAMA |
| 14 | MAHADER |
| 15 | NAJAR |
| 16 | BAGARA |
| 17 | BEACH CAMP |
| 18 | FAWAIDA |
| 19 | ADAM |
| 20 | MONTADA |
| 21 | SAMER |
| 22 | SHEIKH RADWAN NORTH |
| 23 | SHEIKH RADWAN SOUTH |
| 24 | ZAITON |
| 25 | BLOCK B&J_Al Moasker el jaded |
| 26 | EL Hasaina |
| 27 | UNRWA |
| 28 | Block 7 |
| 29 | Block 12 |
| 30 | El Sawarha |
| 31 | EL Berkah |
| 32 | EL Basa |
| 33 | Hesbet Elsamak |
| 34 | Katiba |
| 35 | Eroupy |
| 36 | Maqbarah |
| 37 | Majadlah |
| 38 | Toffah |
| 39 | FIAD (ABU IRREESH) |
| 40 | Block O |
| 41 | Jomizt El Sabel |
| 42 | El jenena |
| 43 | Tal El Soultan |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

## Legend

- Sewage Pump Station
- Sea
- Governorate

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
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central meridian: 35.2121
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latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
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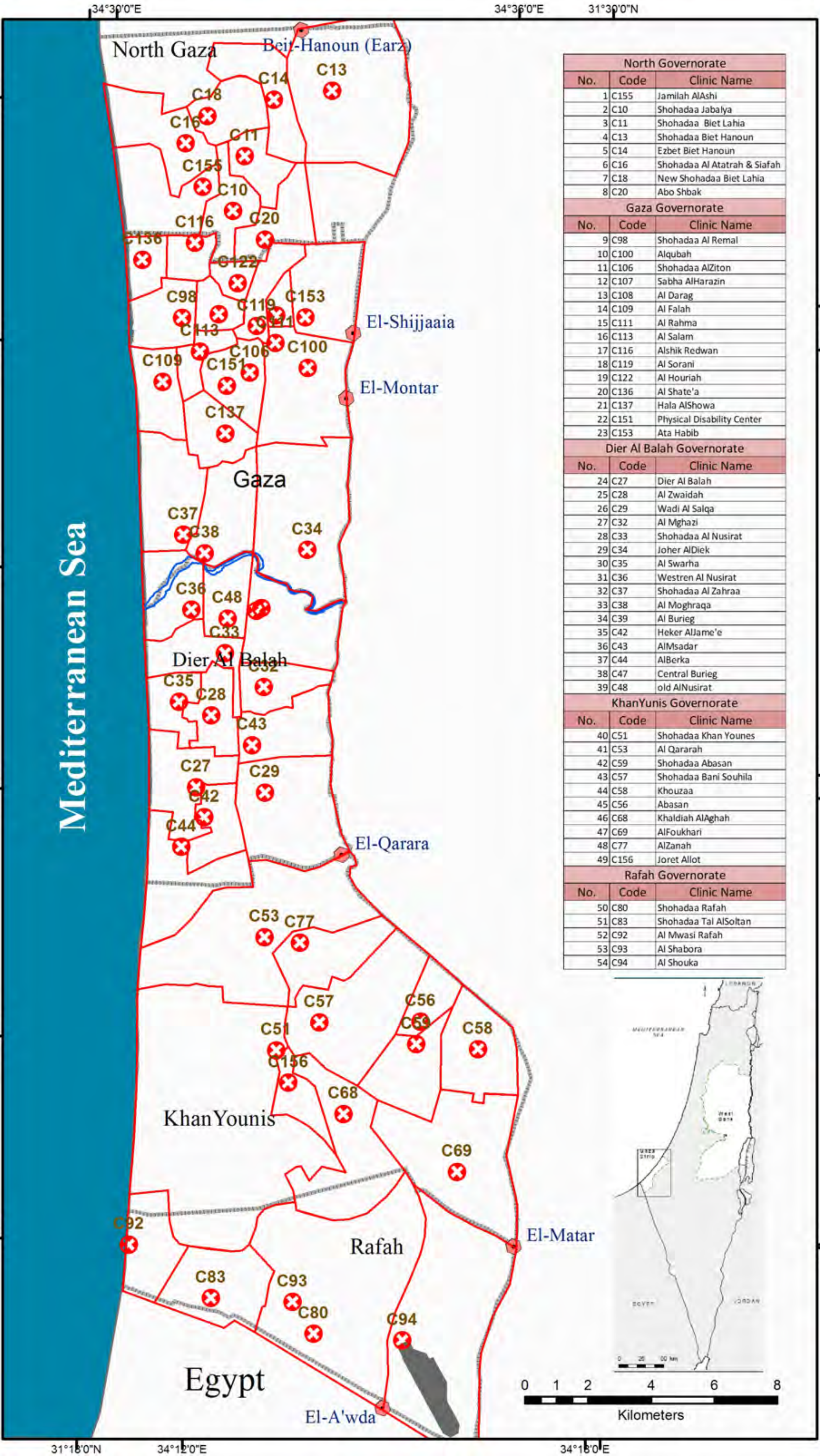
# Minsitry of Health Clinics Gaza -2014

Baseline Study on Water Quality and Public Health - April, 2015




| North Governorate | | |
|---|---|---|
| No. | Code | Clinic Name |
| 1 | C155 | Jamilah AlAshi |
| 2 | C10 | Shohadaa Jabalya |
| 3 | C11 | Shohadaa Biet Lahia |
| 4 | C13 | Shohadaa Biet Hanoun |
| 5 | C14 | Ezbet Biet Hanoun |
| 6 | C16 | Shohadaa Al Atatrah & Siafah |
| 7 | C18 | New Shohadaa Biet Lahia |
| 8 | C20 | Abo Shbak |
| Gaza Governorate | | |
| No. | Code | Clinic Name |
| 9 | C98 | Shohadaa Al Remal |
| 10 | C100 | Alqubah |
| 11 | C106 | Shohadaa AlZiton |
| 12 | C107 | Sabha AlHarazin |
| 13 | C108 | Al Darag |
| 14 | C109 | Al Falah |
| 15 | C111 | Al Rahma |
| 16 | C113 | Al Salam |
| 17 | C116 | Alshik Redwan |
| 18 | C119 | Al Sorani |
| 19 | C122 | Al Houriah |
| 20 | C136 | Al Shate'a |
| 21 | C137 | Hala AlShowa |
| 22 | C151 | Physical Disability Center |
| 23 | C153 | Ata Habib |
| Dier Al Balah Governorate | | |
| No. | Code | Clinic Name |
| 24 | C27 | Dier Al Balah |
| 25 | C28 | Al Zwaidah |
| 26 | C29 | Wadi Al Salqa |
| 27 | C32 | Al Mghazi |
| 28 | C33 | Shohadaa Al Nusirat |
| 29 | C34 | Joher AlDiek |
| 30 | C35 | Al Swarha |
| 31 | C36 | Westren Al Nusirat |
| 32 | C37 | Shohadaa Al Zahraa |
| 33 | C38 | Al Moghraqa |
| 34 | C39 | Al Burieg |
| 35 | C42 | Heker AlJame'e |
| 36 | C43 | AlMsadar |
| 37 | C44 | AlBerka |
| 38 | C47 | Central Burieg |
| 39 | C48 | old AlNusirat |
| KhanYunis Governorate | | |
| No. | Code | Clinic Name |
| 40 | C51 | Shohadaa Khan Younes |
| 41 | C53 | Al Qararah |
| 42 | C59 | Shohadaa Abasan |
| 43 | C57 | Shohadaa Bani Souhila |
| 44 | C58 | Khouzaa |
| 45 | C56 | Abasan |
| 46 | C68 | Khaldiah AlAghah |
| 47 | C69 | AlFoukhari |
| 48 | C77 | AlZanah |
| 49 | C156 | Joret Allot |
| Rafah Governorate | | |
| No. | Code | Clinic Name |
| 50 | C80 | Shohadaa Rafah |
| 51 | C83 | Shohadaa Tal AlSoltan |
| 52 | C92 | Al Mwasi Rafah |
| 53 | C93 | Al Shabora |
| 54 | C94 | Al Shouka |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

- MOH Clinics
- Services Area
- Governorate
- Gaza Airport
- Sea
- Wadi Gaza
- Entry Points

Source:
Palestinian Ministry of Health
Date of Data : 2014

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
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false northing: 126,867.9090
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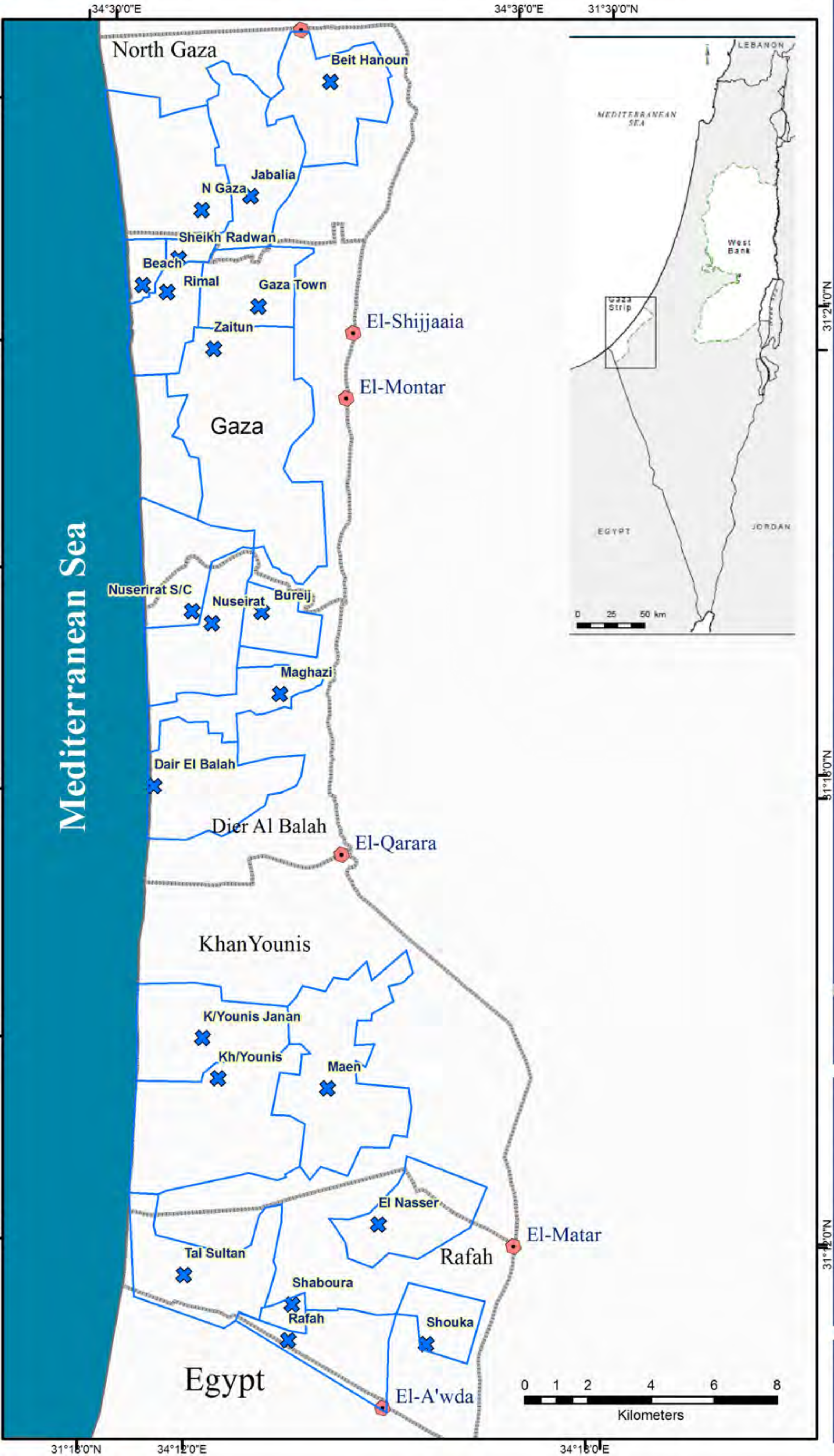
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# UNRWA Clinics. Gaza -2014

Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

- UNRWA Clinics
- Crossing Point
- Service Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2014

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**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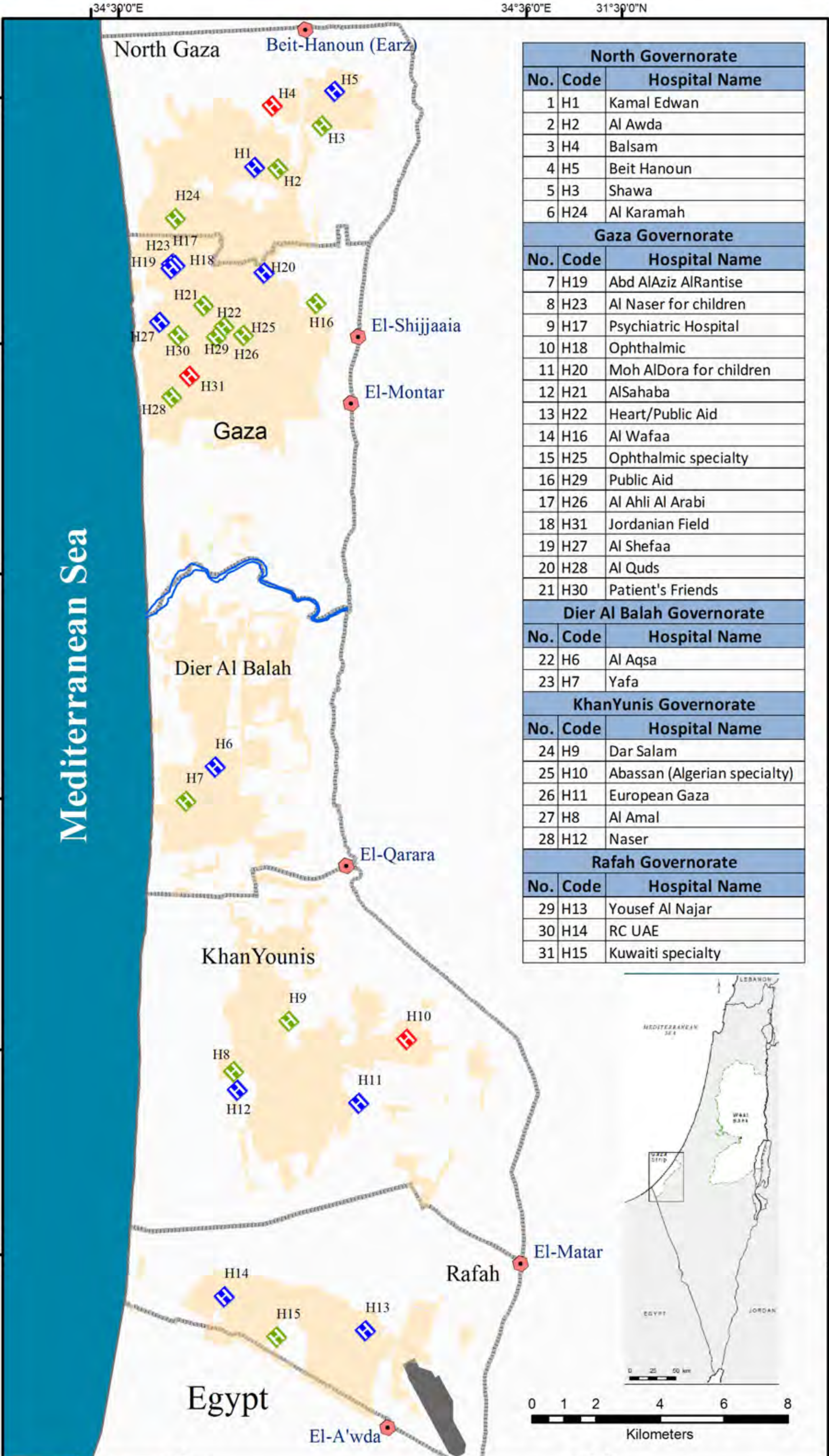
# Hospitals Gaza Strip -2014

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Hospital Name |
|---|---|---|
| **North Governorate** | | |
| 1 | H1 | Kamal Edwan |
| 2 | H2 | Al Awda |
| 3 | H4 | Balsam |
| 4 | H5 | Beit Hanoun |
| 5 | H3 | Shawa |
| 6 | H24 | Al Karamah |
| **Gaza Governorate** | | |
| 7 | H19 | Abd AlAziz AlRantise |
| 8 | H23 | Al Naser for children |
| 9 | H17 | Psychiatric Hospital |
| 10 | H18 | Ophthalmic |
| 11 | H20 | Moh AlDora for children |
| 12 | H21 | AlSahaba |
| 13 | H22 | Heart/Public Aid |
| 14 | H16 | Al Wafaa |
| 15 | H25 | Ophthalmic specialty |
| 16 | H29 | Public Aid |
| 17 | H26 | Al Ahli Al Arabi |
| 18 | H31 | Jordanian Field |
| 19 | H27 | Al Shefaa |
| 20 | H28 | Al Quds |
| 21 | H30 | Patient's Friends |
| **Dier Al Balah Governorate** | | |
| 22 | H6 | Al Aqsa |
| 23 | H7 | Yafa |
| **KhanYunis Governorate** | | |
| 24 | H9 | Dar Salam |
| 25 | H10 | Abassan (Algerian specialty) |
| 26 | H11 | European Gaza |
| 27 | H8 | Al Amal |
| 28 | H12 | Naser |
| **Rafah Governorate** | | |
| 29 | H13 | Yousef Al Najar |
| 30 | H14 | RC UAE |
| 31 | H15 | Kuwaiti specialty |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

## Legend

- Governmental
- Medical Services
- NGO's
- Wadi Gaza
- Entry Points
- Built-up Area
- Gaza Airport
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2014

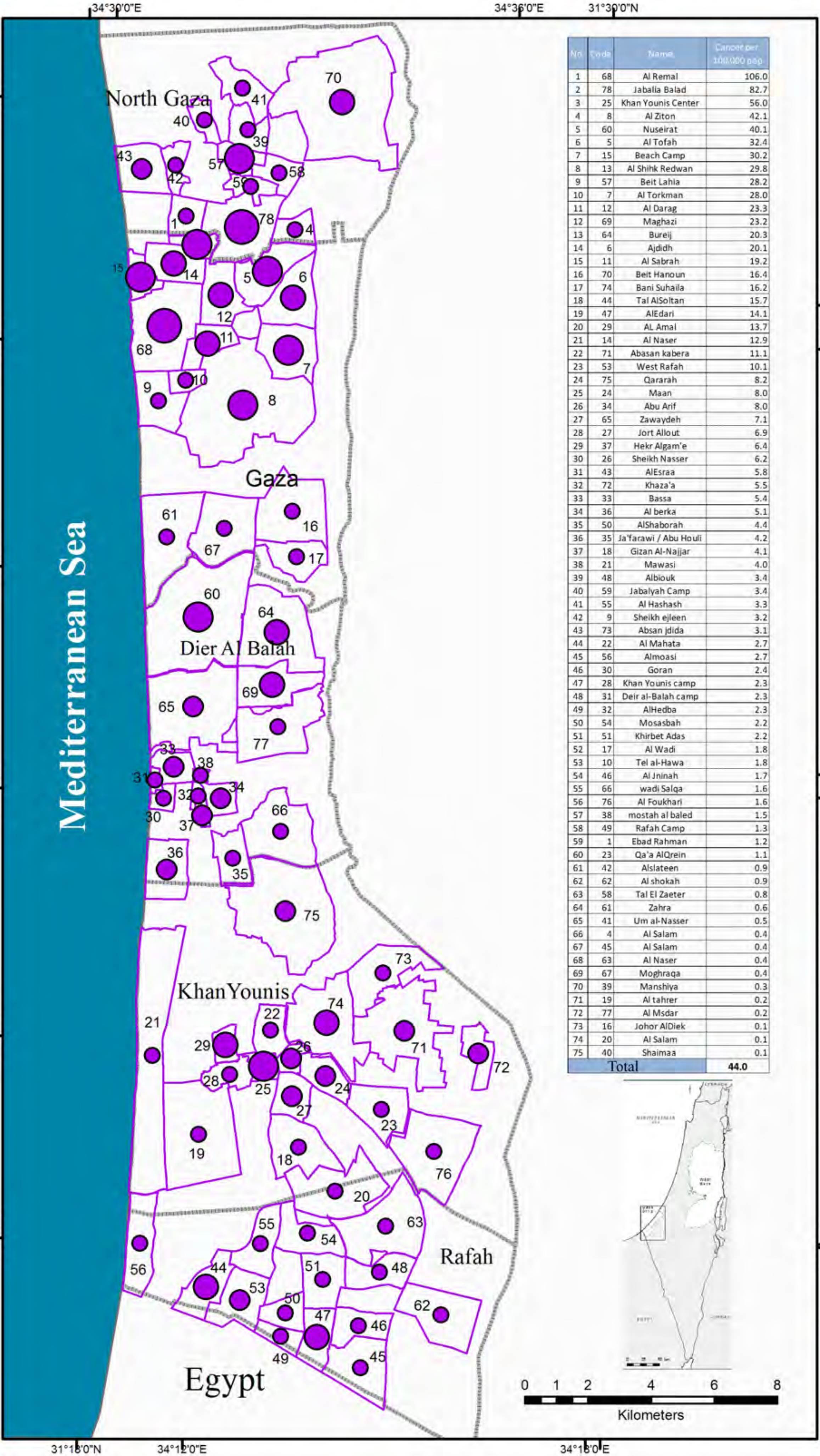
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Overall average Cancer crude incidence rate at Gaza Strip MOH (1995 - 2013)

Baseline Study on Water Quality and Public Health - April, 2015




| No | Code | Name | Cancer per 100,000 pop |
|---|---|---|---|
| 1 | 68 | Al Remal | 106.0 |
| 2 | 78 | Jabalia Balad | 82.7 |
| 3 | 25 | Khan Younis Center | 56.0 |
| 4 | 8 | Al Ziton | 42.1 |
| 5 | 60 | Nuseirat | 40.1 |
| 6 | 5 | Al Tofah | 32.4 |
| 7 | 15 | Beach Camp | 30.2 |
| 8 | 13 | Al Shihk Redwan | 29.8 |
| 9 | 57 | Beit Lahia | 28.2 |
| 10 | 7 | Al Torkman | 28.0 |
| 11 | 12 | Al Darag | 23.3 |
| 12 | 69 | Maghazi | 23.2 |
| 13 | 64 | Bureij | 20.3 |
| 14 | 6 | Ajdidh | 20.1 |
| 15 | 11 | Al Sabrah | 19.2 |
| 16 | 70 | Beit Hanoun | 16.4 |
| 17 | 74 | Bani Suhaila | 16.2 |
| 18 | 44 | Tal AlSoltan | 15.7 |
| 19 | 47 | AlEdari | 14.1 |
| 20 | 29 | AL Amal | 13.7 |
| 21 | 14 | Al Naser | 12.9 |
| 22 | 71 | Abasan kabera | 11.1 |
| 23 | 53 | West Rafah | 10.1 |
| 24 | 75 | Qararah | 8.2 |
| 25 | 24 | Maan | 8.0 |
| 26 | 34 | Abu Arif | 8.0 |
| 27 | 65 | Zawaydeh | 7.1 |
| 28 | 27 | Jort Allout | 6.9 |
| 29 | 37 | Hekr Algam'e | 6.4 |
| 30 | 26 | Sheikh Nasser | 6.2 |
| 31 | 43 | AlEsraa | 5.8 |
| 32 | 72 | Khaza'a | 5.5 |
| 33 | 33 | Bassa | 5.4 |
| 34 | 36 | Al berka | 5.1 |
| 35 | 50 | AlShaborah | 4.4 |
| 36 | 35 | Ja'farawi / Abu Houli | 4.2 |
| 37 | 18 | Gizan Al-Najjar | 4.1 |
| 38 | 21 | Mawasi | 4.0 |
| 39 | 48 | Albiouk | 3.4 |
| 40 | 59 | Jabalyah Camp | 3.4 |
| 41 | 55 | Al Hashash | 3.3 |
| 42 | 9 | Sheikh ejleen | 3.2 |
| 43 | 73 | Absan jdida | 3.1 |
| 44 | 22 | Al Mahata | 2.7 |
| 45 | 56 | Almoasi | 2.7 |
| 46 | 30 | Goran | 2.4 |
| 47 | 28 | Khan Younis camp | 2.3 |
| 48 | 31 | Deir al-Balah camp | 2.3 |
| 49 | 32 | AlHedba | 2.3 |
| 50 | 54 | Mosasbah | 2.2 |
| 51 | 51 | Khirbet Adas | 2.2 |
| 52 | 17 | Al Wadi | 1.8 |
| 53 | 10 | Tel al-Hawa | 1.8 |
| 54 | 46 | Al Jninah | 1.7 |
| 55 | 66 | wadi Salqa | 1.6 |
| 56 | 76 | Al Foukhari | 1.6 |
| 57 | 38 | mostah al baled | 1.5 |
| 58 | 49 | Rafah Camp | 1.3 |
| 59 | 1 | Ebad Rahman | 1.2 |
| 60 | 23 | Qa'a AlQrein | 1.1 |
| 61 | 42 | Alslateen | 0.9 |
| 62 | 62 | Al shokah | 0.9 |
| 63 | 58 | Tal El Zaeter | 0.8 |
| 64 | 61 | Zahra | 0.6 |
| 65 | 41 | Um al-Nasser | 0.5 |
| 66 | 4 | Al Salam | 0.4 |
| 67 | 45 | Al Salam | 0.4 |
| 68 | 63 | Al Naser | 0.4 |
| 69 | 67 | Moghraqa | 0.4 |
| 70 | 39 | Manshiya | 0.3 |
| 71 | 19 | Al tahrer | 0.2 |
| 72 | 77 | Al Msdar | 0.2 |
| 73 | 16 | Johor AlDiek | 0.1 |
| 74 | 20 | Al Salam | 0.1 |
| 75 | 40 | Shaimaa | 0.1 |
| Total | | | 44.0 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

## Legend

**Cancer Incidence per 100,000**

- 0.1 - 4.4
- 4.5 - 11.1
- 11.2 - 23.3
- 23.4 - 56.0
- 56.1 - 106.0
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 1995 - 2013

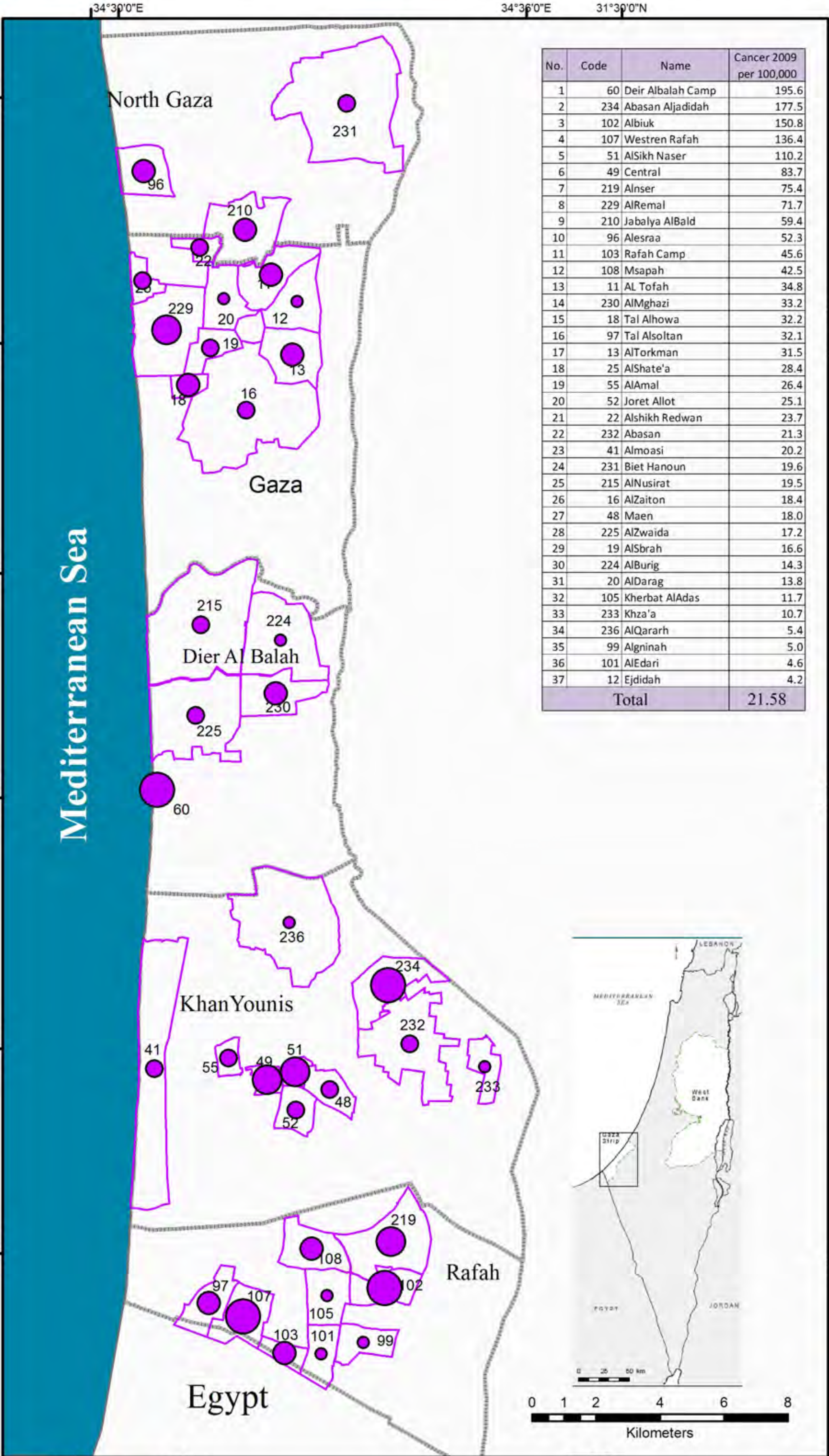
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Cancer Crude incidence rate at Gaza Strip. MOH, 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | Cancer 2009 per 100,000 |
|---|---|---|---|
| 1 | 60 | Deir Albalah Camp | 195.6 |
| 2 | 234 | Abasan Aljadidah | 177.5 |
| 3 | 102 | Albiuk | 150.8 |
| 4 | 107 | Westren Rafah | 136.4 |
| 5 | 51 | AlSikh Naser | 110.2 |
| 6 | 49 | Central | 83.7 |
| 7 | 219 | Alnser | 75.4 |
| 8 | 229 | AlRemal | 71.7 |
| 9 | 210 | Jabalya AlBald | 59.4 |
| 10 | 96 | Alesraa | 52.3 |
| 11 | 103 | Rafah Camp | 45.6 |
| 12 | 108 | Msapah | 42.5 |
| 13 | 11 | AL Tofah | 34.8 |
| 14 | 230 | AlMghazi | 33.2 |
| 15 | 18 | Tal Alhowa | 32.2 |
| 16 | 97 | Tal Alsoltan | 32.1 |
| 17 | 13 | AlTorkman | 31.5 |
| 18 | 25 | AlShate'a | 28.4 |
| 19 | 55 | AlAmal | 26.4 |
| 20 | 52 | Joret Allot | 25.1 |
| 21 | 22 | Alshikh Redwan | 23.7 |
| 22 | 232 | Abasan | 21.3 |
| 23 | 41 | Almoasi | 20.2 |
| 24 | 231 | Biet Hanoun | 19.6 |
| 25 | 215 | AlNusirat | 19.5 |
| 26 | 16 | AlZaiton | 18.4 |
| 27 | 48 | Maen | 18.0 |
| 28 | 225 | AlZwaida | 17.2 |
| 29 | 19 | AlSbrah | 16.6 |
| 30 | 224 | AlBurig | 14.3 |
| 31 | 20 | AlDarag | 13.8 |
| 32 | 105 | Kherbat AlAdas | 11.7 |
| 33 | 233 | Khza'a | 10.7 |
| 34 | 236 | AlQararh | 5.4 |
| 35 | 99 | Algninah | 5.0 |
| 36 | 101 | AlEdari | 4.6 |
| 37 | 12 | Ejdidah | 4.2 |
| Total | | | 21.58 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Cancer Incidence per 100,000**

- 4.2 - 14.3
- 14.4 - 28.4
- 28.5 - 59.4
- 59.5 - 110.2
- 110.3 - 195.6
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

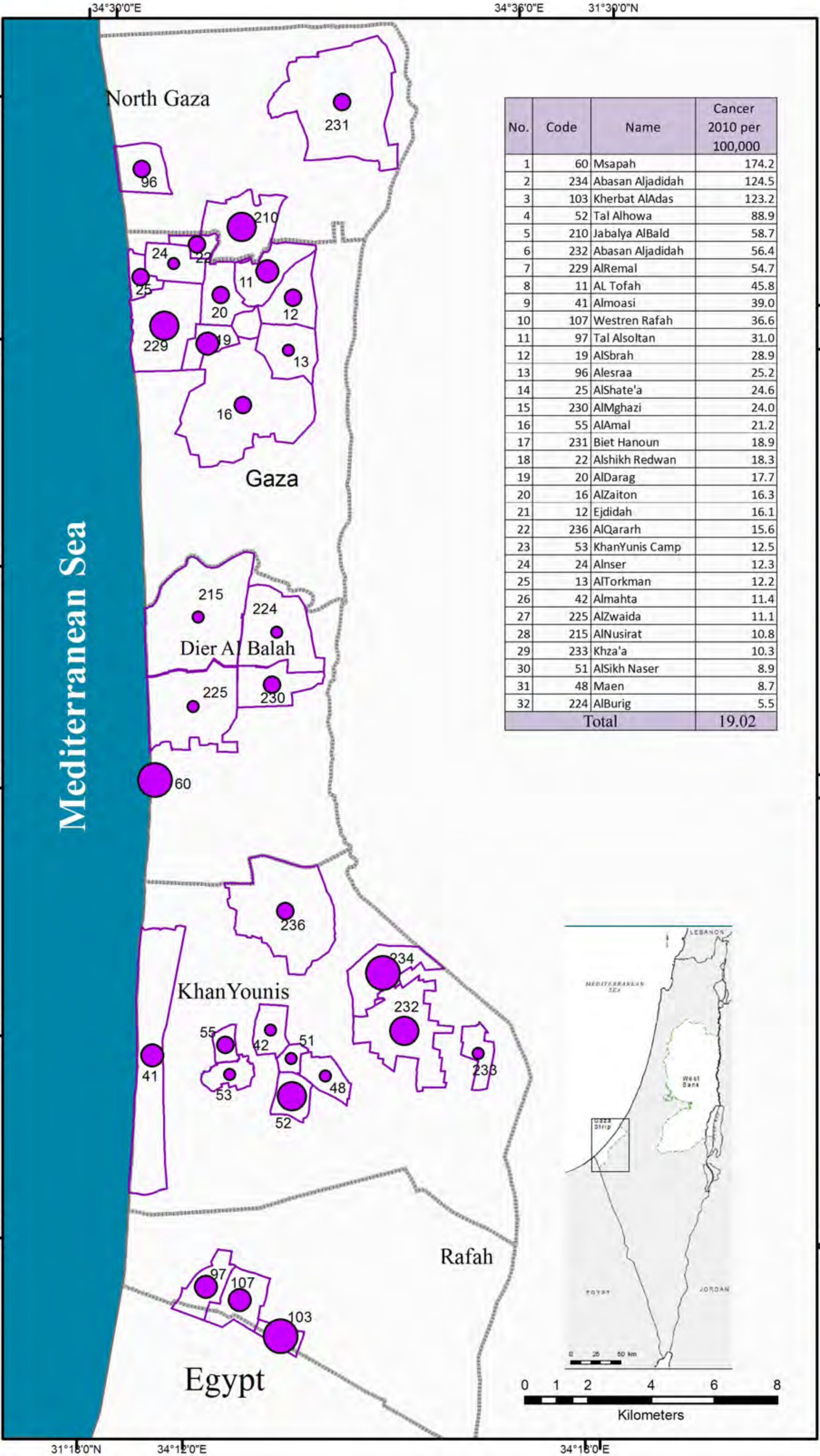
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# Cancer Crude incidence rate at Gaza Strip. MOH, 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | Cancer 2010 per 100,000 |
|---|---|---|---|
| 1 | 60 | Msapah | 174.2 |
| 2 | 234 | Abasan Aljadidah | 124.5 |
| 3 | 103 | Kherbat AlAdas | 123.2 |
| 4 | 52 | Tal Alhowa | 88.9 |
| 5 | 210 | Jabalya AlBald | 58.7 |
| 6 | 232 | Abasan Aljadidah | 56.4 |
| 7 | 229 | AlRemal | 54.7 |
| 8 | 11 | AL Tofah | 45.8 |
| 9 | 41 | Almoasi | 39.0 |
| 10 | 107 | Westren Rafah | 36.6 |
| 11 | 97 | Tal Alsoltan | 31.0 |
| 12 | 19 | AlSbrah | 28.9 |
| 13 | 96 | Alesraa | 25.2 |
| 14 | 25 | AlShate'a | 24.6 |
| 15 | 230 | AlMghazi | 24.0 |
| 16 | 55 | AlAmal | 21.2 |
| 17 | 231 | Biet Hanoun | 18.9 |
| 18 | 22 | Alshikh Redwan | 18.3 |
| 19 | 20 | AlDarag | 17.7 |
| 20 | 16 | AlZaiton | 16.3 |
| 21 | 12 | Ejdidah | 16.1 |
| 22 | 236 | AlQararh | 15.6 |
| 23 | 53 | KhanYunis Camp | 12.5 |
| 24 | 24 | AlInser | 12.3 |
| 25 | 13 | AlTorkman | 12.2 |
| 26 | 42 | Almahta | 11.4 |
| 27 | 225 | AlZwaida | 11.1 |
| 28 | 215 | AlNusirat | 10.8 |
| 29 | 233 | Khza'a | 10.3 |
| 30 | 51 | AlSikh Naser | 8.9 |
| 31 | 48 | Maen | 8.7 |
| 32 | 224 | AlBurig | 5.5 |
| | | Total | 19.02 |

سلطة المياه الفلسطينية
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## Legend

**Cancer Incidence per 100,000**

- 5.5 - 12.5
- 12.6 - 25.2
- 25.3 - 45.8
- 45.9 - 88.9
- 89.0 - 174.2
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
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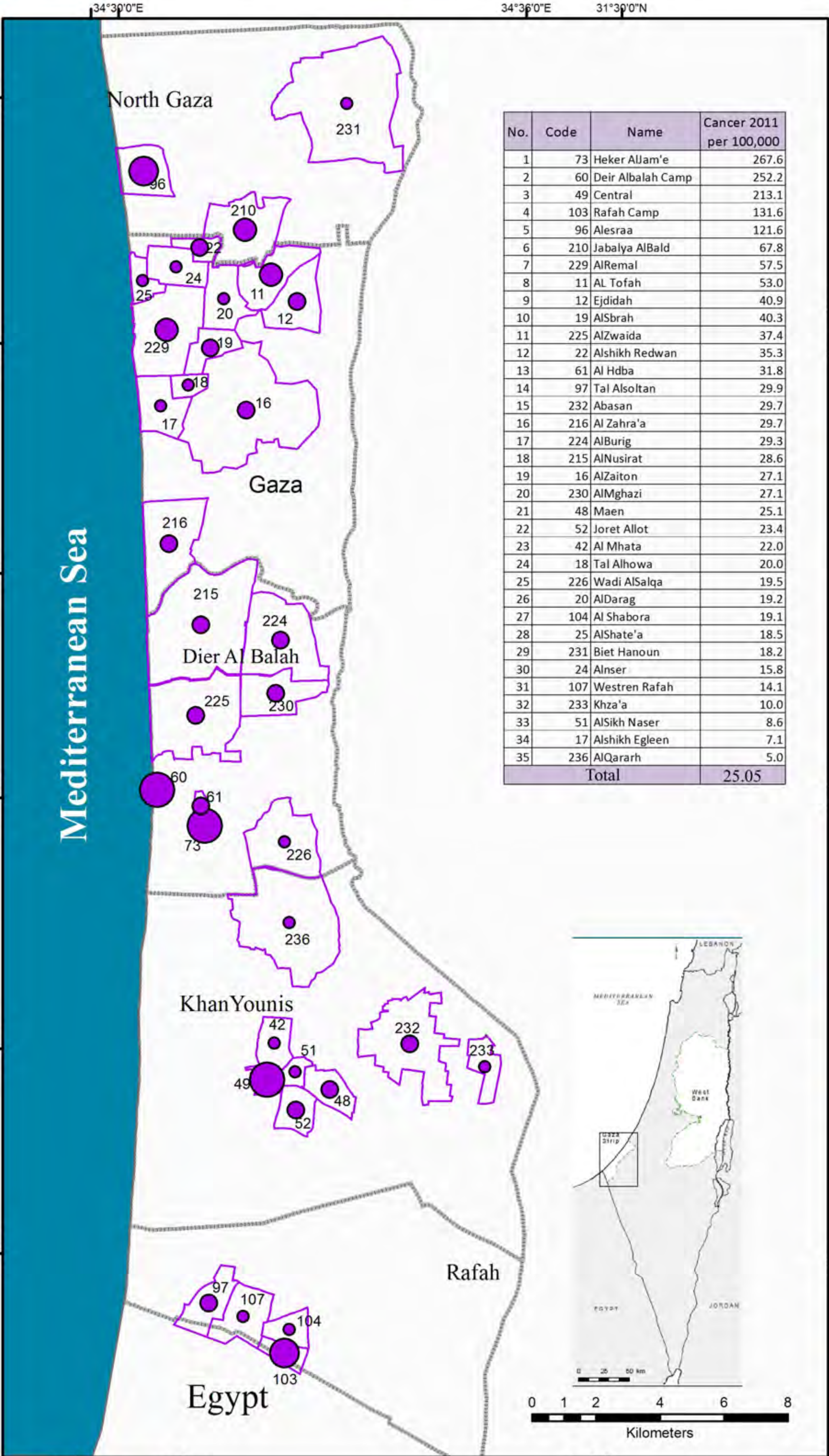
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# Cancer Crude incidence rate at Gaza Strip. MOH, 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | Cancer 2011 per 100,000 |
|---|---|---|---|
| 1 | 73 | Heker AlJam'e | 267.6 |
| 2 | 60 | Deir Albalah Camp | 252.2 |
| 3 | 49 | Central | 213.1 |
| 4 | 103 | Rafah Camp | 131.6 |
| 5 | 96 | Alesraa | 121.6 |
| 6 | 210 | Jabalya AlBald | 67.8 |
| 7 | 229 | AlRemal | 57.5 |
| 8 | 11 | AL Tofah | 53.0 |
| 9 | 12 | Ejdidah | 40.9 |
| 10 | 19 | AlSbrah | 40.3 |
| 11 | 225 | AlZwaida | 37.4 |
| 12 | 22 | Alshikh Redwan | 35.3 |
| 13 | 61 | Al Hdba | 31.8 |
| 14 | 97 | Tal Alsoltan | 29.9 |
| 15 | 232 | Abasan | 29.7 |
| 16 | 216 | Al Zahra'a | 29.7 |
| 17 | 224 | AlBurig | 29.3 |
| 18 | 215 | AlNusirat | 28.6 |
| 19 | 16 | AlZaiton | 27.1 |
| 20 | 230 | AlMghazi | 27.1 |
| 21 | 48 | Maen | 25.1 |
| 22 | 52 | Joret Allot | 23.4 |
| 23 | 42 | Al Mhata | 22.0 |
| 24 | 18 | Tal Alhowa | 20.0 |
| 25 | 226 | Wadi AlSalqa | 19.5 |
| 26 | 20 | AlDarag | 19.2 |
| 27 | 104 | Al Shabora | 19.1 |
| 28 | 25 | AlShate'a | 18.5 |
| 29 | 231 | Biet Hanoun | 18.2 |
| 30 | 24 | Alnser | 15.8 |
| 31 | 107 | Westren Rafah | 14.1 |
| 32 | 233 | Khza'a | 10.0 |
| 33 | 51 | AlSikh Naser | 8.6 |
| 34 | 17 | Alshikh Egleen | 7.1 |
| 35 | 236 | AlQararh | 5.0 |
| Total | | | 25.05 |

PALESTINIAN WATER AUTHORITY

## Legend

**Cancer Incidence per 100,000**

- 5.0 - 22.0
- 22.1 - 40.9
- 41.0 - 67.8
- 67.9 - 131.6
- 131.7 - 267.6
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

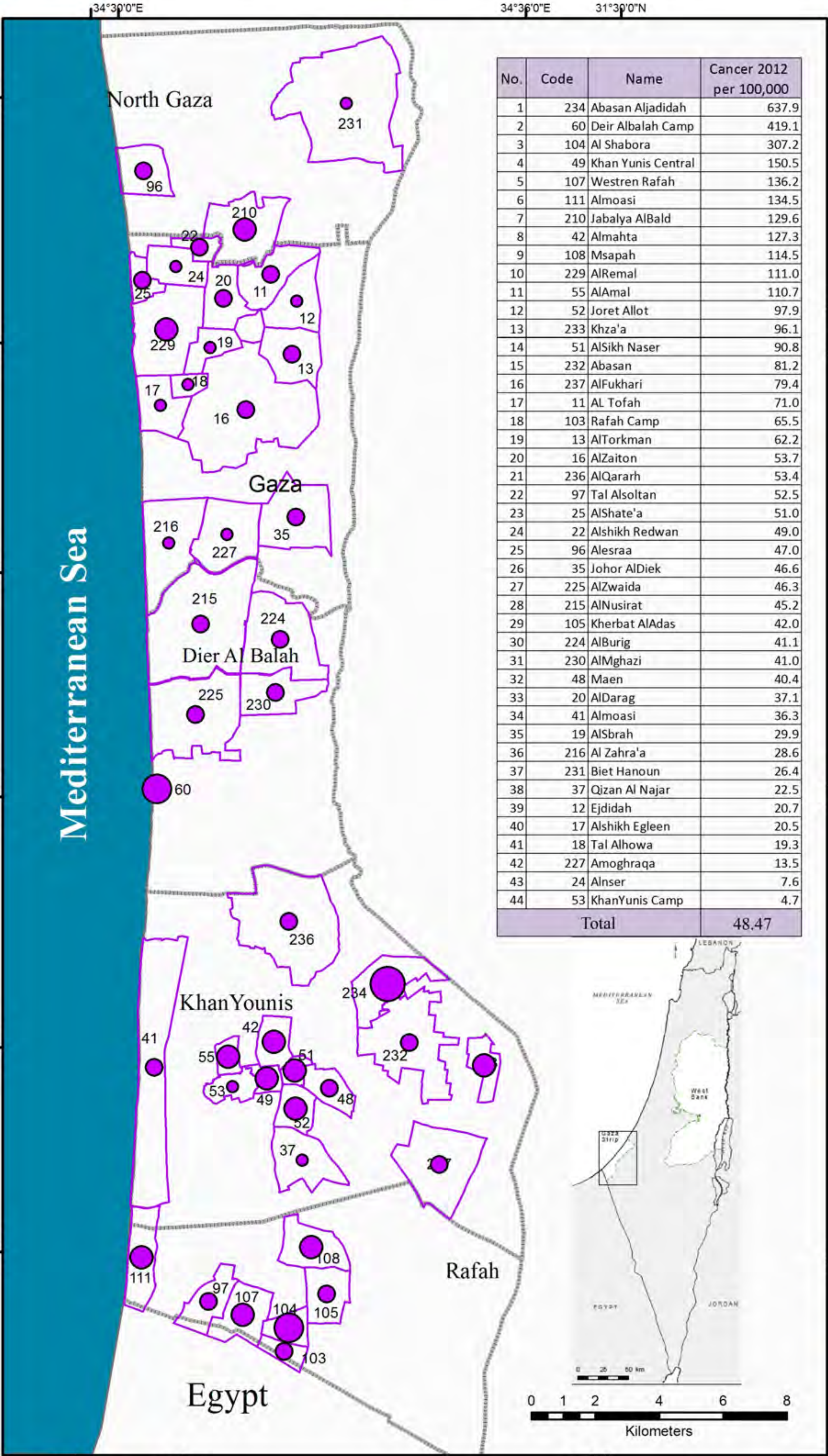
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Cancer Crude incidence rate at Gaza Strip. MOH, 2012

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | Cancer 2012 per 100,000 |
|---|---|---|---|
| 1 | 234 | Abasan Aljadidah | 637.9 |
| 2 | 60 | Deir Albalah Camp | 419.1 |
| 3 | 104 | Al Shabora | 307.2 |
| 4 | 49 | Khan Yunis Central | 150.5 |
| 5 | 107 | Westren Rafah | 136.2 |
| 6 | 111 | Almoasi | 134.5 |
| 7 | 210 | Jabalya AlBald | 129.6 |
| 8 | 42 | Almahta | 127.3 |
| 9 | 108 | Msapah | 114.5 |
| 10 | 229 | AlRemal | 111.0 |
| 11 | 55 | AlAmal | 110.7 |
| 12 | 52 | Joret Allot | 97.9 |
| 13 | 233 | Khza'a | 96.1 |
| 14 | 51 | AlSikh Naser | 90.8 |
| 15 | 232 | Abasan | 81.2 |
| 16 | 237 | AlFukhari | 79.4 |
| 17 | 11 | AL Tofah | 71.0 |
| 18 | 103 | Rafah Camp | 65.5 |
| 19 | 13 | AlTorkman | 62.2 |
| 20 | 16 | AlZaiton | 53.7 |
| 21 | 236 | AlQarark | 53.4 |
| 22 | 97 | Tal Alsoltan | 52.5 |
| 23 | 25 | AlShate'a | 51.0 |
| 24 | 22 | Alshikh Redwan | 49.0 |
| 25 | 96 | Alesraa | 47.0 |
| 26 | 35 | Johor AlDiek | 46.6 |
| 27 | 225 | AlZwaida | 46.3 |
| 28 | 215 | AlNusirat | 45.2 |
| 29 | 105 | Kherbat AlAdas | 42.0 |
| 30 | 224 | AlBurig | 41.1 |
| 31 | 230 | AlMghazi | 41.0 |
| 32 | 48 | Maen | 40.4 |
| 33 | 20 | AlDarag | 37.1 |
| 34 | 41 | Almoasi | 36.3 |
| 35 | 19 | AlSbrah | 29.9 |
| 36 | 216 | Al Zahra'a | 28.6 |
| 37 | 231 | Biet Hanoun | 26.4 |
| 38 | 37 | Qizan Al Najar | 22.5 |
| 39 | 12 | Ejdidah | 20.7 |
| 40 | 17 | Alshikh Egleen | 20.5 |
| 41 | 18 | Tal Alhowa | 19.3 |
| 42 | 227 | Amoghraqa | 13.5 |
| 43 | 24 | Alnser | 7.6 |
| 44 | 53 | KhanYunis Camp | 4.7 |
| | | Total | 48.47 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Cancer Incidence per 100,000**

- 4.7 - 29.9
- 30.0 - 81.2
- 81.3 - 150.5
- 150.6 - 419.1
- 419.2 - 637.9

Governorate

Catchment Area

Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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Datum: Palestine 1923
false easting: 170,251.5550
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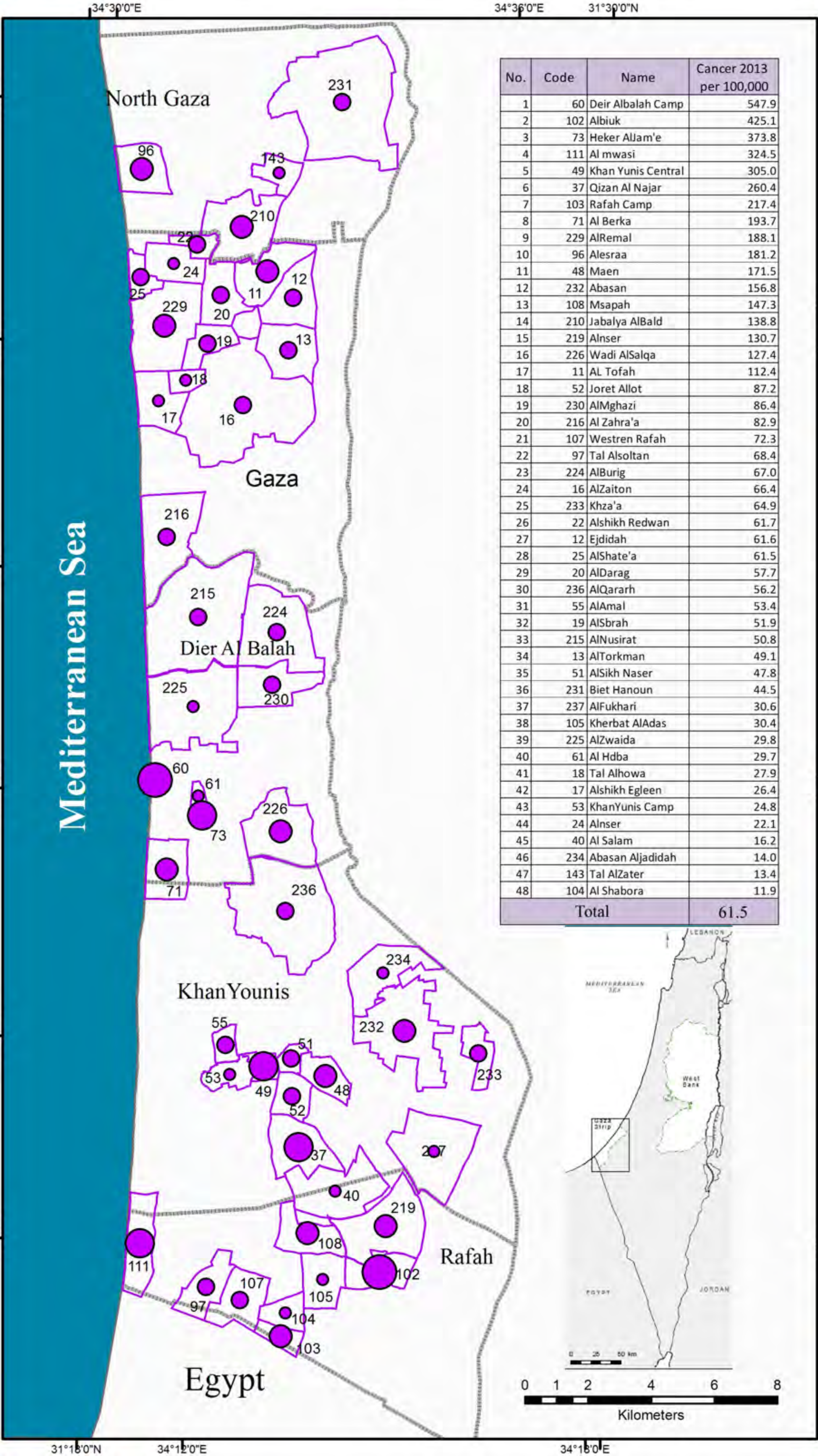
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian
Development Agency

# Cancer Crude incidence rate at Gaza Strip. MOH, 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | Cancer 2013 per 100,000 |
|---|---|---|---|
| 1 | 60 | Deir Albalah Camp | 547.9 |
| 2 | 102 | Albiuk | 425.1 |
| 3 | 73 | Heker AlJam'e | 373.8 |
| 4 | 111 | Al mwasi | 324.5 |
| 5 | 49 | Khan Yunis Central | 305.0 |
| 6 | 37 | Qizan Al Najar | 260.4 |
| 7 | 103 | Rafah Camp | 217.4 |
| 8 | 71 | Al Berka | 193.7 |
| 9 | 229 | AlRemal | 188.1 |
| 10 | 96 | Alesraa | 181.2 |
| 11 | 48 | Maen | 171.5 |
| 12 | 232 | Abasan | 156.8 |
| 13 | 108 | Msapah | 147.3 |
| 14 | 210 | Jabalya AlBald | 138.8 |
| 15 | 219 | Alnser | 130.7 |
| 16 | 226 | Wadi AlSalqa | 127.4 |
| 17 | 11 | AL Tofah | 112.4 |
| 18 | 52 | Joret Allot | 87.2 |
| 19 | 230 | AlMghazi | 86.4 |
| 20 | 216 | Al Zahra'a | 82.9 |
| 21 | 107 | Westren Rafah | 72.3 |
| 22 | 97 | Tal Alsoltan | 68.4 |
| 23 | 224 | AlBurig | 67.0 |
| 24 | 16 | AlZaiton | 66.4 |
| 25 | 233 | Khza'a | 64.9 |
| 26 | 22 | Alshikh Redwan | 61.7 |
| 27 | 12 | Ejdidah | 61.6 |
| 28 | 25 | AlShate'a | 61.5 |
| 29 | 20 | AlDarag | 57.7 |
| 30 | 236 | AlQararh | 56.2 |
| 31 | 55 | AlAmal | 53.4 |
| 32 | 19 | AlSbrah | 51.9 |
| 33 | 215 | AlNusirat | 50.8 |
| 34 | 13 | AlTorkman | 49.1 |
| 35 | 51 | AlSikh Naser | 47.8 |
| 36 | 231 | Biet Hanoun | 44.5 |
| 37 | 237 | AlFukhari | 30.6 |
| 38 | 105 | Kherbat AlAdas | 30.4 |
| 39 | 225 | AlZwaida | 29.8 |
| 40 | 61 | Al Hdba | 29.7 |
| 41 | 18 | Tal Alhowa | 27.9 |
| 42 | 17 | Alshikh Egleen | 26.4 |
| 43 | 53 | KhanYunis Camp | 24.8 |
| 44 | 24 | Alnser | 22.1 |
| 45 | 40 | Al Salam | 16.2 |
| 46 | 234 | Abasan Aljadidah | 14.0 |
| 47 | 143 | Tal AlZater | 13.4 |
| 48 | 104 | Al Shabora | 11.9 |
| | | Total | 61.5 |

## Legend

**Cancer Incidence per 100,000**

- 11.9 - 30.6
- 30.7 - 87.2
- 87.3 - 217.4
- 217.5 - 373.8
- 373.9 - 547.9
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
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**Date: 4/22/2015**

**Funded by:**
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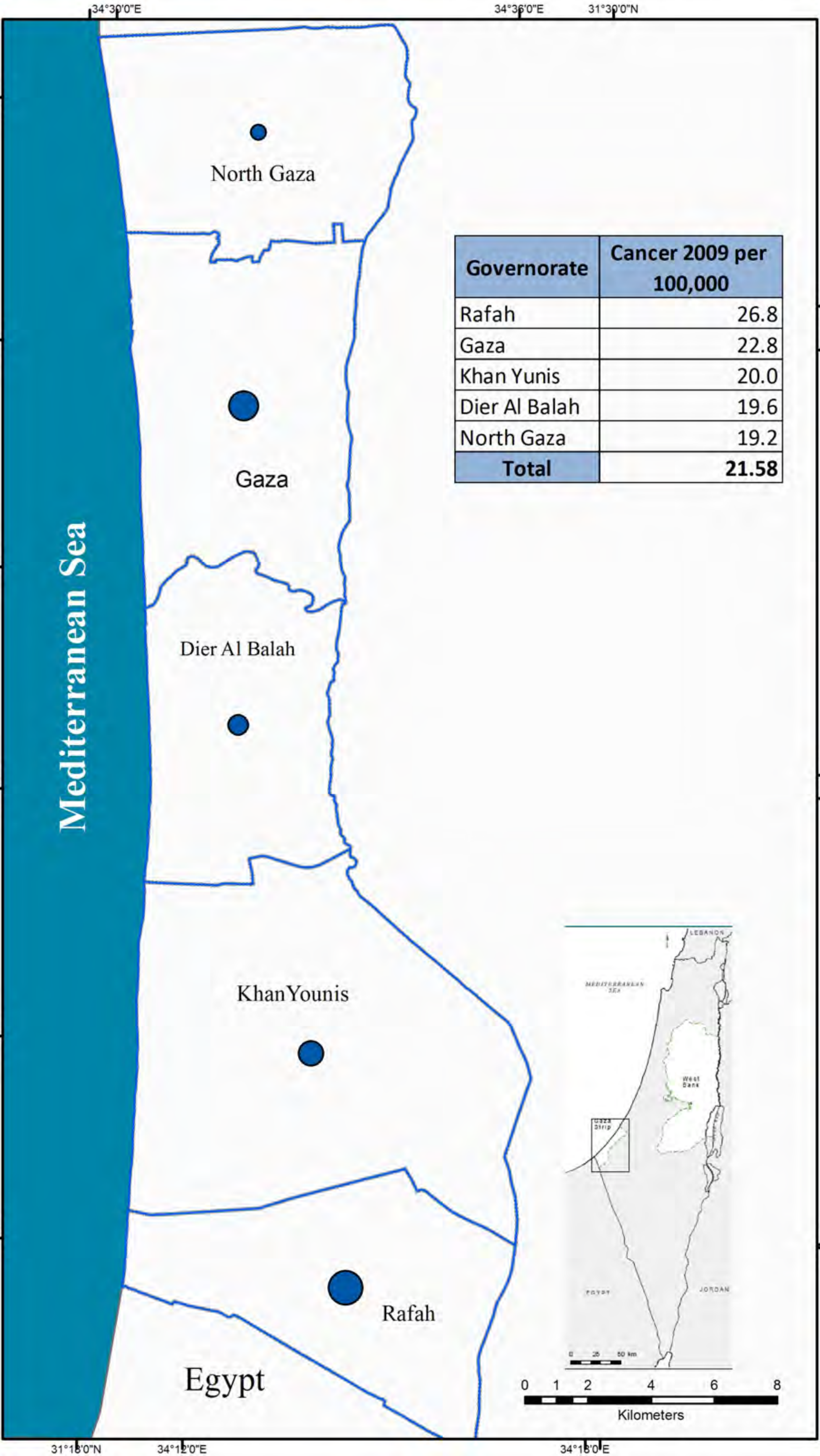
# Cancer Crude incidence rate at Gaza Strip. MOH, 2009

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | Cancer 2009 per 100,000 |
|---|---|
| Rafah | 26.8 |
| Gaza | 22.8 |
| Khan Yunis | 20.0 |
| Dier Al Balah | 19.6 |
| North Gaza | 19.2 |
| **Total** | **21.58** |

## Legend

**Cancer**

**Incidence per 100,000**

- 1 - 19.2
- 19.3 - 19.6
- 19.7 - 20.0
- 20.1 - 22.8
- 22.9 - 26.8
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009 - 2013

Coordinate System:
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Projection: Cassini
Datum: Palestine 1923
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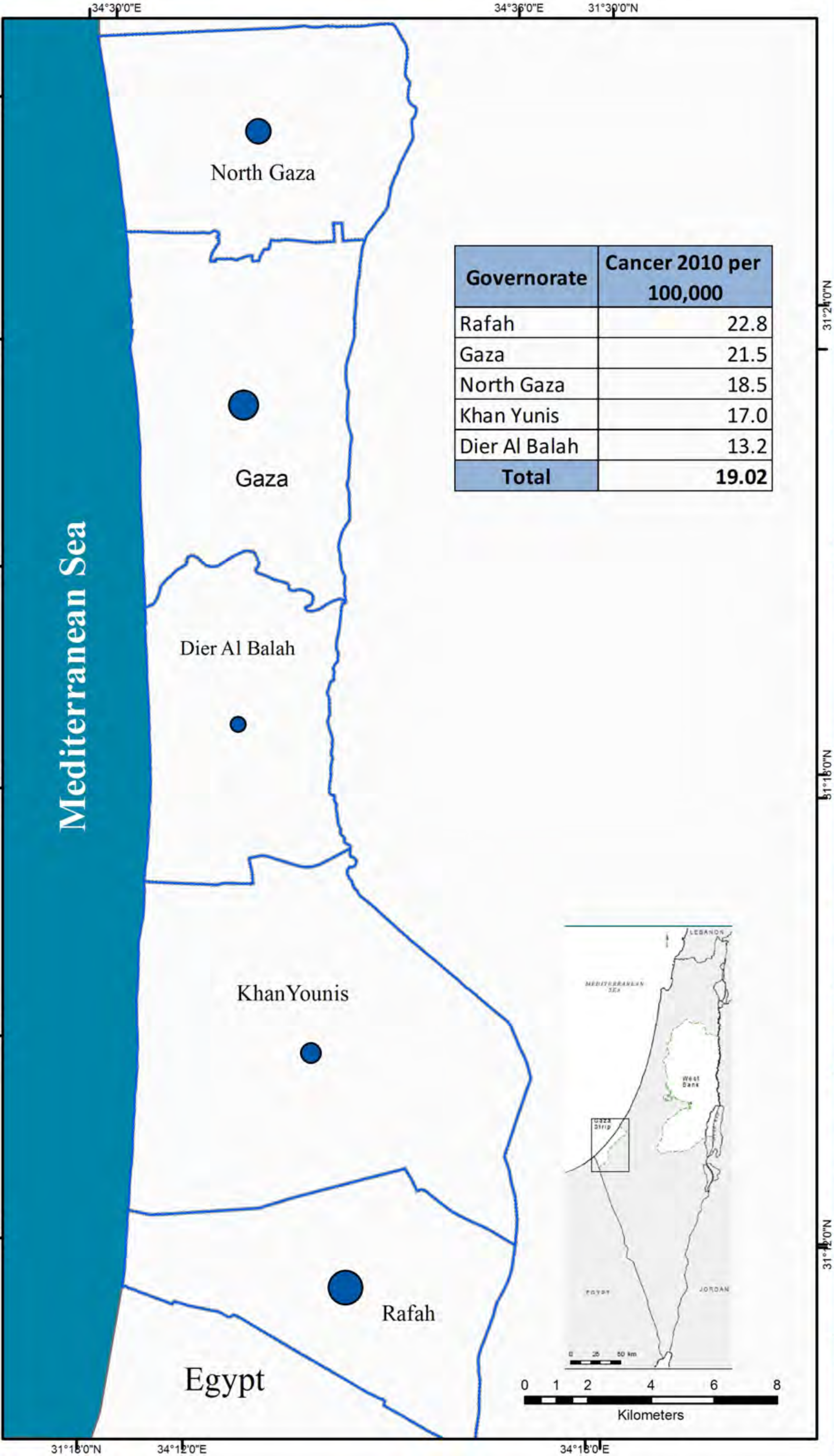
Units: Meter

**Date: 4/23/2015**

**Funded by:**
Austrian
Development Agency

# Cancer Crude incidence rate at Gaza Strip. MOH, 2010

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | Cancer 2010 per 100,000 |
|---|---|
| Rafah | 22.8 |
| Gaza | 21.5 |
| North Gaza | 18.5 |
| Khan Yunis | 17.0 |
| Dier Al Balah | 13.2 |
| **Total** | **19.02** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Cancer**

**Incidence per 100,000**

- 1 -13.2
- 13.3 - 17.0
- 17.1 - 18.5
- 18.6 - 21.5
- 21.6 - 22.8
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009 - 2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/23/2015**

**Funded by:**
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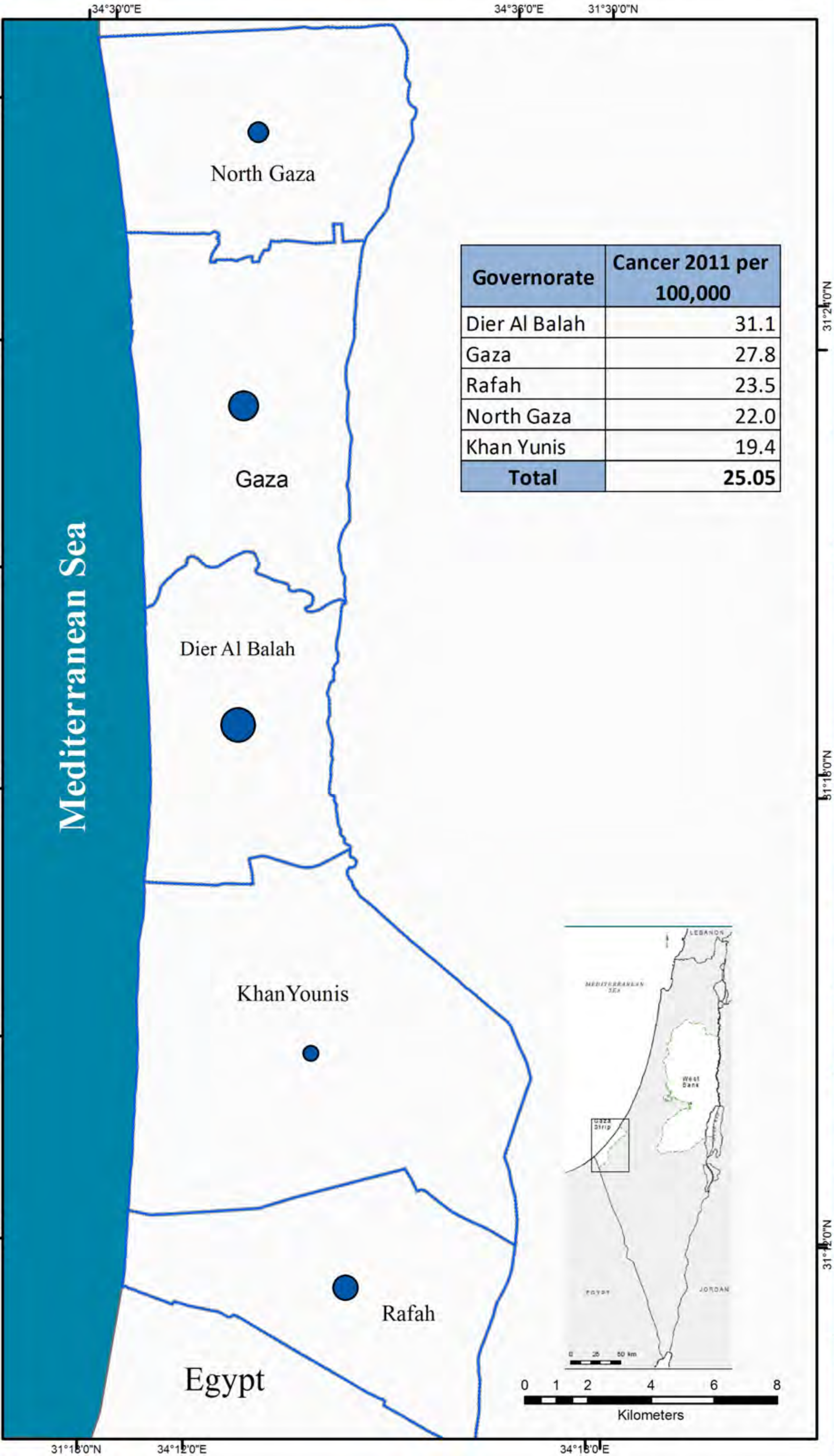
# Cancer Crude incidence rate at Gaza Strip. MOH, 2011

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | Cancer 2011 per 100,000 |
|---|---|
| Dier Al Balah | 31.1 |
| Gaza | 27.8 |
| Rafah | 23.5 |
| North Gaza | 22.0 |
| Khan Yunis | 19.4 |
| **Total** | **25.05** |

**Legend**

**Cancer**

**Incidence per 100,000**

- 1- 19.4
- 19.5 - 22.0
- 22.1 - 23.5
- 23.6 - 27.8
- 27.9 - 31.1
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009 - 2013

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## Cancer Crude incidence rate at Gaza Strip. MOH, 2012

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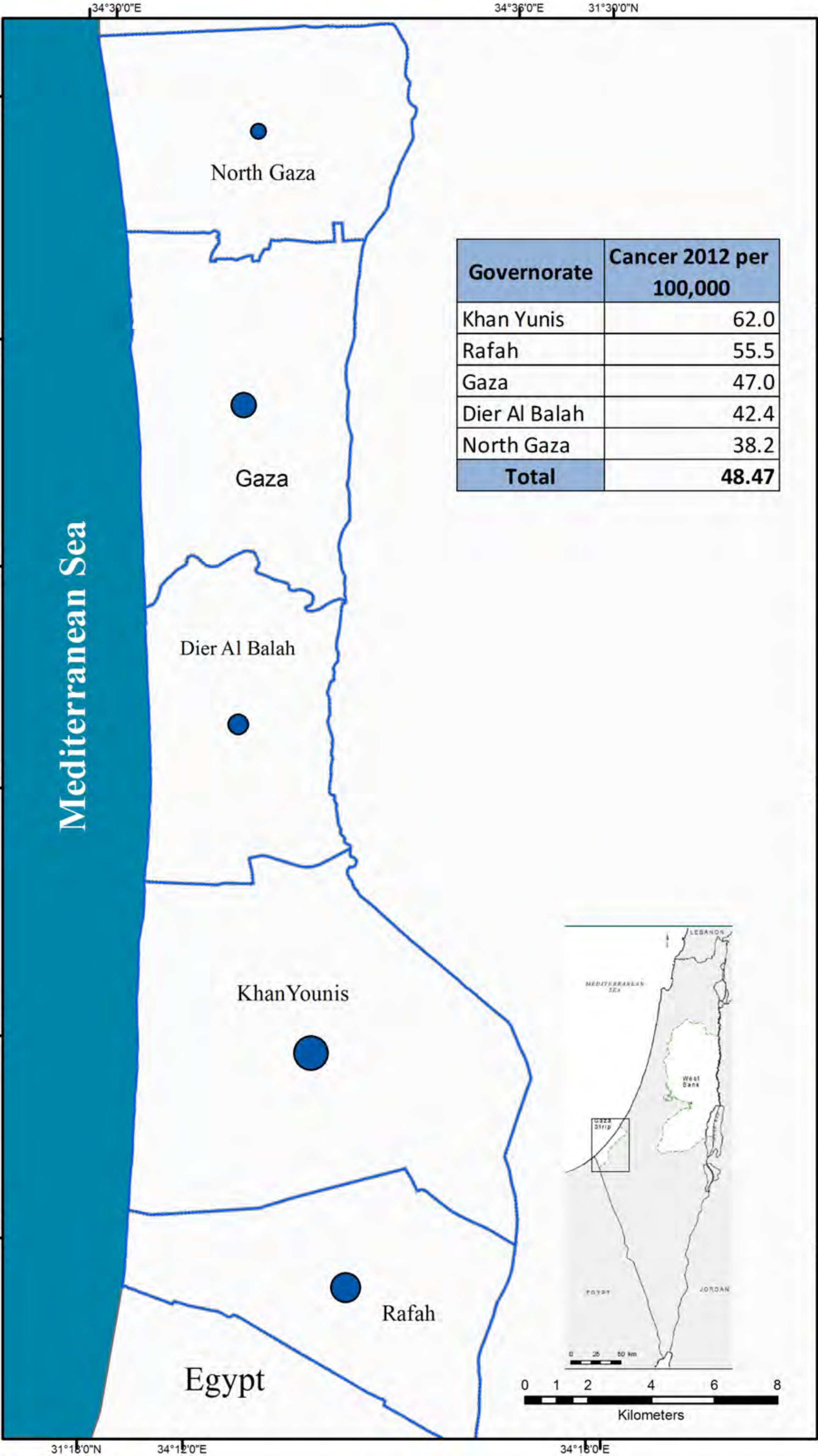


| Governorate | Cancer 2012 per 100,000 |
|---|---|
| Khan Yunis | 62.0 |
| Rafah | 55.5 |
| Gaza | 47.0 |
| Dier Al Balah | 42.4 |
| North Gaza | 38.2 |
| **Total** | **48.47** |

# Legend

**Cancer**

**Incidence per 100,000**

- 1 - 38.2
- 38.3 - 42.4
- 42.5 - 47.0
- 47.1 - 55.5
- 55.6 - 62.0
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009 - 2013

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# Cancer Crude incidence rate at Gaza Strip. MOH, 2013

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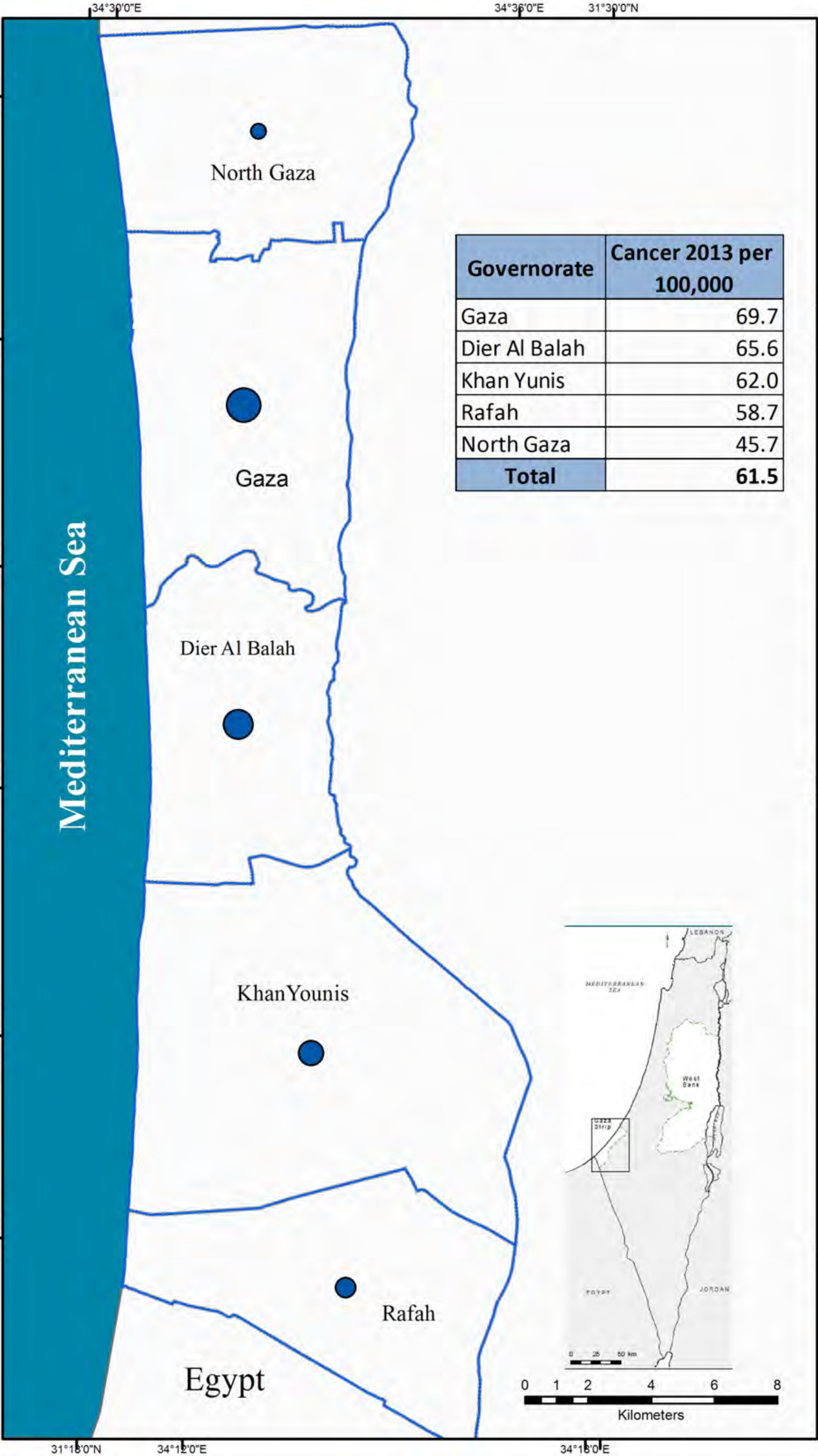


| Governorate | Cancer 2013 per 100,000 |
|---|---|
| Gaza | 69.7 |
| Dier Al Balah | 65.6 |
| Khan Yunis | 62.0 |
| Rafah | 58.7 |
| North Gaza | 45.7 |
| **Total** | **61.5** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

## Legend

**Cancer**

**Incidence per 100,000**

- 1 - 45.7
- 45.8 - 58.7
- 58.8 - 62.0
- 62.1 - 65.6
- 65.7 - 69.7
- Governorate
- Sea

Source:
Palestinian Ministry of Health
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**Date: 4/23/2015**


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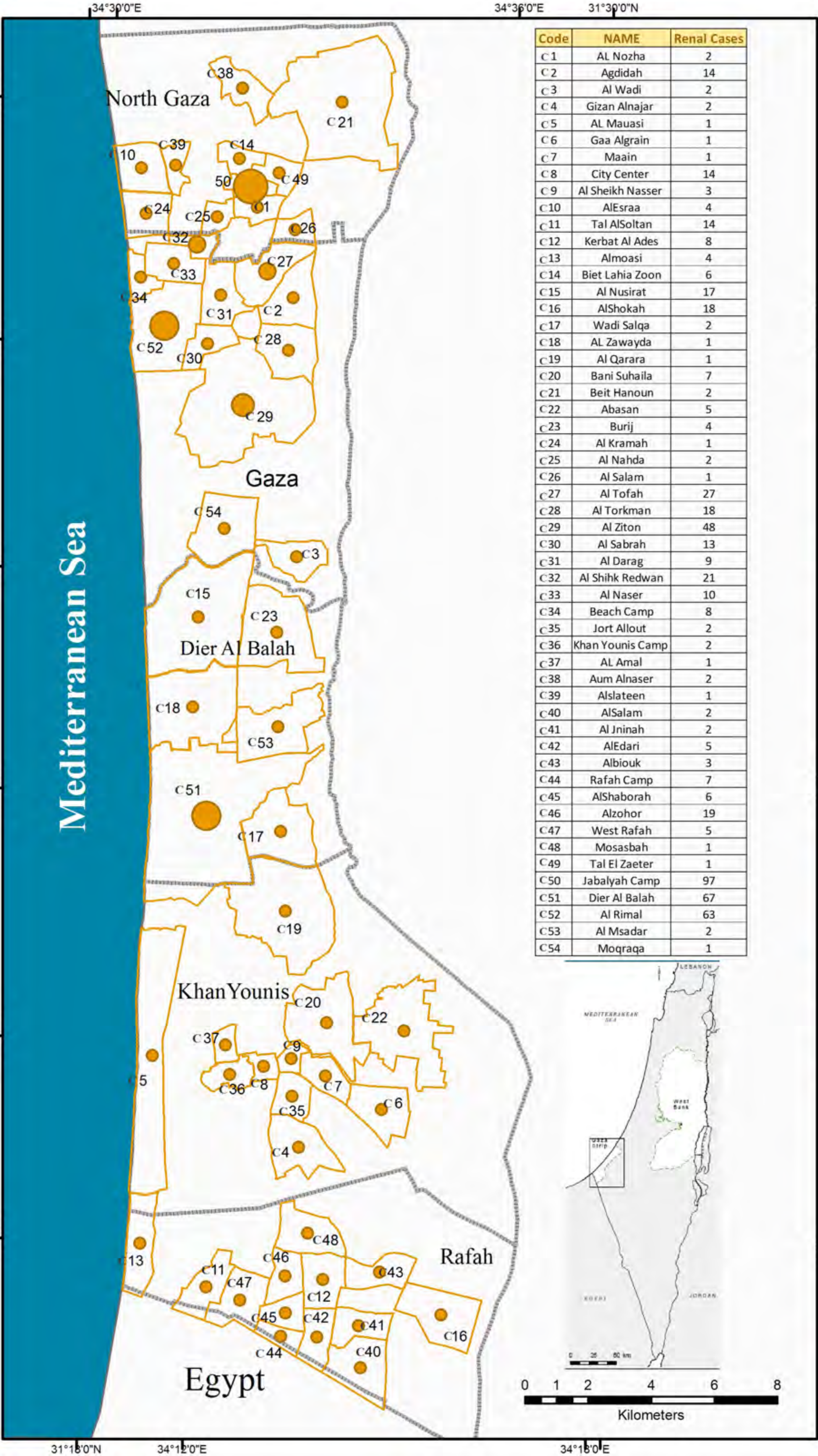
# Distribution of Renal Failure at Gaza Strip. MOH - 2013

Baseline Study on Water Quality and Public Health - April, 2015




| Code | NAME | Renal Cases |
|---|---|---|
| C1 | AL Nozha | 2 |
| C2 | Agdidah | 14 |
| C3 | Al Wadi | 2 |
| C4 | Gizan Alnajar | 2 |
| C5 | AL Mauasi | 1 |
| C6 | Gaa Algrain | 1 |
| C7 | Maain | 1 |
| C8 | City Center | 14 |
| C9 | Al Sheikh Nasser | 3 |
| C10 | AlEsraa | 4 |
| C11 | Tal AlSoltan | 14 |
| C12 | Kerbat Al Ades | 8 |
| C13 | Almoasi | 4 |
| C14 | Biet Lahia Zoon | 6 |
| C15 | Al Nusirat | 17 |
| C16 | AlShokah | 18 |
| C17 | Wadi Salqa | 2 |
| C18 | AL Zawayda | 1 |
| C19 | Al Qarara | 1 |
| C20 | Bani Suhaila | 7 |
| C21 | Beit Hanoun | 2 |
| C22 | Abasan | 5 |
| C23 | Burij | 4 |
| C24 | Al Kramah | 1 |
| C25 | Al Nahda | 2 |
| C26 | Al Salam | 1 |
| C27 | Al Tofah | 27 |
| C28 | Al Torkman | 18 |
| C29 | Al Ziton | 48 |
| C30 | Al Sabrah | 13 |
| C31 | Al Darag | 9 |
| C32 | Al Shihk Redwan | 21 |
| C33 | Al Naser | 10 |
| C34 | Beach Camp | 8 |
| C35 | Jort Allout | 2 |
| C36 | Khan Younis Camp | 2 |
| C37 | AL Amal | 1 |
| C38 | Aum Alnaser | 2 |
| C39 | Alslateen | 1 |
| C40 | AlSalam | 2 |
| C41 | Al Jninah | 2 |
| C42 | AlEdari | 5 |
| C43 | Albiouk | 3 |
| C44 | Rafah Camp | 7 |
| C45 | AlShaborah | 6 |
| C46 | Alzohor | 19 |
| C47 | West Rafah | 5 |
| C48 | Mosasbah | 1 |
| C49 | Tal El Zaeter | 1 |
| C50 | Jabalyah Camp | 97 |
| C51 | Dier Al Balah | 67 |
| C52 | Al Rimal | 63 |
| C53 | Al Msadar | 2 |
| C54 | Moqraqa | 1 |

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## Legend

**Renal failure cases**

- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- Neighborhood
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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Units: Meter

**Date: 4/22/2015**

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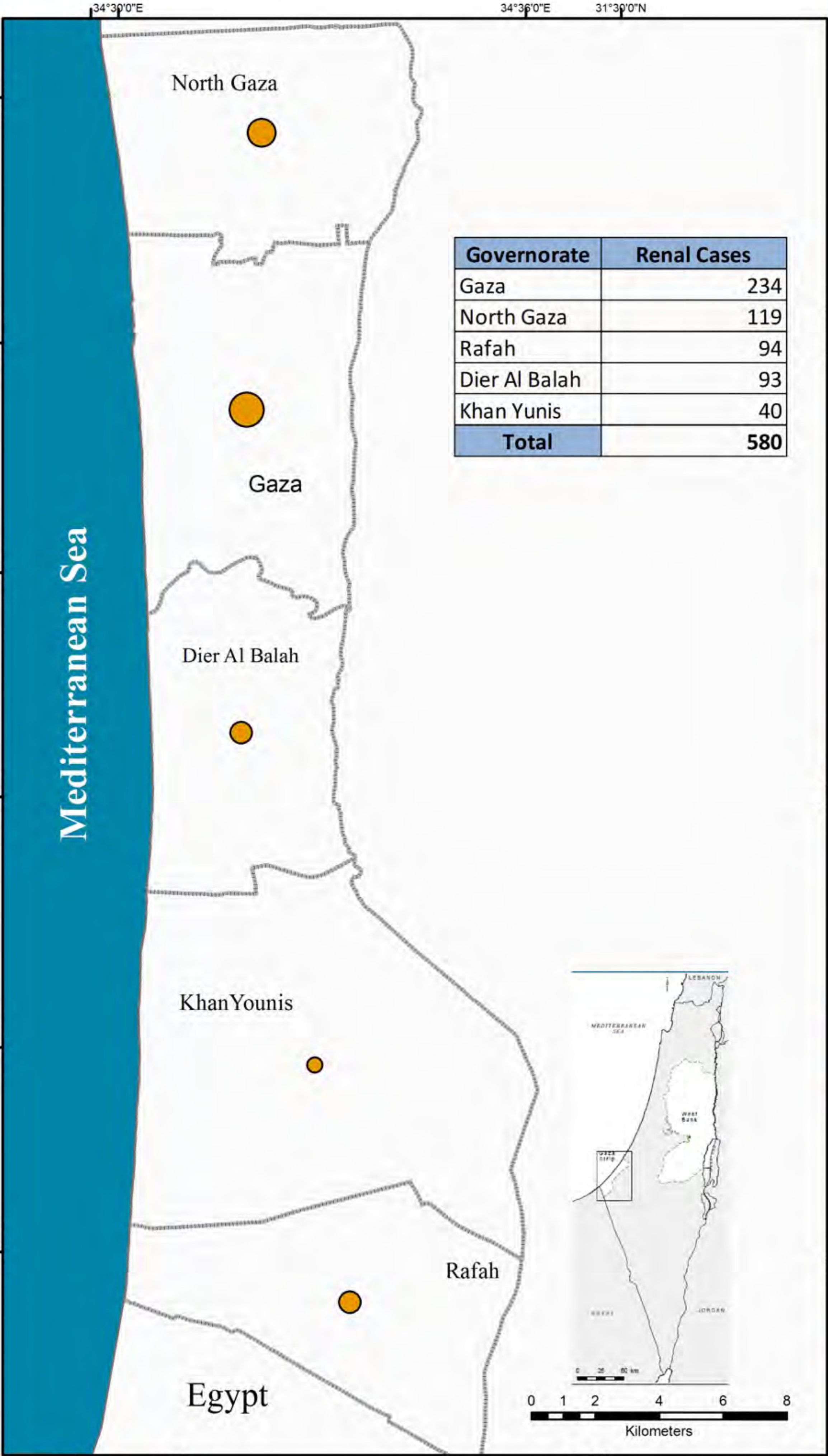
# Distribution of Renal Failure at Gaza Strip. MOH - 2013

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | Renal Cases |
|---|---|
| Gaza | 234 |
| North Gaza | 119 |
| Rafah | 94 |
| Dier Al Balah | 93 |
| Khan Yunis | 40 |
| **Total** | **580** |

سلطة المياه الفلسطينية
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## Legend

**Renal failure cases**

- 1 - 40
- 41 - 100
- 101 - 120
- 121 - 240
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2013

Coordinate System:
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Units: Meter

**Date: 4/23/2015**

**Funded by:**
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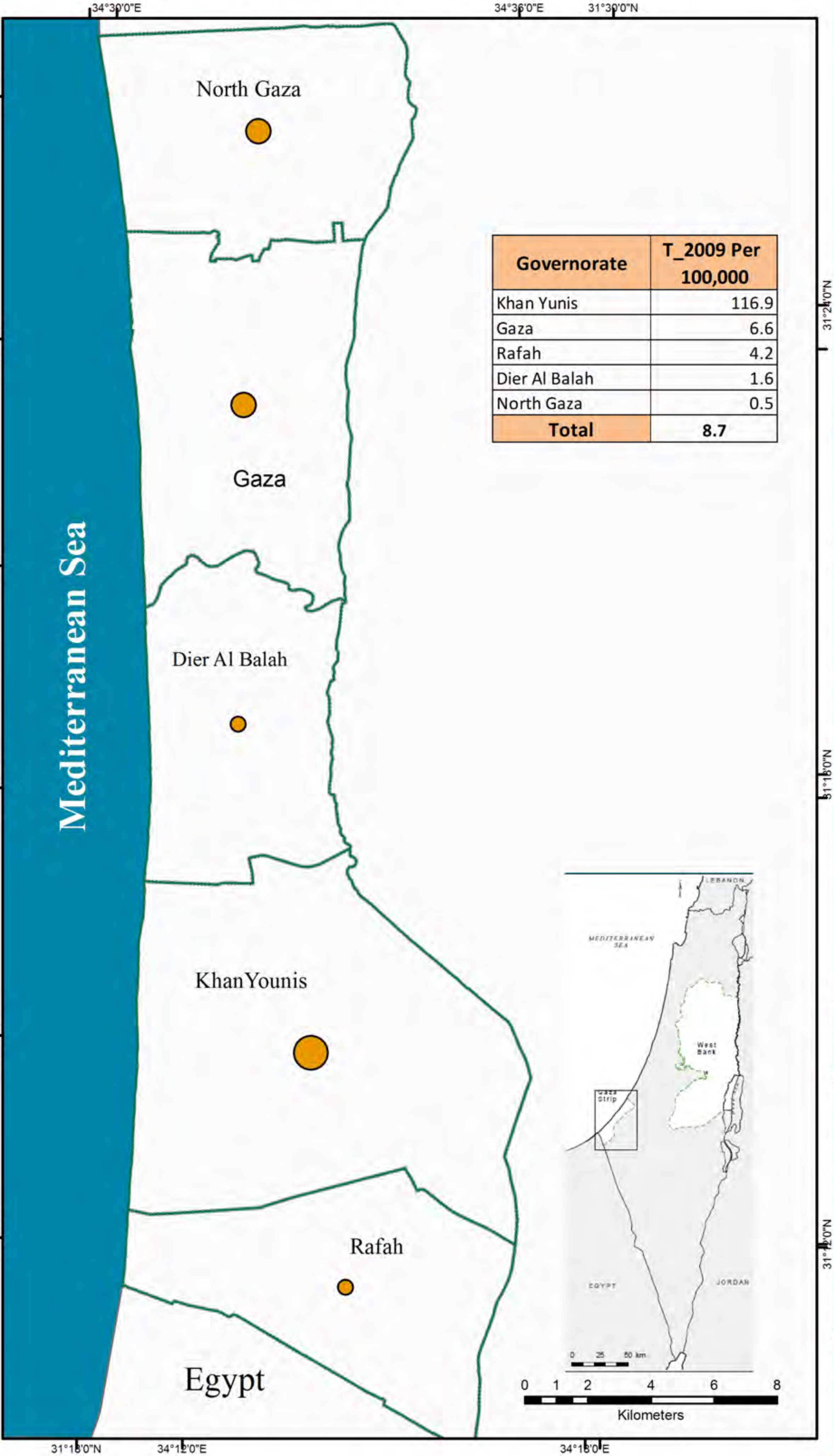
# Overall Typhoid incidence rate in Gaza Strip
# (All providers -2009)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | T_2009 Per 100,000 |
|---|---|
| Khan Yunis | 116.9 |
| Gaza | 6.6 |
| Rafah | 4.2 |
| Dier Al Balah | 1.6 |
| North Gaza | 0.5 |
| **Total** | **8.7** |

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PALESTINIAN WATER AUTHORITY

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## Legend

**Typhoid**

**Incidence per 100,000**

0.5 - 1.6

1.7 - 6.6

6.7 - 116.9

Governorate

Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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**Date: 4/22/2015**


**Funded by:**

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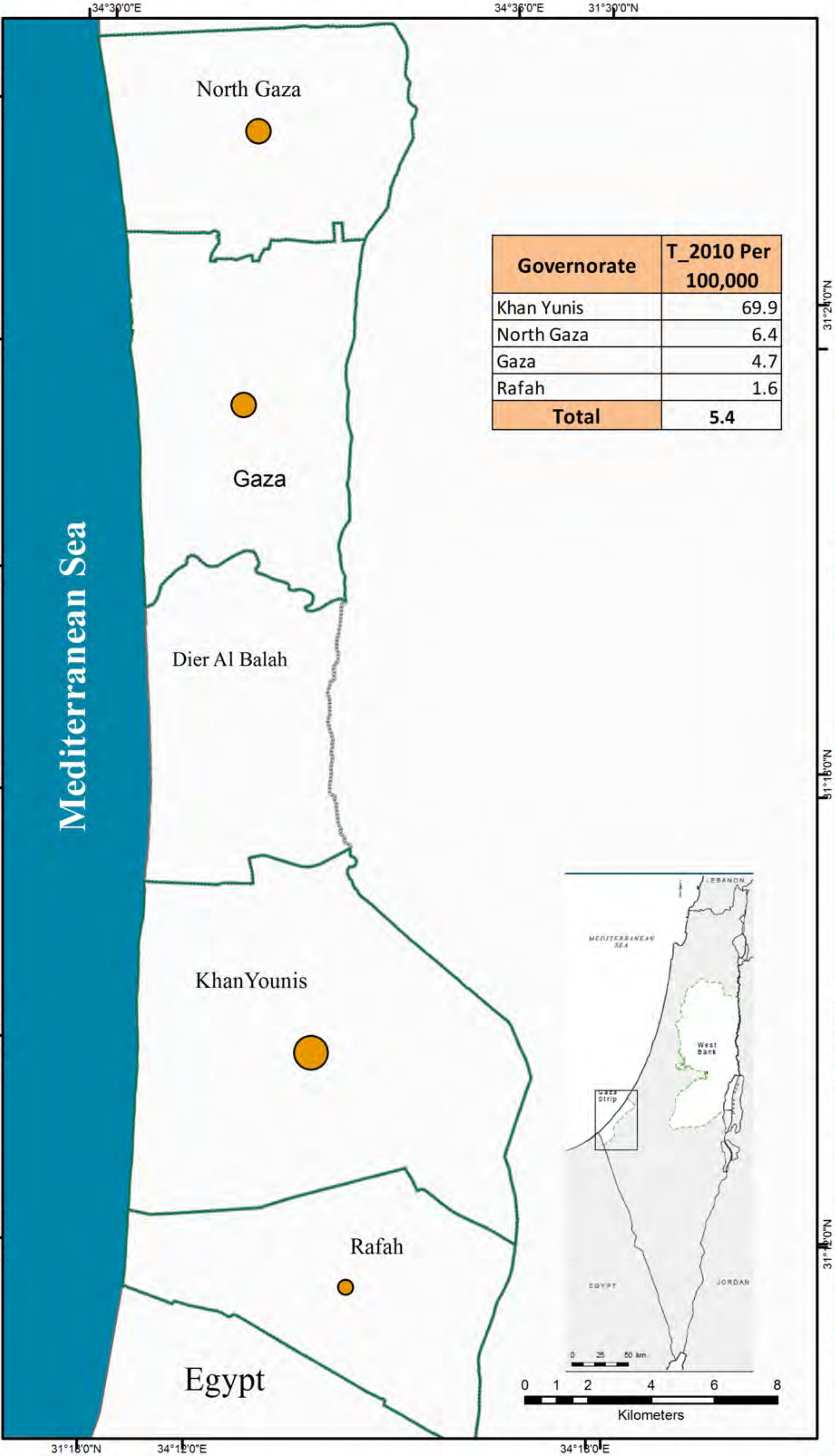
# Overall Typhoid incidence rate in Gaza Strip (All providers -2010)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | T_2010 Per 100,000 |
|---|---|
| Khan Yunis | 69.9 |
| North Gaza | 6.4 |
| Gaza | 4.7 |
| Rafah | 1.6 |
| **Total** | **5.4** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Typhoid**
**Incidence per 100,000**

- 1.6 - 3.0
- 3.1 - 6.4
- 6.5 - 69.9
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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**Date: 4/22/2015**


**Funded by:**
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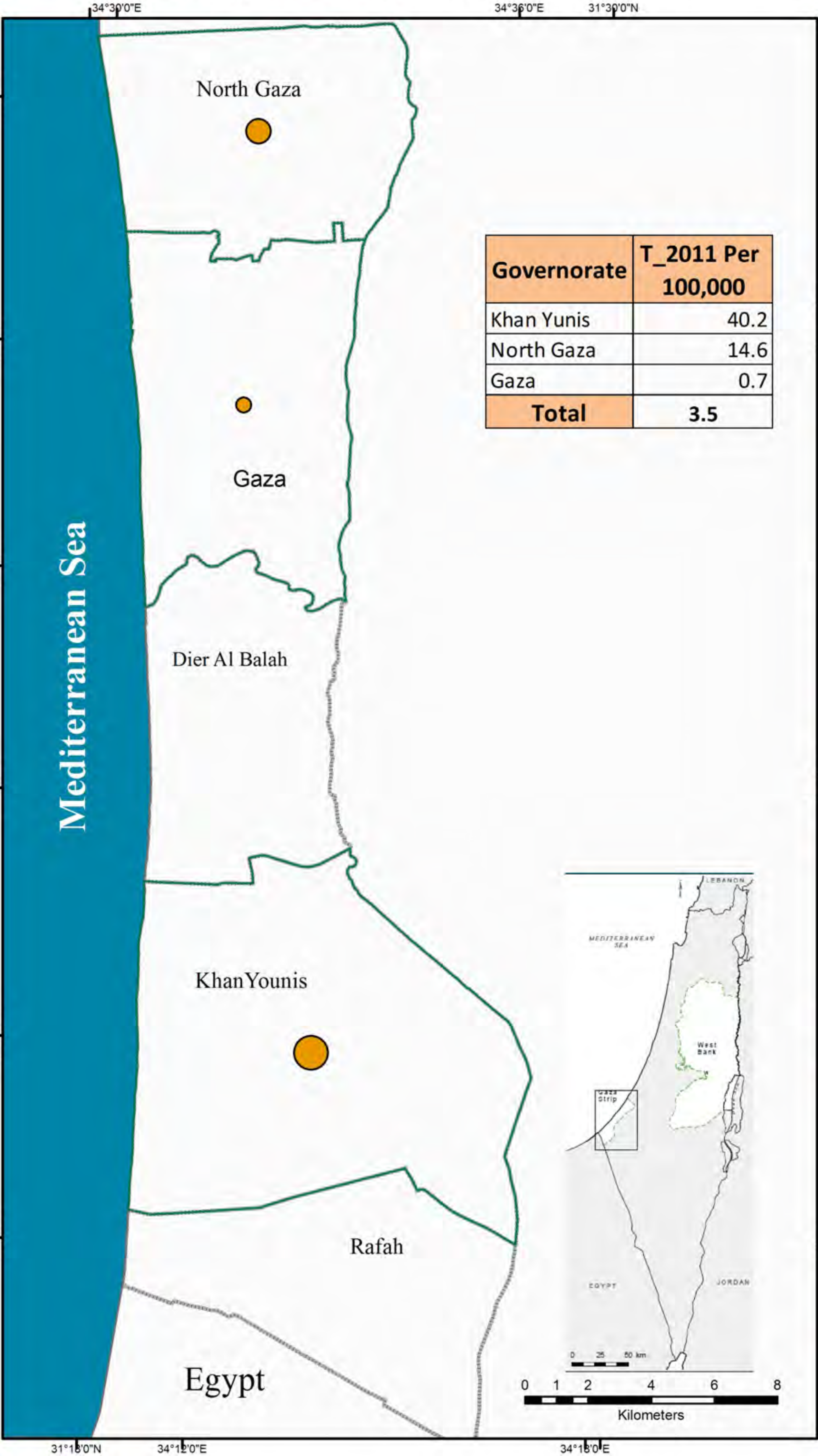
# Overall Typhoid incidence rate in Gaza Strip (All providers -2011)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | T_2011 Per 100,000 |
|---|---|
| Khan Yunis | 40.2 |
| North Gaza | 14.6 |
| Gaza | 0.7 |
| **Total** | **3.5** |

سلطة المياه الفلسطينية

PALESTINIAN WATER AUTHORITY

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## Legend

**Typhoid**

**Incidence per 100,000**

- 0.7 - 7.0
- 7.1 - 14.6
- 14.7 - 40.2
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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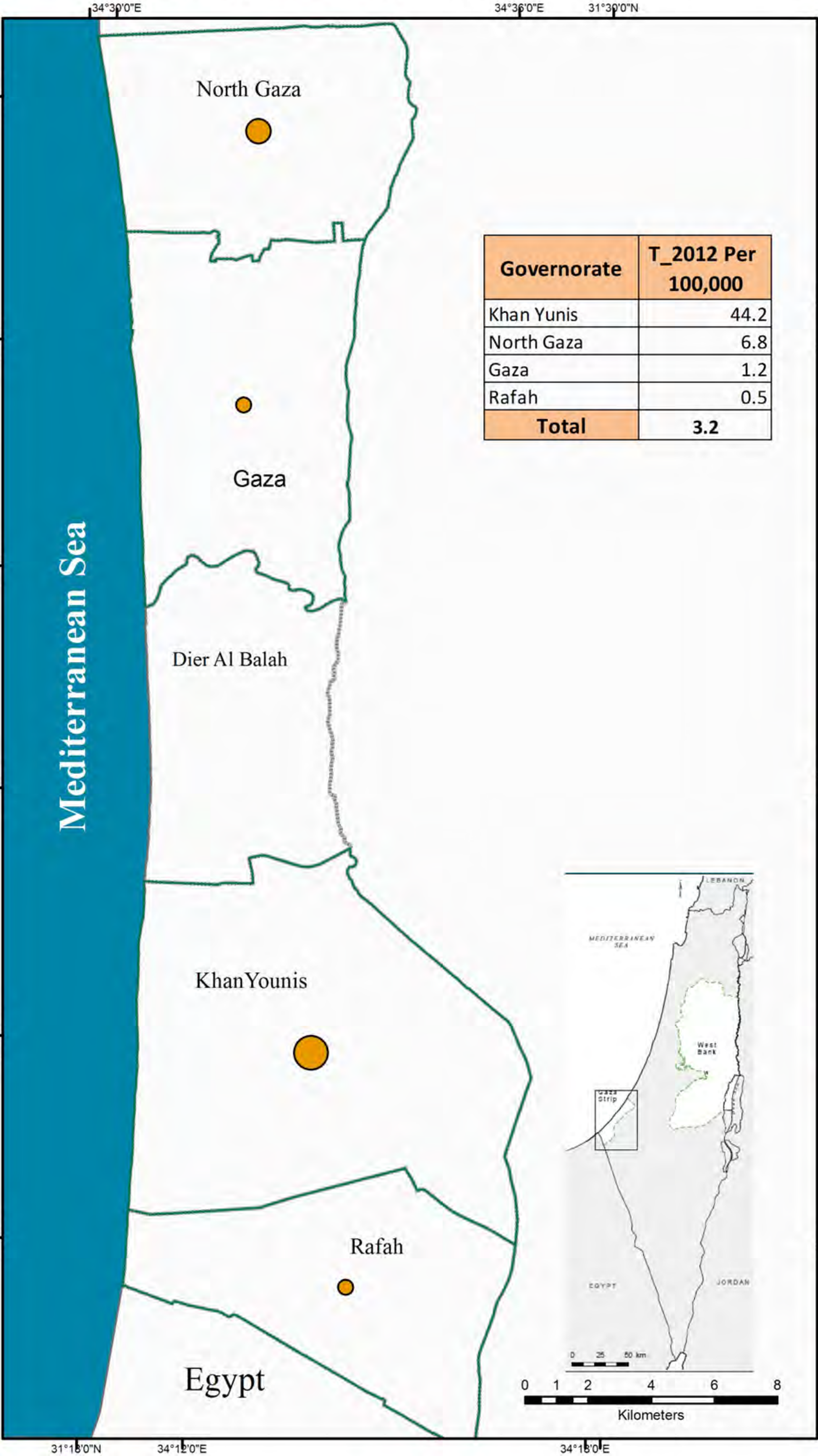
**Date: 4/22/2015**


**Funded by:**

Austrian Development Agency

# Overall Typhoid incidence rate in Gaza Strip (All providers -2012)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | T_2012 Per 100,000 |
|---|---|
| Khan Yunis | 44.2 |
| North Gaza | 6.8 |
| Gaza | 1.2 |
| Rafah | 0.5 |
| **Total** | **3.2** |

PALESTINIAN WATER AUTHORITY

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## Legend

**Typhoid Incidence per 100,000**

- 0.5 - 1.2
- 1.3 - 6.8
- 6.9 - 44.2
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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Units: Meter

**Date: 4/22/2015**

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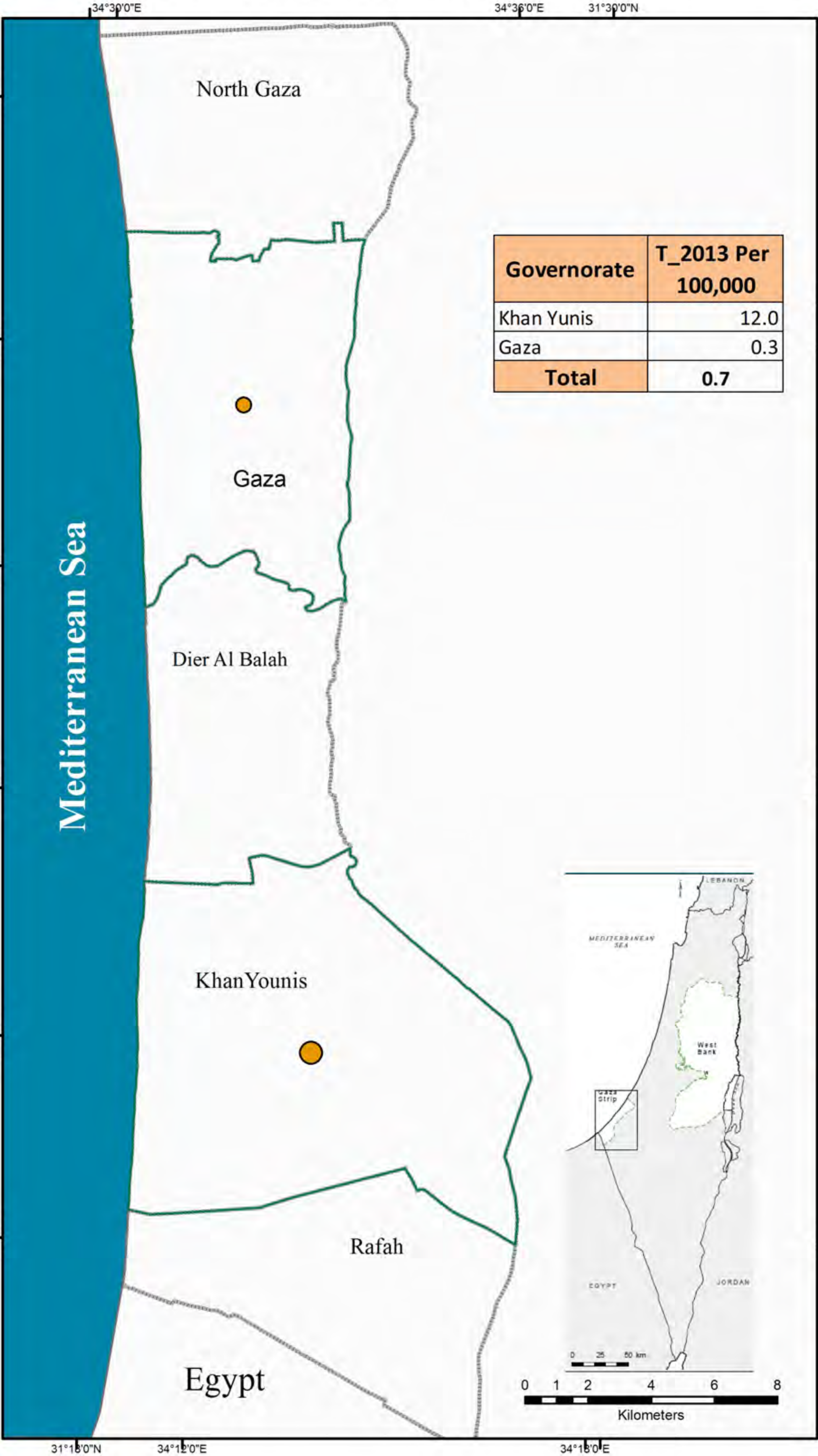
# Overall Typhoid incidence rate in Gaza Strip (All providers -2013)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | T_2013 Per 100,000 |
|---|---|
| Khan Yunis | 12.0 |
| Gaza | 0.3 |
| **Total** | **0.7** |

## Legend

**Typhoid**

**Incidence per 100,000**

- 0.3 - 5.0
- 5.1 - 12.0
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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Palestine 1923 Palestine Grid
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**Date: 4/22/2015**


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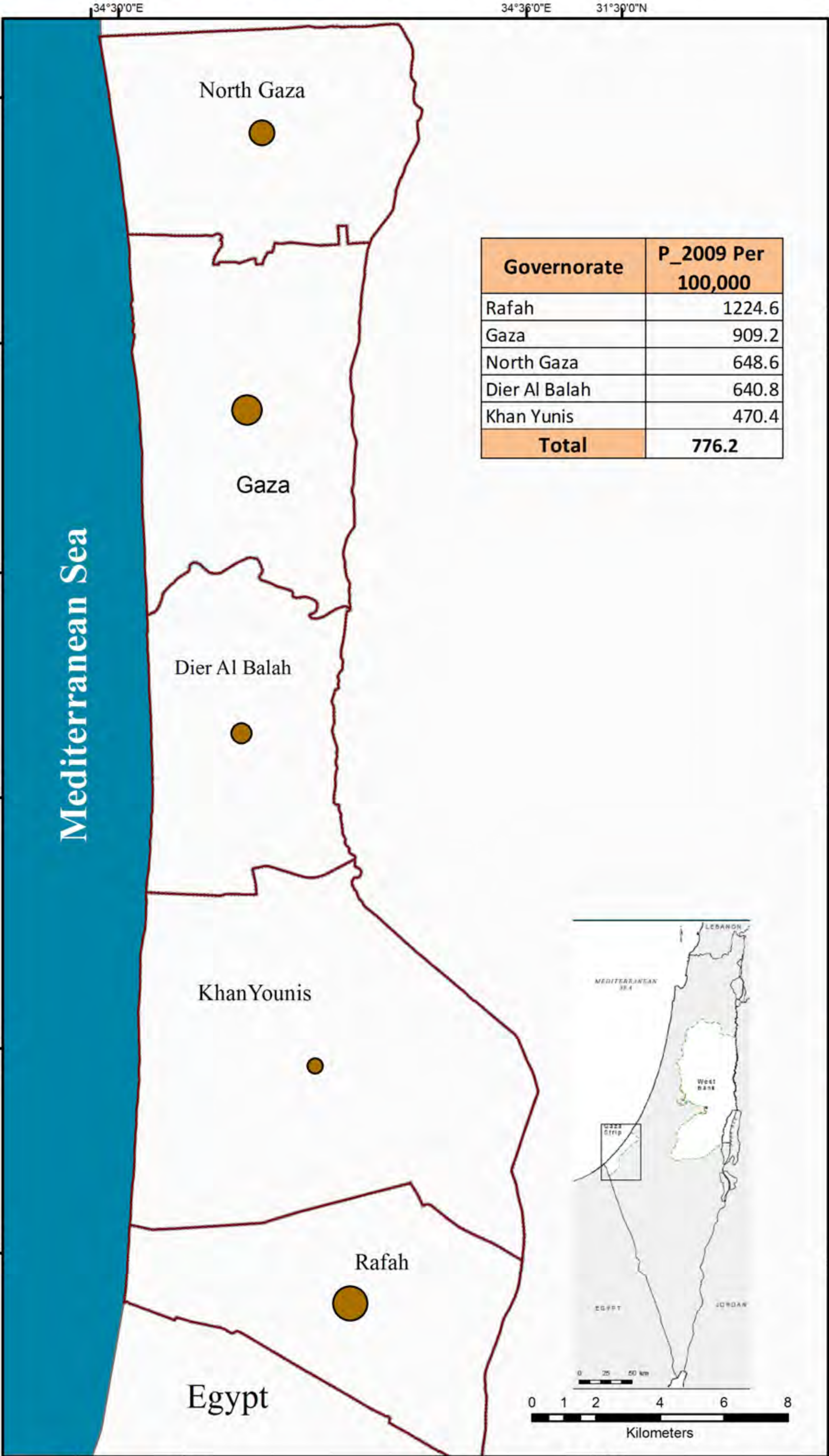
# Overall Parasitic infestations incidence rate in Gaza Strip (All providers -2009)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | P_2009 Per 100,000 |
|---|---|
| Rafah | 1224.6 |
| Gaza | 909.2 |
| North Gaza | 648.6 |
| Dier Al Balah | 640.8 |
| Khan Yunis | 470.4 |
| **Total** | **776.2** |

PALESTINIAN WATER AUTHORITY

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## Legend

**Parasites Incidence per 100,000**

- 470.4 - 550.0
- 550.1 - 640.8
- 640.9 - 648.6
- 648.7 - 909.2
- 909.3 - 1224.6
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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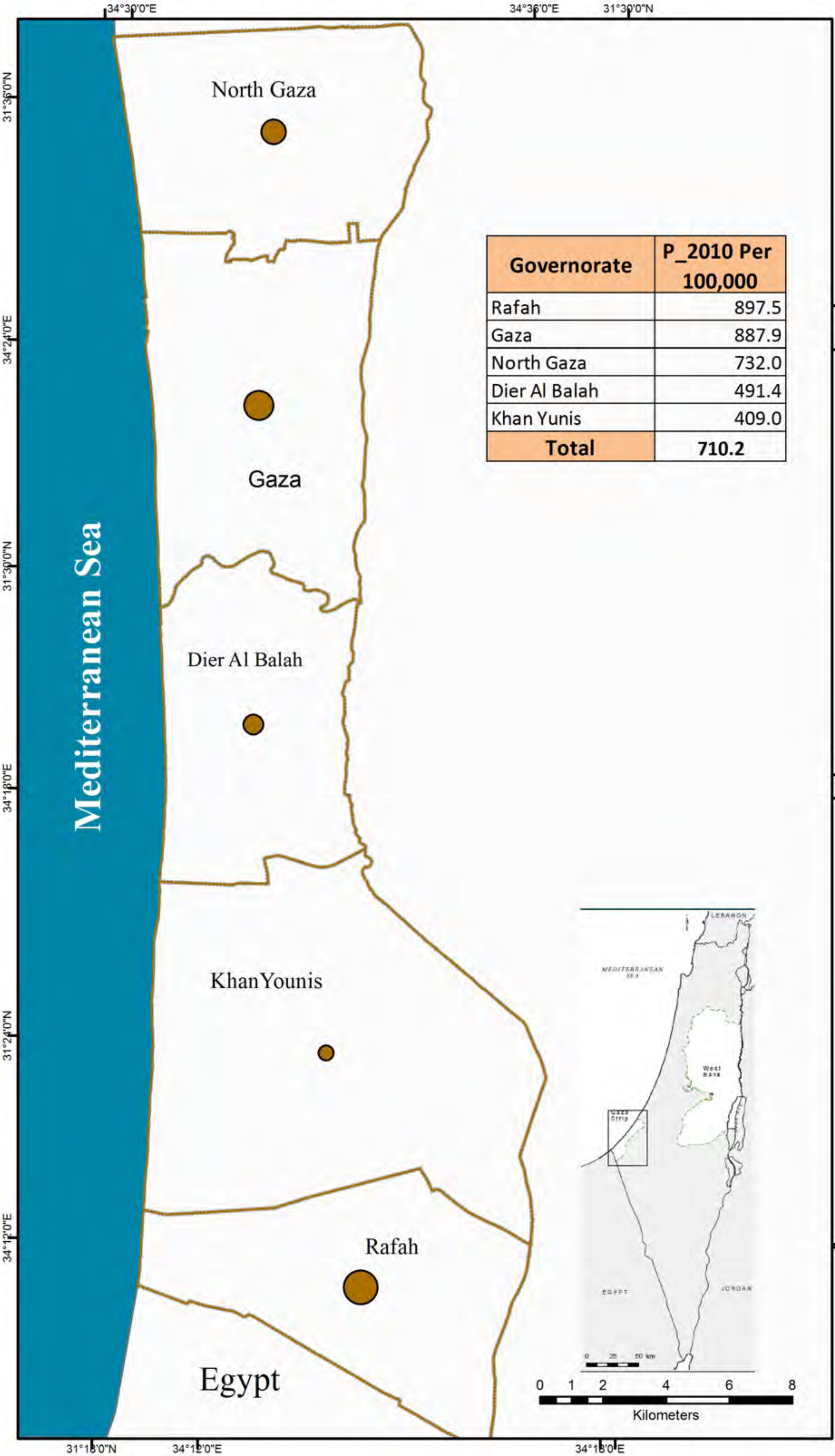
# Overall Parasitic infestations incidence rate in Gaza Strip (All providers -2010)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | P_2010 Per 100,000 |
|---|---|
| Rafah | 897.5 |
| Gaza | 887.9 |
| North Gaza | 732.0 |
| Dier Al Balah | 491.4 |
| Khan Yunis | 409.0 |
| **Total** | **710.2** |

## Legend

**Parasites Incidence per 100,000**

- 409.0 - 430.0
- 430.1 - 491.4
- 491.5 - 732.0
- 732.1 - 887.9
- 888.0 - 897.5
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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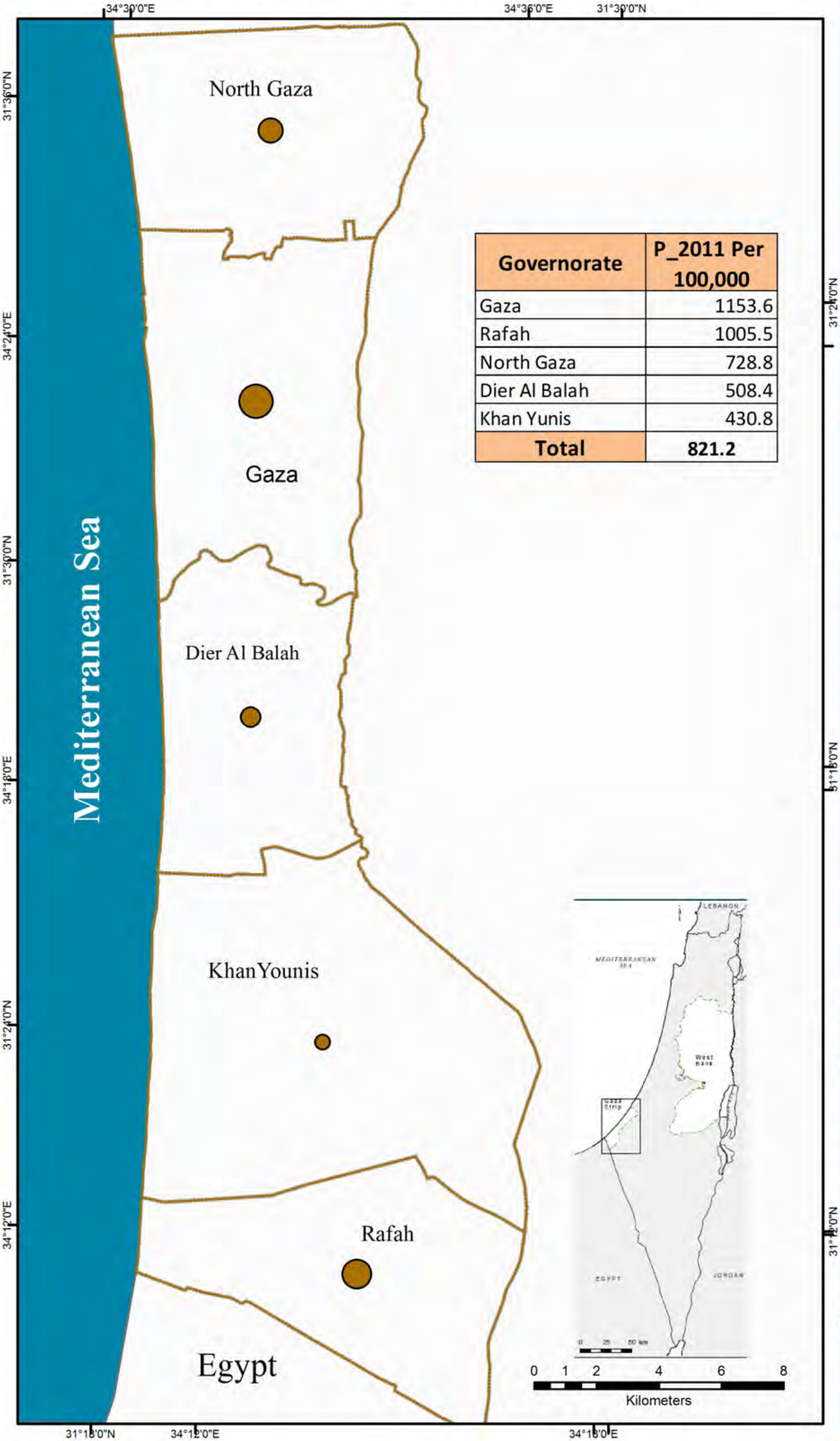
# Overall Parasitic infestations incidence rate in Gaza Strip (All providers -2011)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | P_2011 Per 100,000 |
|---|---|
| Gaza | 1153.6 |
| Rafah | 1005.5 |
| North Gaza | 728.8 |
| Dier Al Balah | 508.4 |
| Khan Yunis | 430.8 |
| **Total** | **821.2** |

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PALESTINIAN WATER AUTHORITY

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# Legend

**Parasites**

**Incidence per 100,000**

- 430.8 - 470.0
- 470.1 - 508.4
- 508.5 - 728.8
- 728.9 - 1005.5
- 1005.6 - 1153.6
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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**Date: 4/22/2015**

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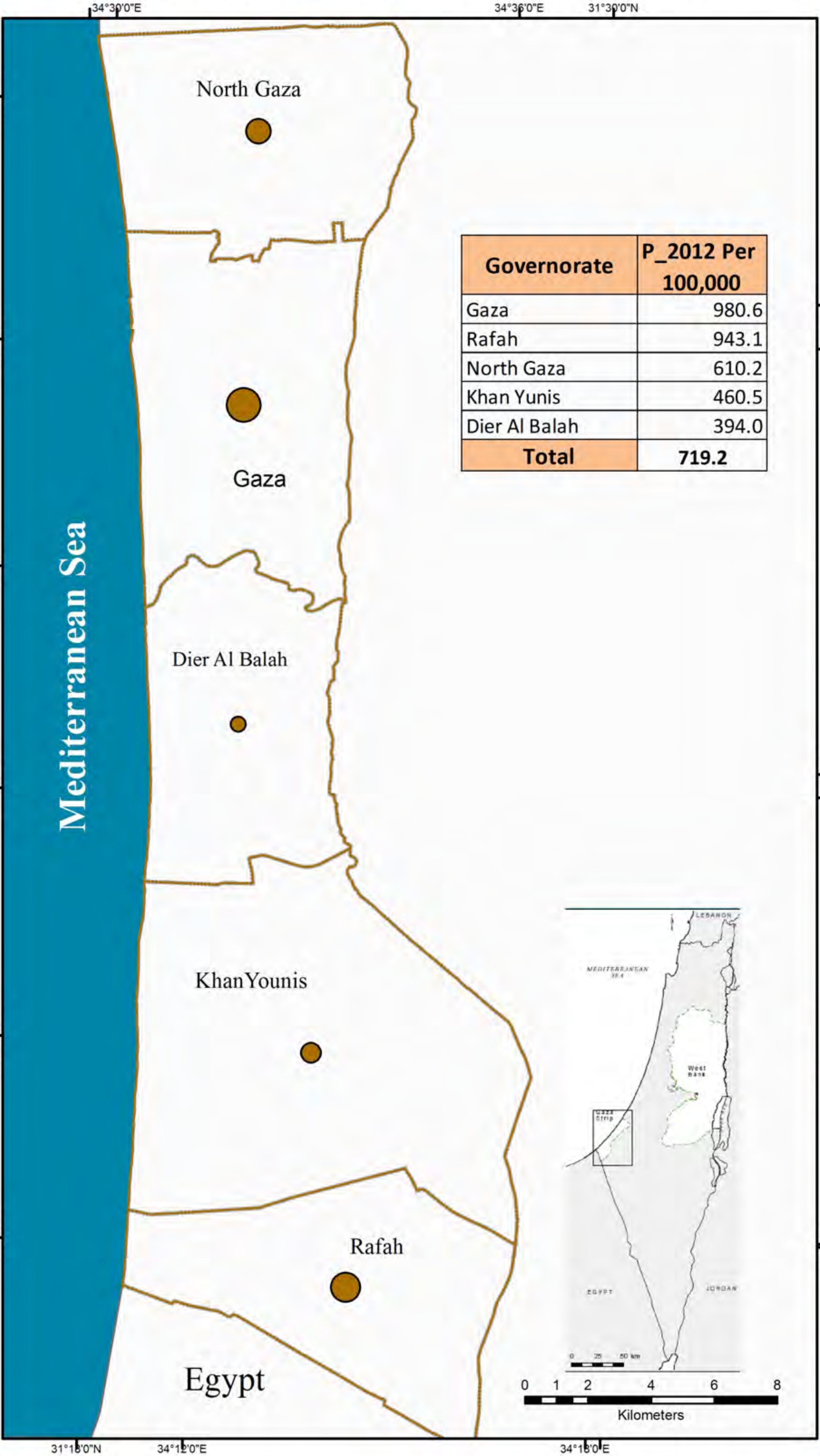
# Overall Parasitic infestations incidence rate in Gaza Strip (All providers -2012)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | P_2012 Per 100,000 |
|---|---|
| Gaza | 980.6 |
| Rafah | 943.1 |
| North Gaza | 610.2 |
| Khan Yunis | 460.5 |
| Dier Al Balah | 394.0 |
| **Total** | **719.2** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Parasites Incidence per 100,000**

- 394.0 - 410.0
- 410.1 - 460.5
- 460.6 - 610.2
- 610.3 - 943.1
- 943.2 - 980.6
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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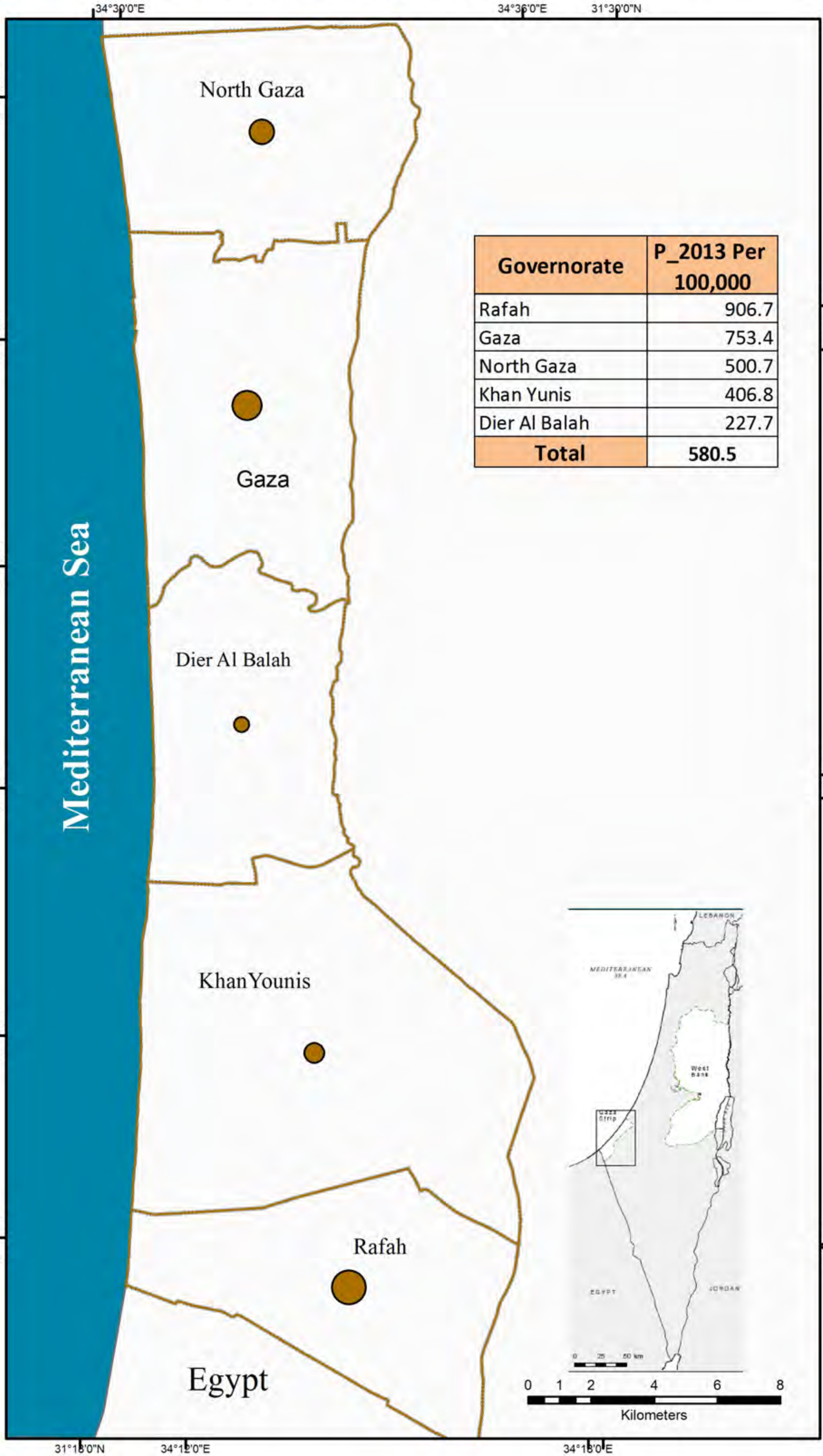
# Overall Parasitic infestations incidence rate in Gaza Strip (All providers -2013)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | P_2013 Per 100,000 |
|---|---|
| Rafah | 906.7 |
| Gaza | 753.4 |
| North Gaza | 500.7 |
| Khan Yunis | 406.8 |
| Dier Al Balah | 227.7 |
| **Total** | **580.5** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Parasites Incidence per 100,000**

- 227.7 - 350.0
- 350.1 - 406.8
- 406.9 - 500.7
- 500.8 - 753.4
- 753.5 - 906.7
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
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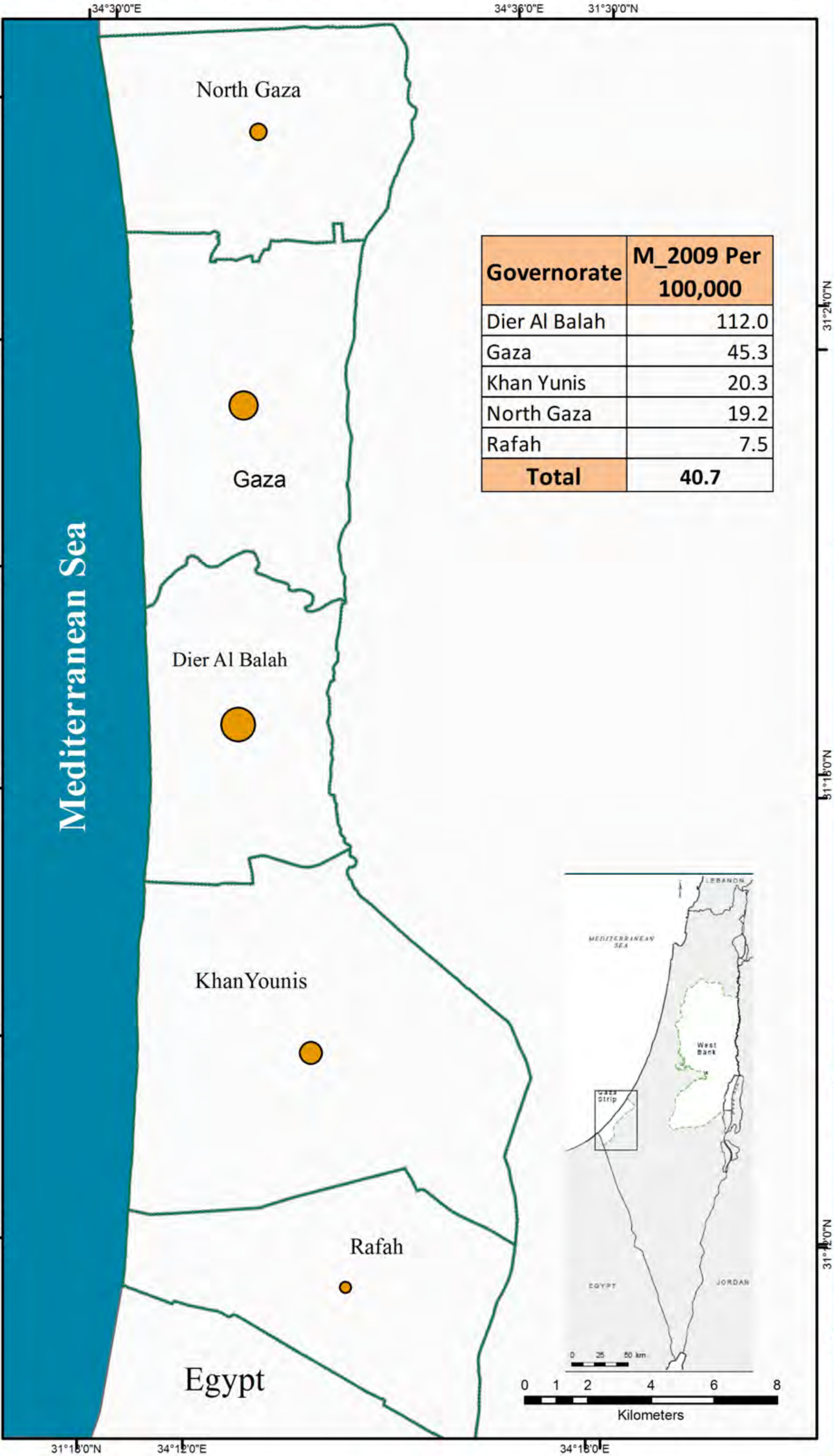
# Overall Meningitis incidence rate in Gaza Strip (All providers -2009)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | M_2009 Per 100,000 |
|---|---|
| Dier Al Balah | 112.0 |
| Gaza | 45.3 |
| Khan Yunis | 20.3 |
| North Gaza | 19.2 |
| Rafah | 7.5 |
| **Total** | **40.7** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Meningitis Incidence per 100,000**

- 7.5 - 15.0
- 15.1 - 19.2
- 19.3 - 20.3
- 20.4 - 45.3
- 45.4 - 112.0
- Governorates
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
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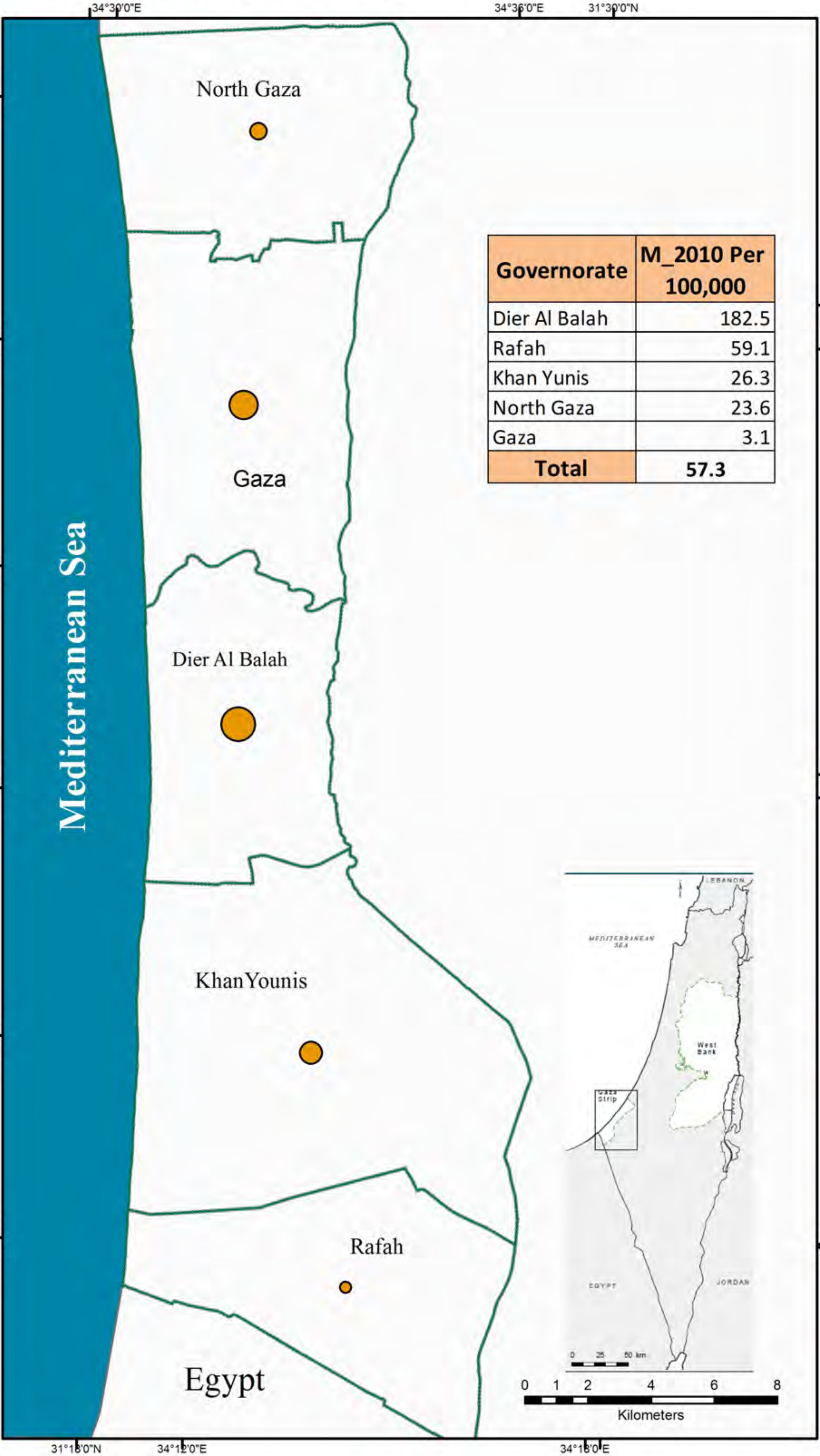
# Overall Meningitis incidence rate in Gaza Strip (All providers -2010)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | M_2010 Per 100,000 |
|---|---|
| Dier Al Balah | 182.5 |
| Rafah | 59.1 |
| Khan Yunis | 26.3 |
| North Gaza | 23.6 |
| Gaza | 3.1 |
| **Total** | **57.3** |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Meningitis Incidence per 100,000**

- 3.1 - 15.0
- 15.1 - 23.6
- 23.7 - 26.3
- 26.4 - 59.1
- 59.2 - 182.5
- Governorates
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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**Date: 4/22/2015**


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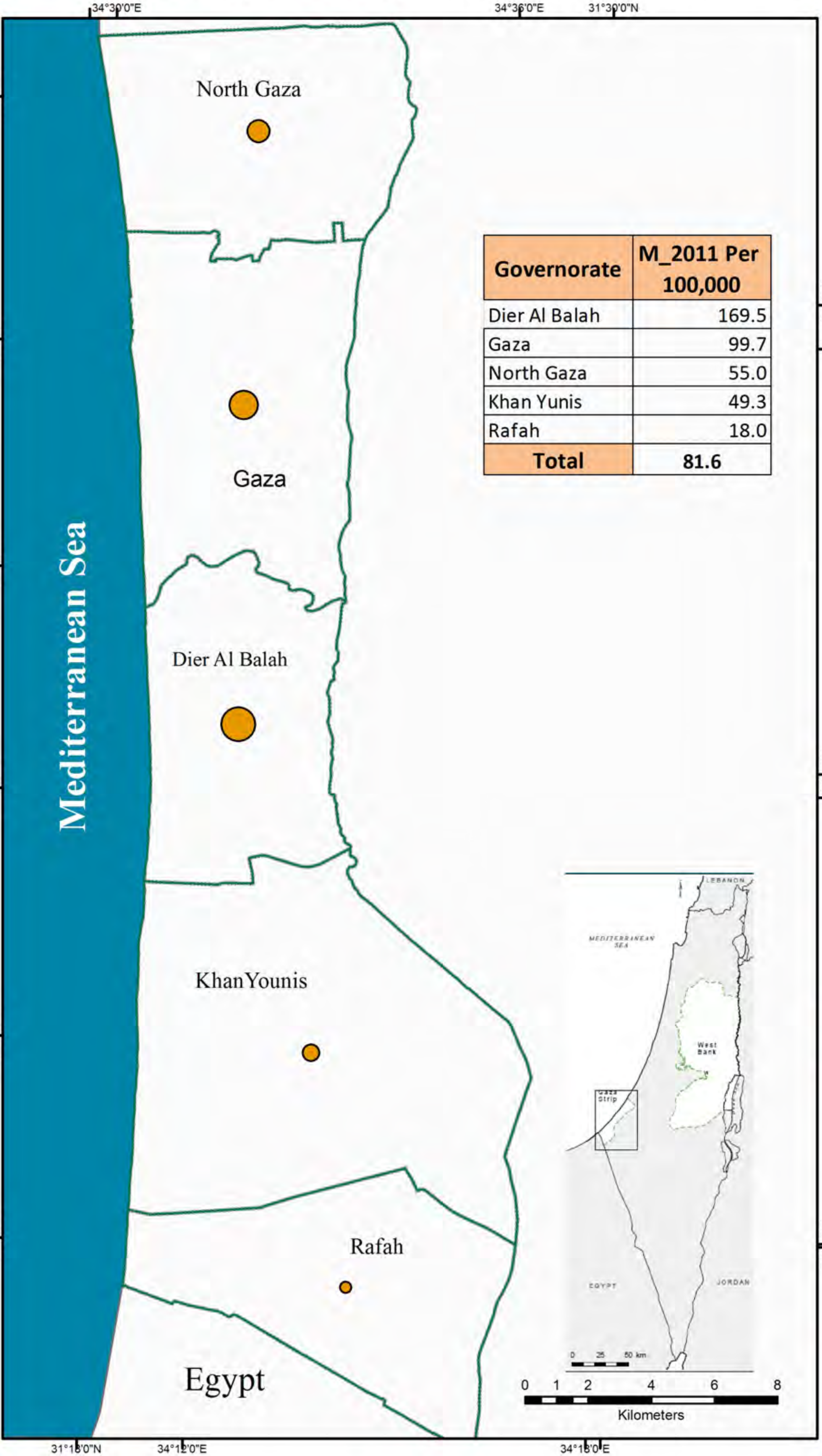
# Overall Meningitis incidence rate in Gaza Strip (All providers -2011)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | M_2011 Per 100,000 |
|---|---|
| Dier Al Balah | 169.5 |
| Gaza | 99.7 |
| North Gaza | 55.0 |
| Khan Yunis | 49.3 |
| Rafah | 18.0 |
| **Total** | **81.6** |

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PALESTINIAN WATER AUTHORITY

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## Legend

**Meningitis Incidence per 100,000**

- 18.0 - 30.0
- 30.1 - 49.3
- 49.4 - 55.0
- 55.1 - 99.7
- 99.8 - 169.5
- Governorates
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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Datum: Palestine 1923
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Units: Meter

**Date: 4/22/2015**

**Funded by:**
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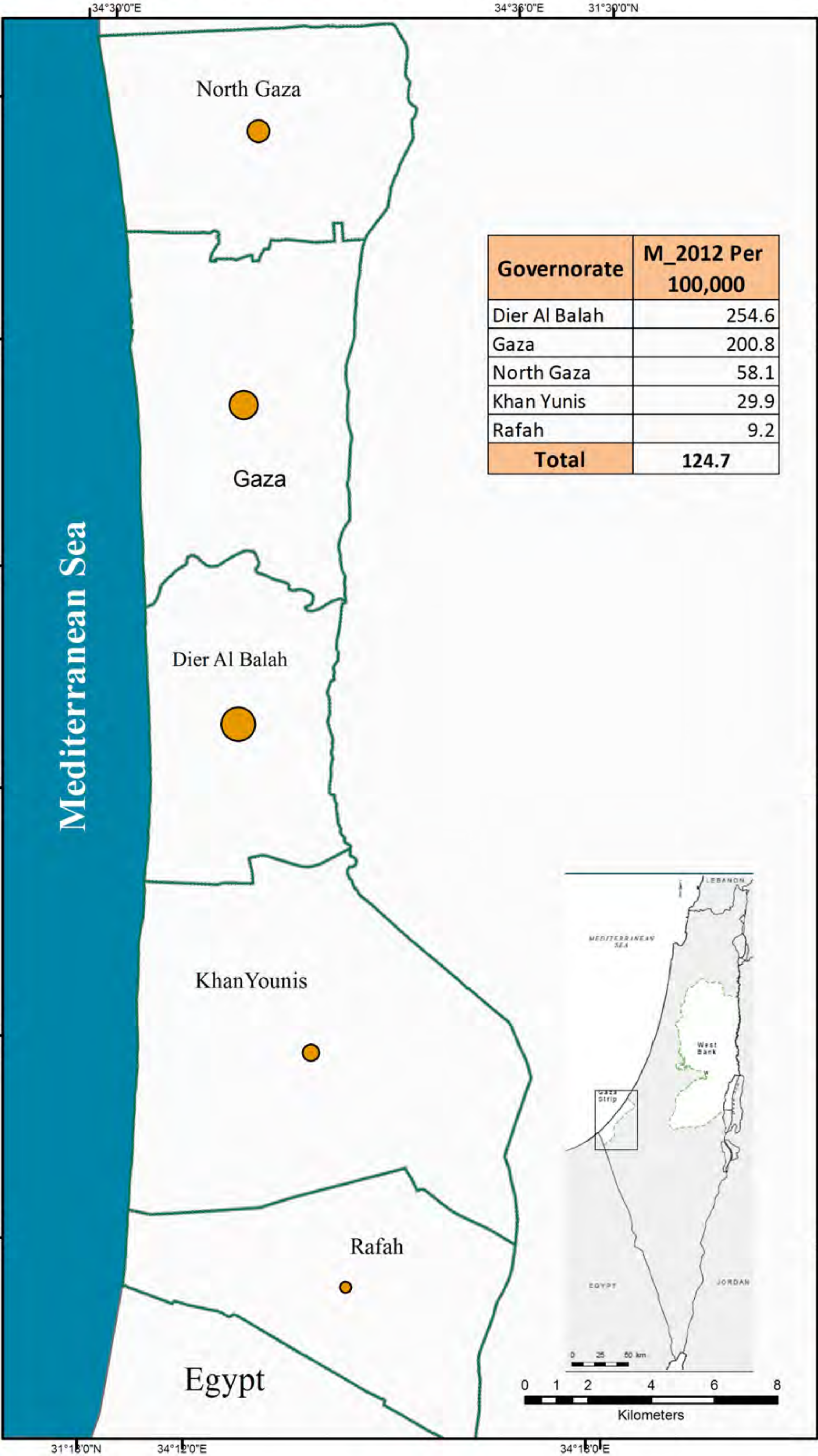
# Overall Meningitis incidence rate in Gaza Strip
# (All providers -2012)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | M_2012 Per 100,000 |
|---|---|
| Dier Al Balah | 254.6 |
| Gaza | 200.8 |
| North Gaza | 58.1 |
| Khan Yunis | 29.9 |
| Rafah | 9.2 |
| **Total** | **124.7** |

سلطة المياه الفلسطينية
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## Legend

**Meningitis Incidence per 100,000**

- 9.2 - 20.0
- 20.1 - 29.9
- 30.0 - 58.1
- 58.2 - 200.8
- 200.9 - 254.6
- Governorates
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
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latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
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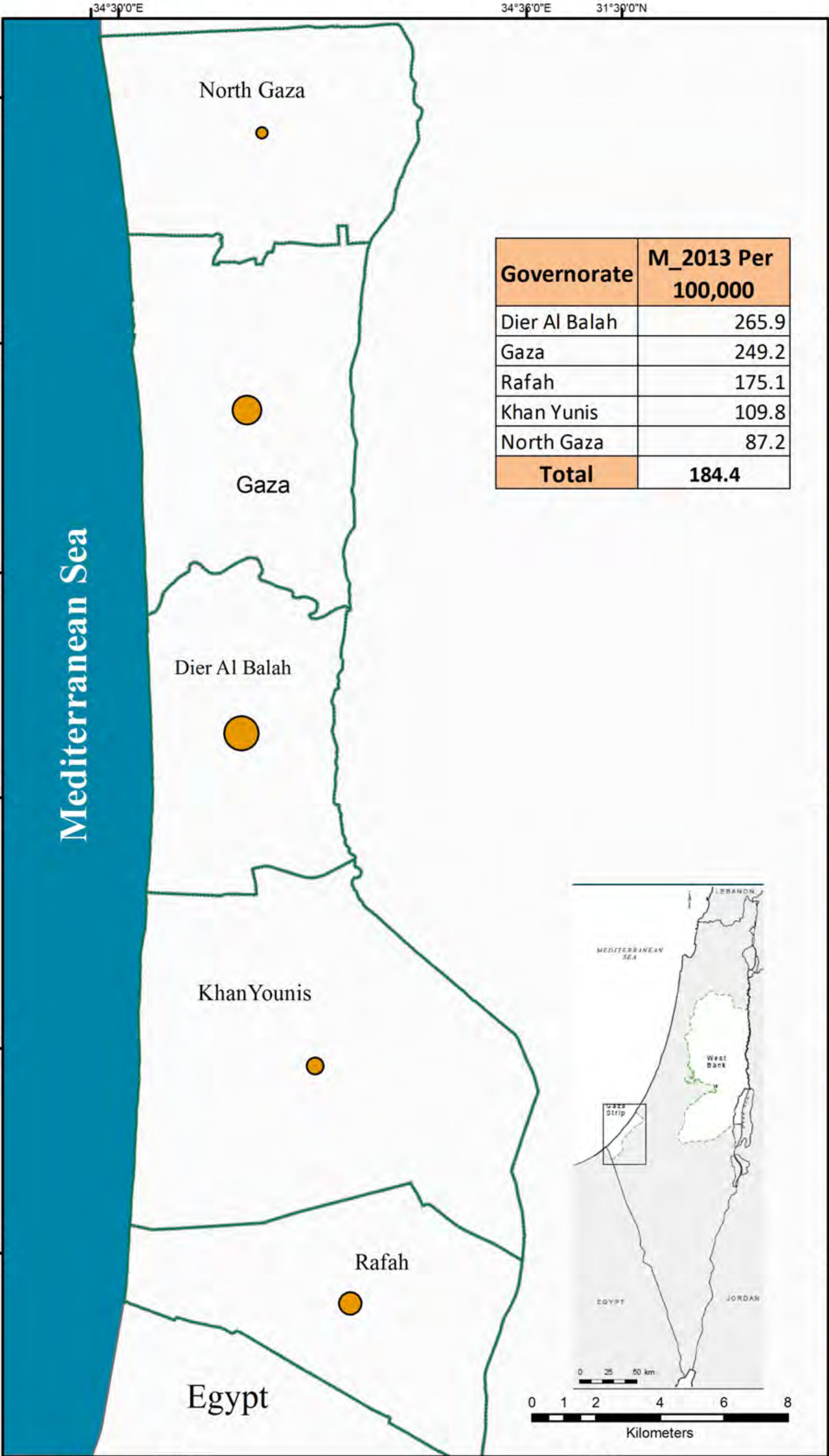
# Overall Meningitis incidence rate in Gaza Strip (All providers -2013)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | M_2013 Per 100,000 |
|---|---|
| Dier Al Balah | 265.9 |
| Gaza | 249.2 |
| Rafah | 175.1 |
| Khan Yunis | 109.8 |
| North Gaza | 87.2 |
| **Total** | **184.4** |

## Legend

**Meningitis Incidence per 100,000**

- 87.2 - 100.0
- 100.1 - 109.8
- 109.9 - 175.1
- 175.2 - 249.2
- 249.3 - 265.9
- Governorates
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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false easting: 170,251.5550
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Units: Meter

**Date: 4/22/2015**

**Funded by:**
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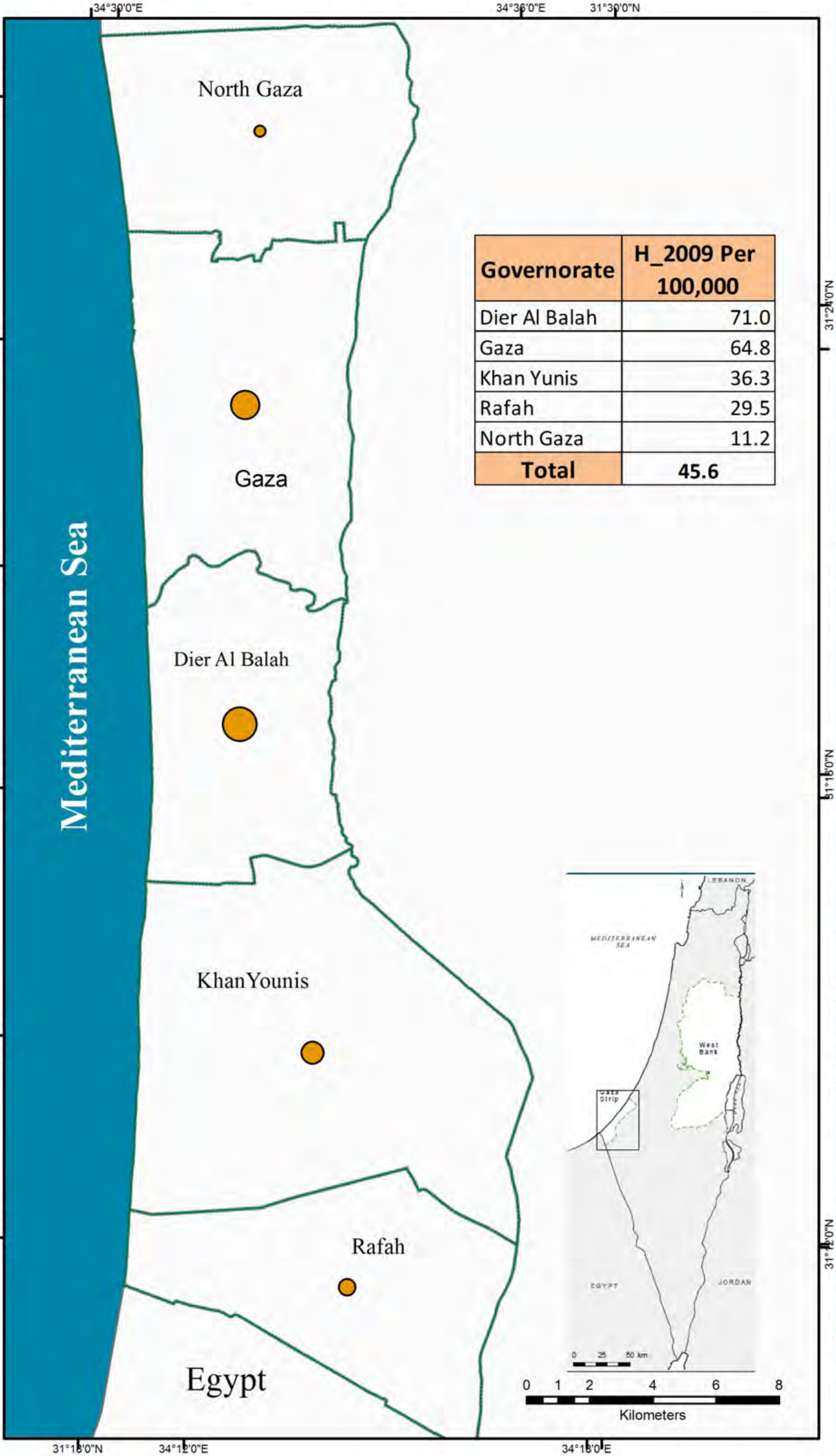
# Overall Hepatitis (A) incidence rate in Gaza Strip (All providers -2009)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | H_2009 Per 100,000 |
|---|---|
| Dier Al Balah | 71.0 |
| Gaza | 64.8 |
| Khan Yunis | 36.3 |
| Rafah | 29.5 |
| North Gaza | 11.2 |
| **Total** | **45.6** |

## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 11.2 - 20.0
- 20.1 - 29.5
- 29.6 - 36.3
- 36.4 - 64.8
- 64.9 - 71.0
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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Units: Meter

**Date: 4/22/2015**

**Funded by:**
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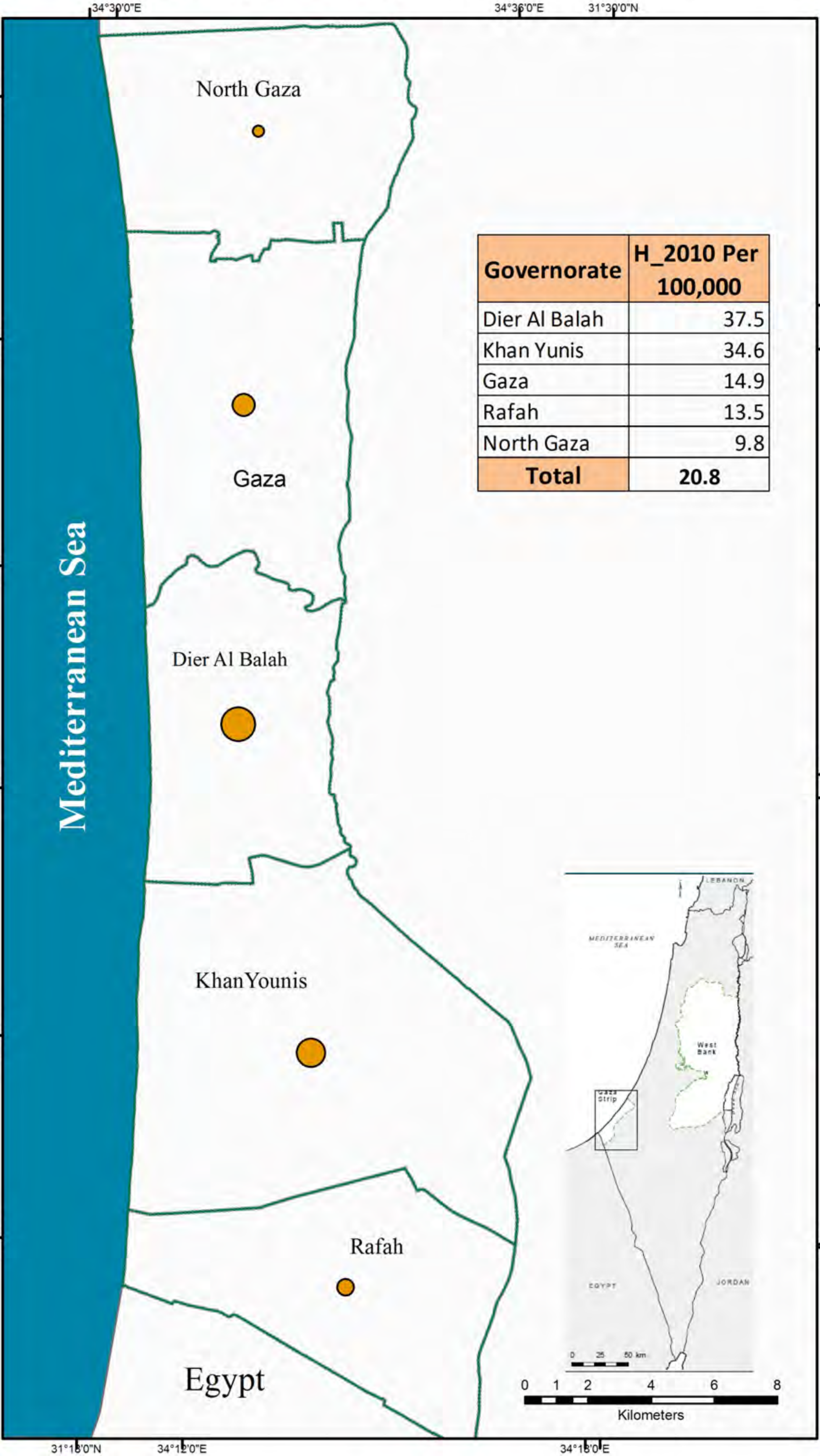
# Overall Hepatitis (A) incidence rate in Gaza Strip (All providers -2010)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | H_2010 Per 100,000 |
|---|---|
| Dier Al Balah | 37.5 |
| Khan Yunis | 34.6 |
| Gaza | 14.9 |
| Rafah | 13.5 |
| North Gaza | 9.8 |
| **Total** | **20.8** |

سلطة المياه الفلسطينية
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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 9.8 - 11.0
- 11.1 - 13.5
- 13.6 - 14.9
- 15.0 - 34.6
- 34.7 - 37.5
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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**Date: 4/22/2015**


**Funded by:**
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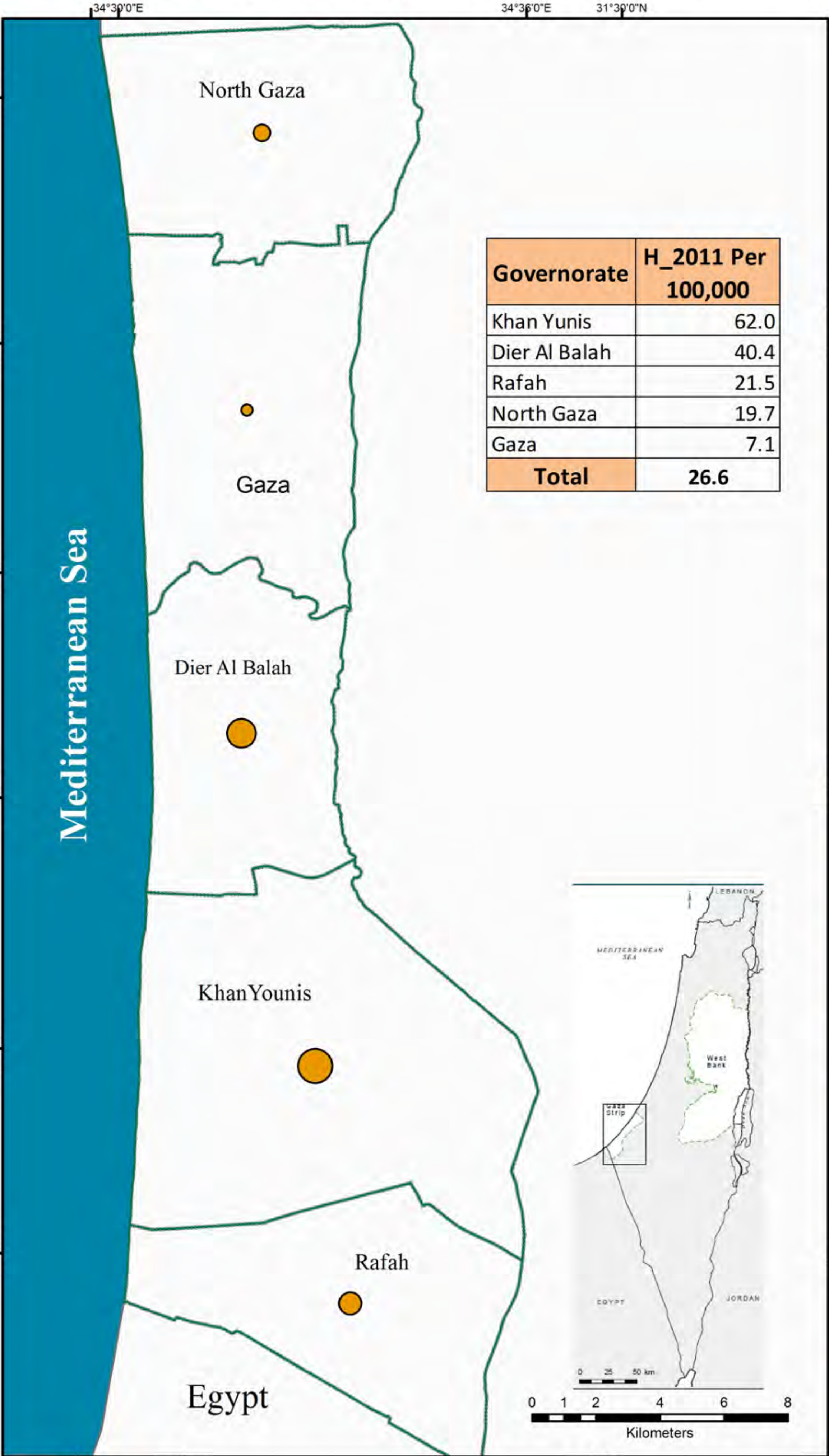
# Overall Hepatitis (A) incidence rate in Gaza Strip (All providers -2011)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | H_2011 Per 100,000 |
|---|---|
| Khan Yunis | 62.0 |
| Dier Al Balah | 40.4 |
| Rafah | 21.5 |
| North Gaza | 19.7 |
| Gaza | 7.1 |
| **Total** | **26.6** |

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 7.1 - 10.0
- 10.1 - 19.7
- 19.8 - 21.5
- 21.6 - 40.4
- 40.5 - 62.0
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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**Date: 4/22/2015**

**Funded by:**
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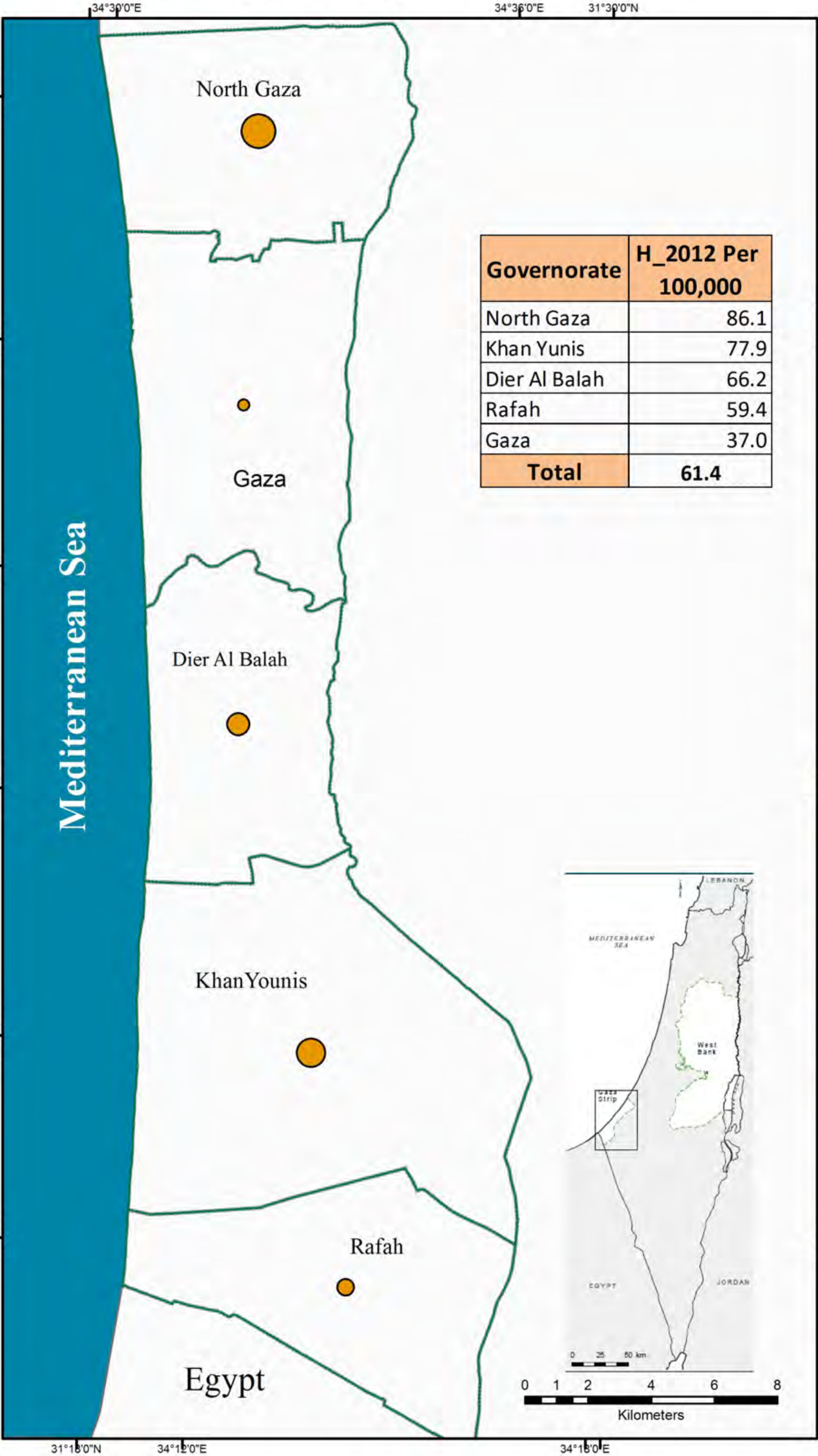
# Overall Hepatitis (A) incidence rate in Gaza Strip (All providers -2012)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | H_2012 Per 100,000 |
|---|---|
| North Gaza | 86.1 |
| Khan Yunis | 77.9 |
| Dier Al Balah | 66.2 |
| Rafah | 59.4 |
| Gaza | 37.0 |
| **Total** | **61.4** |

## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 37.0 - 45.0
- 45.1 - 59.4
- 59.5 - 66.2
- 66.3 - 77.9
- 78.0 - 86.1
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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Units: Meter

**Date: 4/22/2015**

**Funded by:**
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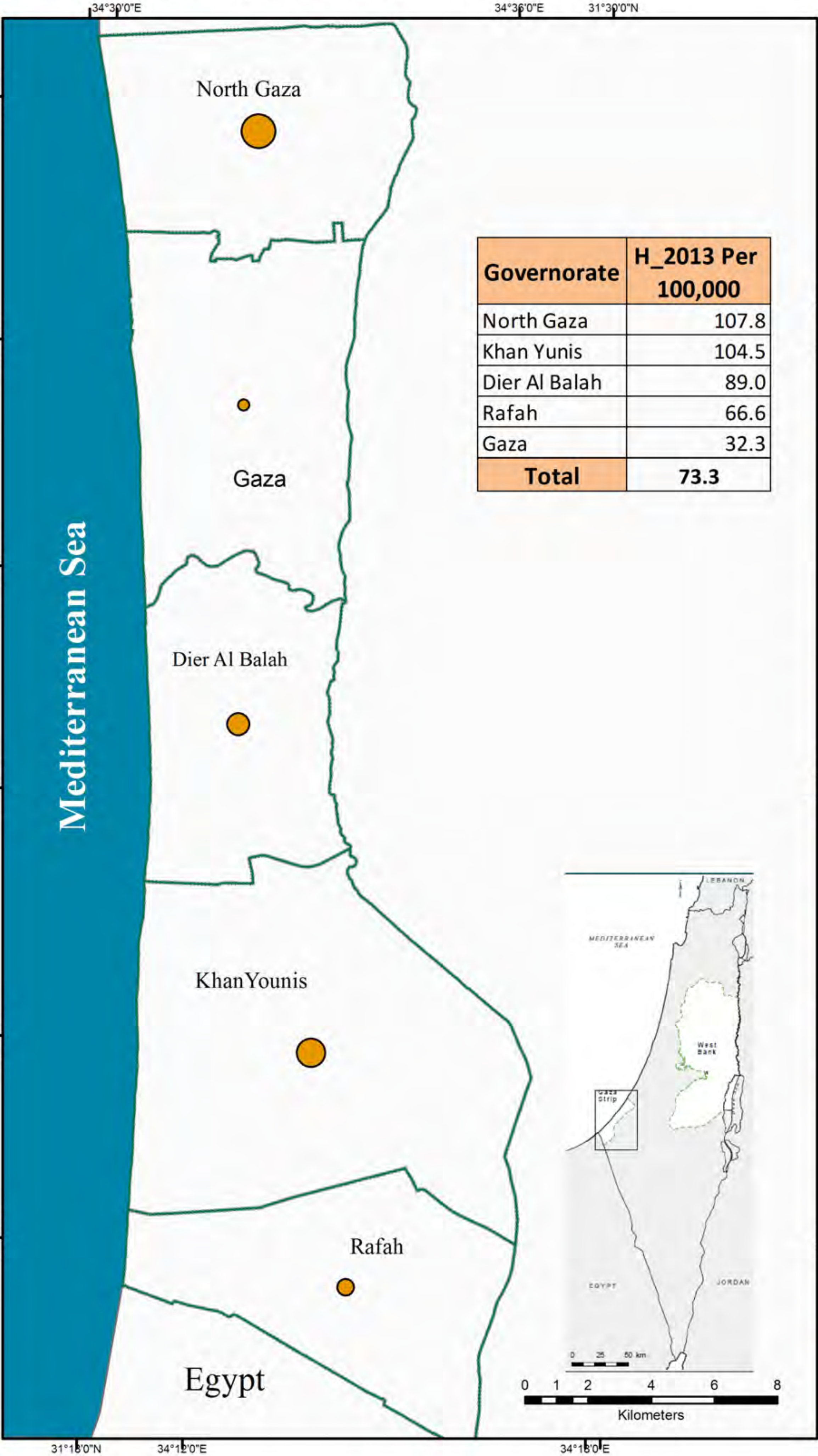
# Overall Hepatitis (A) incidence rate in Gaza Strip (All providers -2013)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | H_2013 Per 100,000 |
|---|---|
| North Gaza | 107.8 |
| Khan Yunis | 104.5 |
| Dier Al Balah | 89.0 |
| Rafah | 66.6 |
| Gaza | 32.3 |
| **Total** | **73.3** |

## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 32.3 - 50.0
- 50.1 - 66.6
- 66.7 - 89.0
- 89.1 - 104.5
- 104.6 - 107.8
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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false easting: 170,251.5550
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latitude of origin: 31.7341
Units: Meter

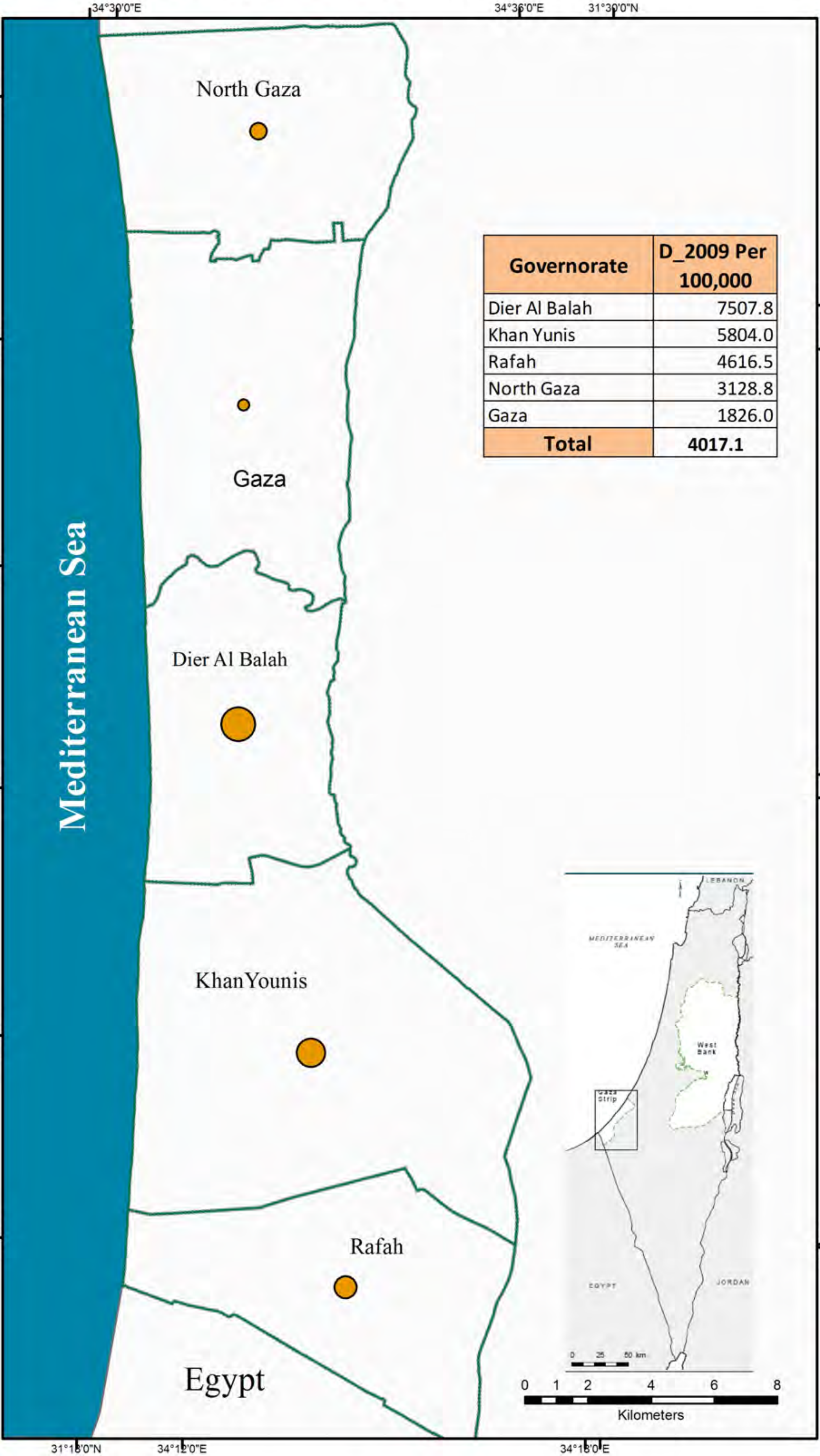
**Date: 4/22/2015**


**Funded by:**

Austrian Development Agency

# Overall Diarrheal incidence rate in Gaza Strip (All providers -2009)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | D_2009 Per 100,000 |
|---|---|
| Dier Al Balah | 7507.8 |
| Khan Yunis | 5804.0 |
| Rafah | 4616.5 |
| North Gaza | 3128.8 |
| Gaza | 1826.0 |
| **Total** | **4017.1** |

## Legend

**Diarrheal Incidence per 100,000**

- 1,826.0 - 2,000.0
- 2,000.1 - 3,128.8
- 3,128.9 - 4,616.5
- 4,616.6 - 5,804.0
- 5,804.1 - 7,507.8
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
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false easting: 170,251.5550
false northing: 126,867.9090
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scale factor: 1.0000
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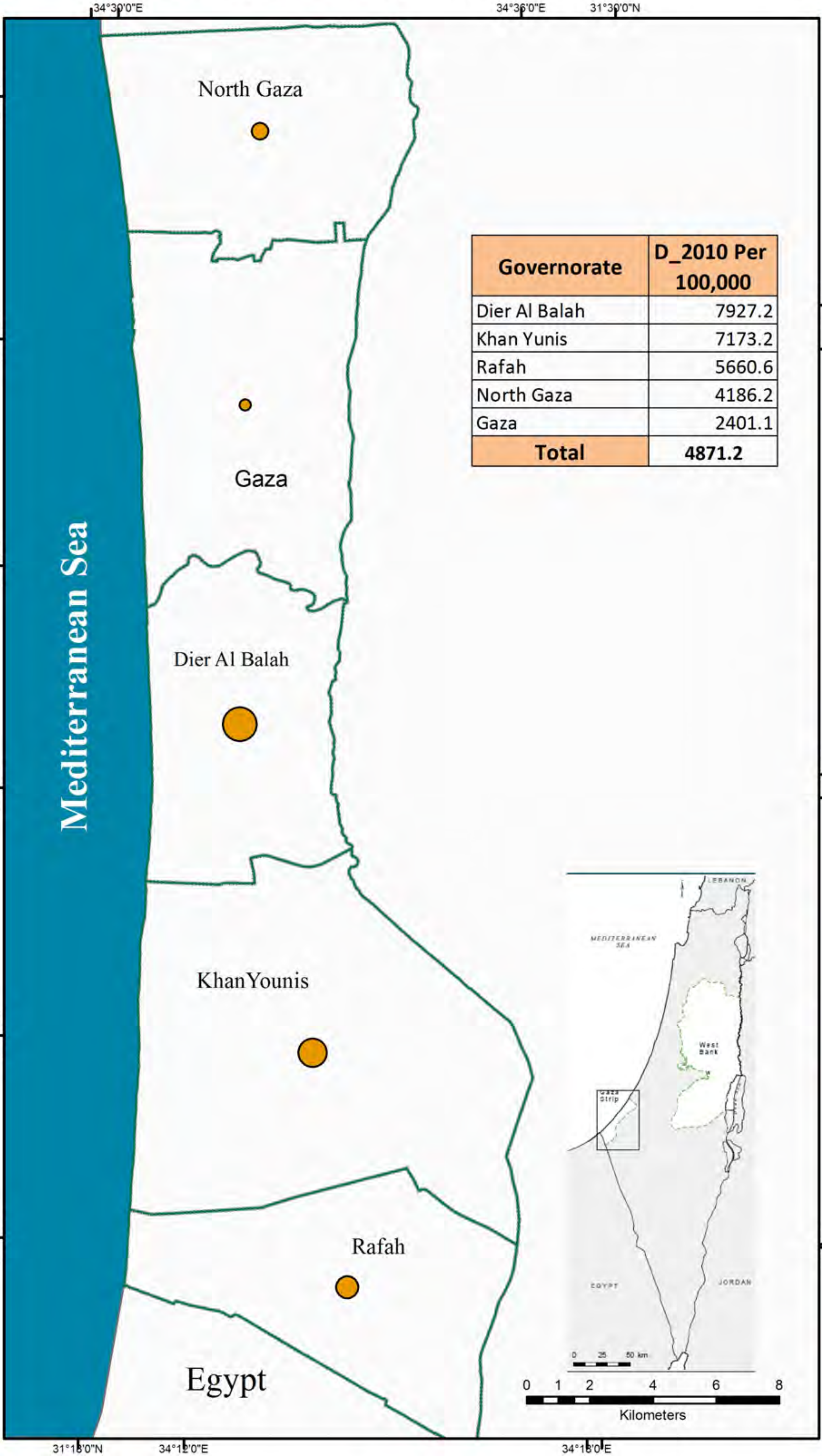
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Overall Diarrheal incidence rate in Gaza Strip
# (All providers -2010)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | D_2010 Per 100,000 |
|---|---|
| Dier Al Balah | 7927.2 |
| Khan Yunis | 7173.2 |
| Rafah | 5660.6 |
| North Gaza | 4186.2 |
| Gaza | 2401.1 |
| **Total** | **4871.2** |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PALESTINIAN WATER AUTHORITY

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## Legend

**Diarrheal**
**Incidence per 100,000**

- 2,401.1 - 3,000.0
- 3,000.1 - 4,186.2
- 4,186.3 - 5,660.6
- 5,660.7 - 7,173.2
- 7,173.3 - 7,927.2
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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**Date: 4/22/2015**


**Funded by:**
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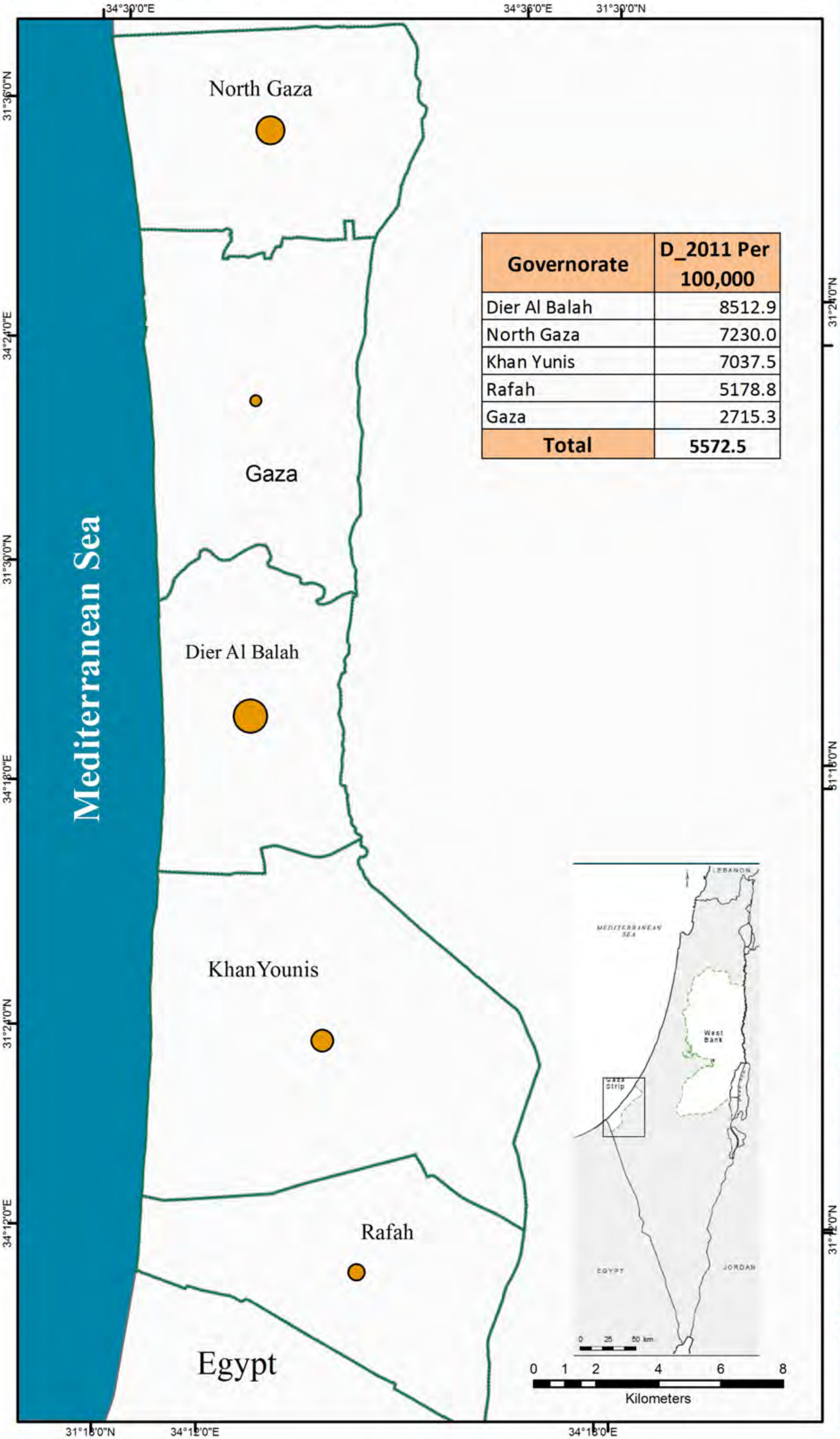
# Overall Diarrheal incidence rate in Gaza Strip (All providers -2011)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | D_2011 Per 100,000 |
|---|---|
| Dier Al Balah | 8512.9 |
| North Gaza | 7230.0 |
| Khan Yunis | 7037.5 |
| Rafah | 5178.8 |
| Gaza | 2715.3 |
| **Total** | **5572.5** |

## Legend

**Diarrheal Incidence per 100,000**

- 2,715.3 - 3,000.0
- 3,000.1 - 5,178.8
- 5,178.9 - 7,037.5
- 7,037.6 - 7,230.0
- 7,230.1 - 8,512.9
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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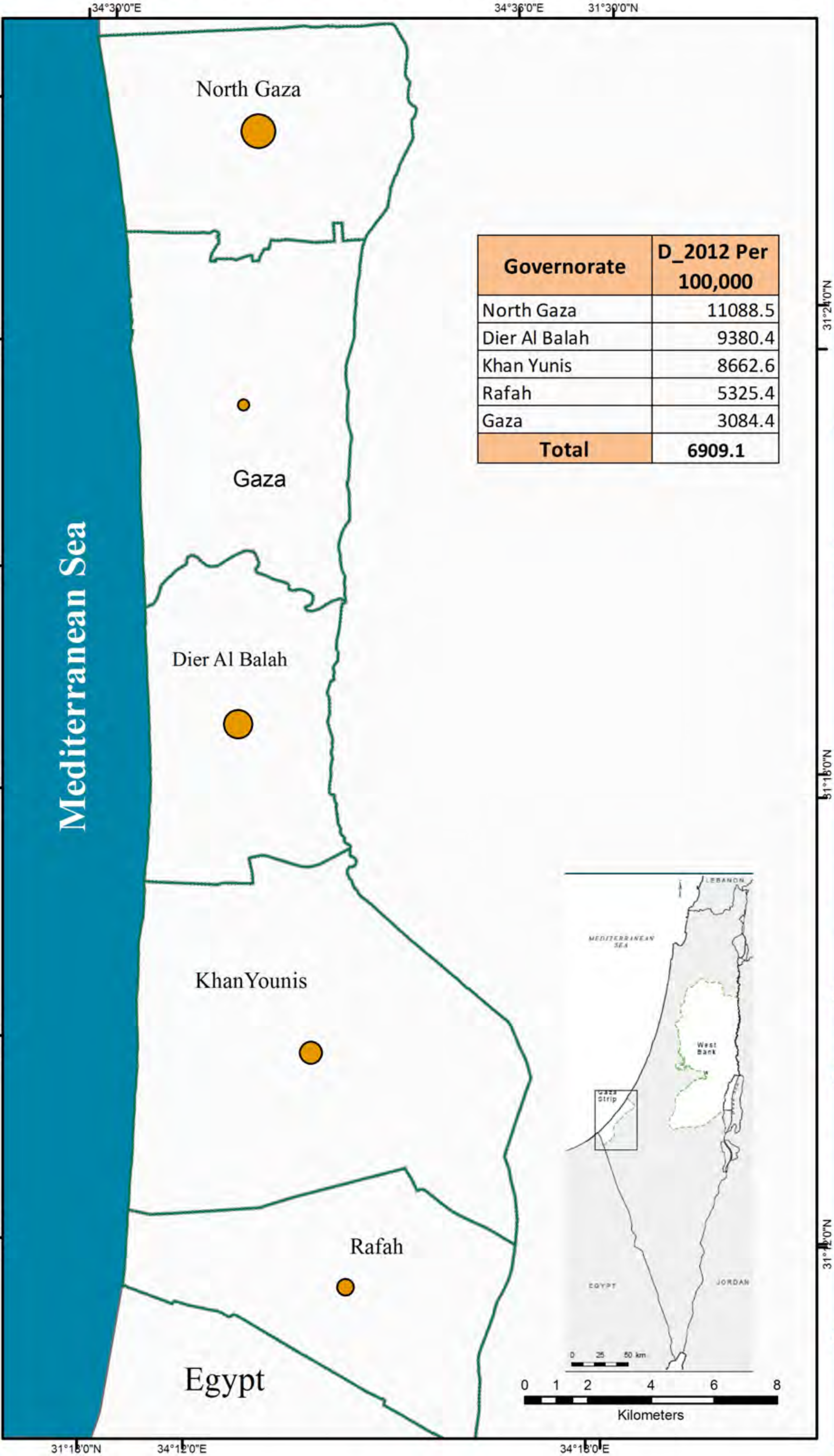
**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Overall Diarrheal incidence rate in Gaza Strip (All providers -2012)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | D_2012 Per 100,000 |
|---|---|
| North Gaza | 11088.5 |
| Dier Al Balah | 9380.4 |
| Khan Yunis | 8662.6 |
| Rafah | 5325.4 |
| Gaza | 3084.4 |
| **Total** | **6909.1** |

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## Legend

**Diarrheal Incidence per 100,000**

- 3,084.4 - 4,000.0
- 4,000.1 - 5,325.4
- 5,325.5 - 8,662.6
- 8,662.7 - 9,380.4
- 9,380.5 - 11,088.5
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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Units: Meter

**Date: 4/22/2015**


**Funded by:**
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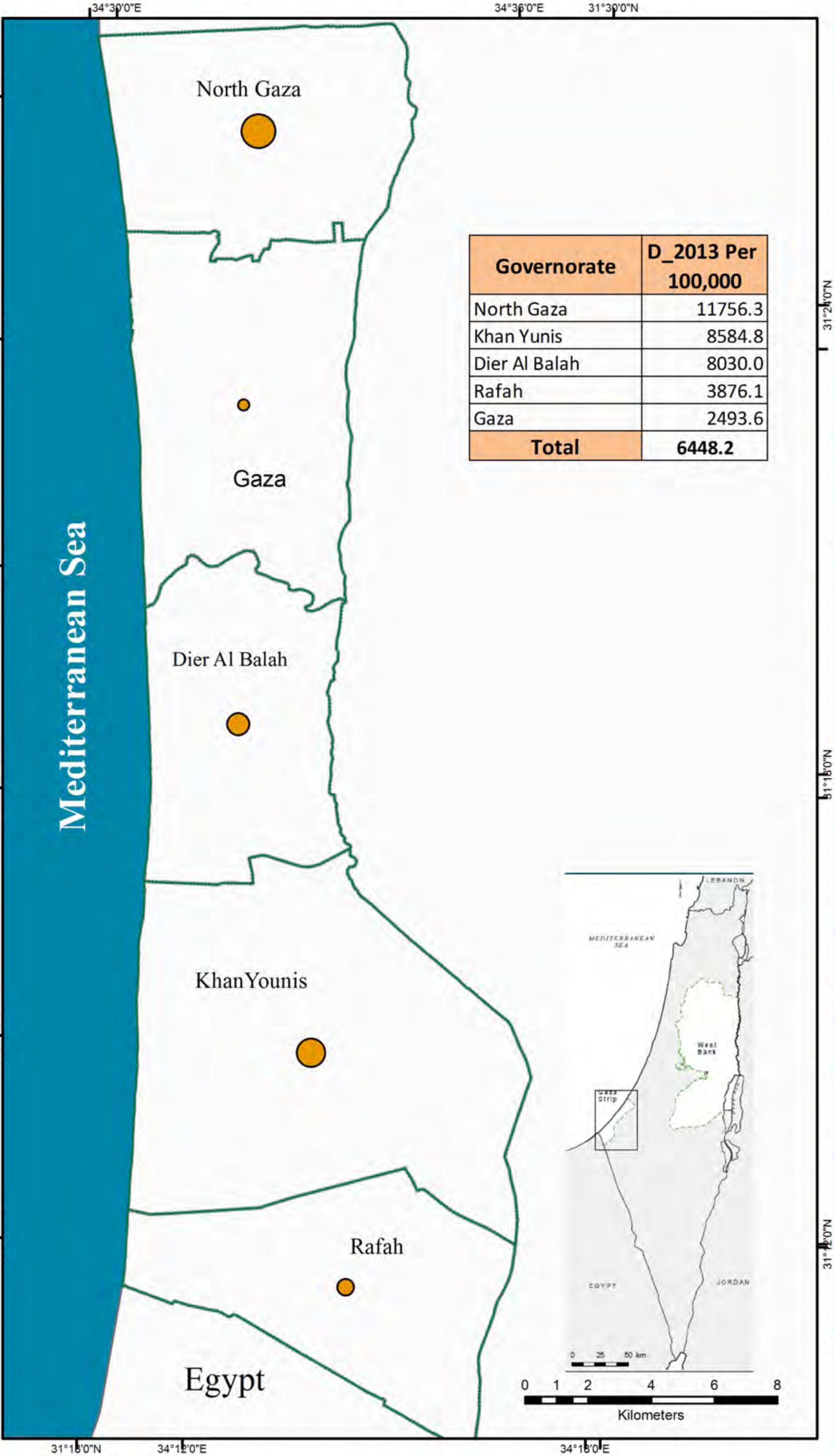
# Overall Diarrheal incidence rate in Gaza Strip (All providers -2013)

Baseline Study on Water Quality and Public Health - April, 2015




| Governorate | D_2013 Per 100,000 |
|---|---|
| North Gaza | 11756.3 |
| Khan Yunis | 8584.8 |
| Dier Al Balah | 8030.0 |
| Rafah | 3876.1 |
| Gaza | 2493.6 |
| **Total** | **6448.2** |

## Legend

**Diarrheal Incidence per 100,000**

- 2,493.6 - 3,000.0
- 3,000.1 - 3,876.1
- 3,876.2 - 8,030.0
- 8,030.1 - 8,584.8
- 8,584.9 - 11,756.3
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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**Date: 4/22/2015**


**Funded by:**
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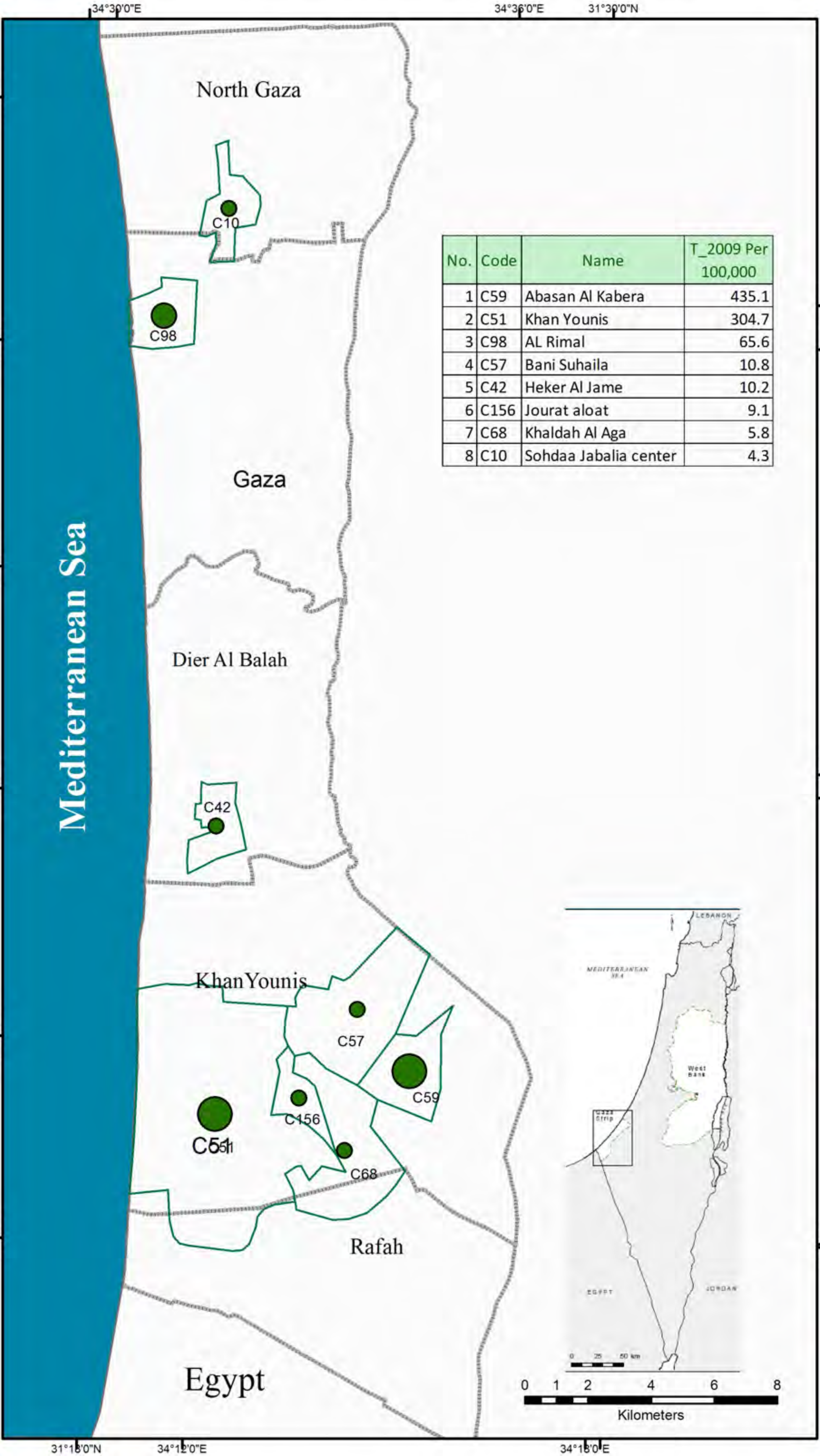
# Typhoid incidence rate in Gaza Strip - MOH 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2009 Per 100,000 |
|---|---|---|---|
| 1 | C59 | Abasan Al Kabera | 435.1 |
| 2 | C51 | Khan Younis | 304.7 |
| 3 | C98 | AL Rimal | 65.6 |
| 4 | C57 | Bani Suhaila | 10.8 |
| 5 | C42 | Heker Al Jame | 10.2 |
| 6 | C156 | Jourat aloat | 9.1 |
| 7 | C68 | Khaldah Al Aga | 5.8 |
| 8 | C10 | Sohdaa Jabalia center | 4.3 |

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## Legend

**Typhoid**

**Incidence per 100,000**

- 4.3 - 10.8
- 10.9 - 65.6
- 56.7 - 435.1
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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Datum: Palestine 1923
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**Date: 4/22/2015**


**Funded by:**
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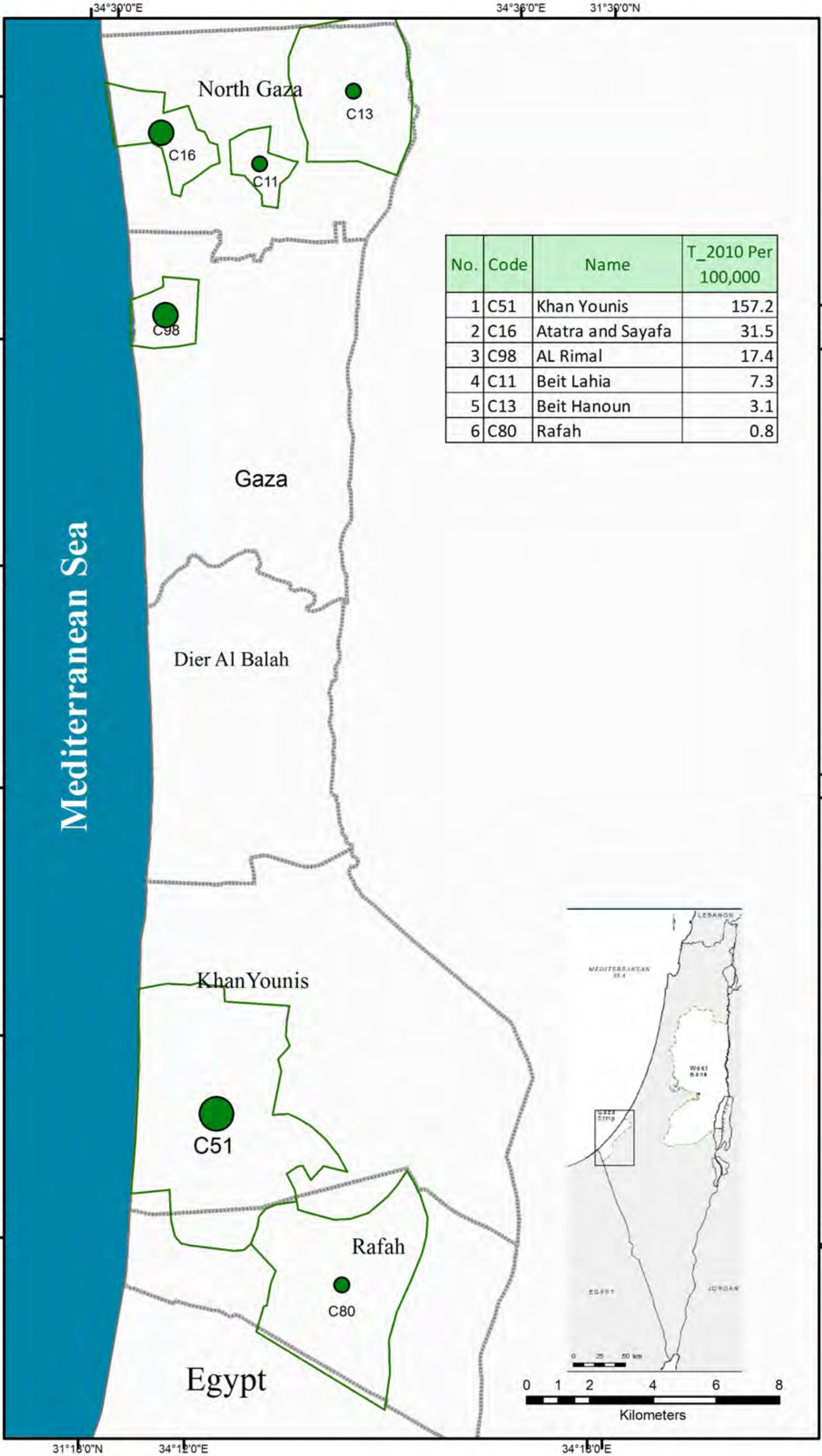
# Typhoid incidence rate in Gaza Strip - MOH 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2010 Per 100,000 |
|---|---|---|---|
| 1 | C51 | Khan Younis | 157.2 |
| 2 | C16 | Atatra and Sayafa | 31.5 |
| 3 | C98 | AL Rimal | 17.4 |
| 4 | C11 | Beit Lahia | 7.3 |
| 5 | C13 | Beit Hanoun | 3.1 |
| 6 | C80 | Rafah | 0.8 |

## Legend

**Typhoid**

**Incidence per 100,000**

- 0.8 - 7.3
- 7.4 - 31.5
- 31.6 - 157.2
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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**Date: 4/22/2015**

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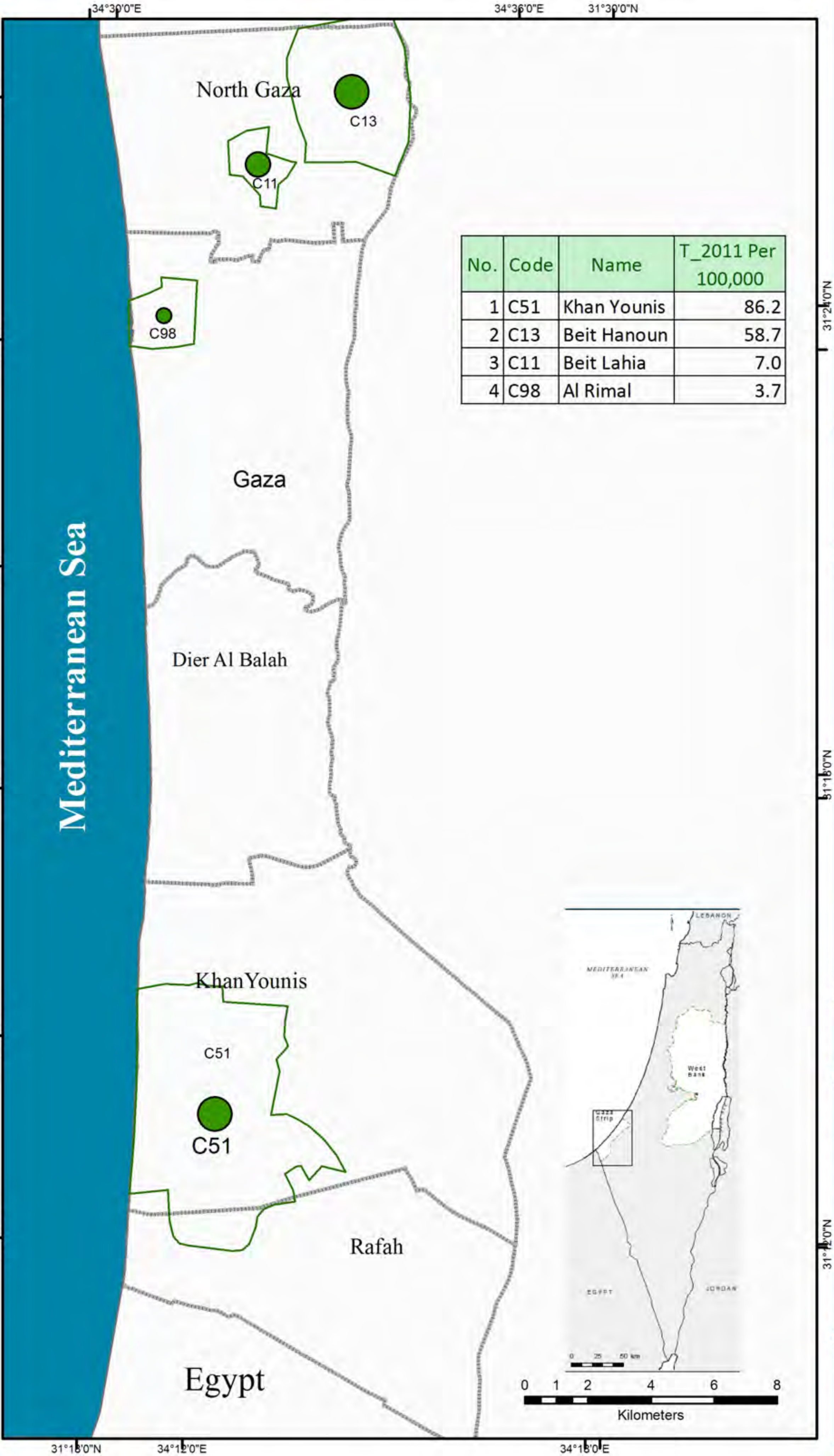
# Typhoid incidence rate in Gaza Strip - MOH 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2011 Per 100,000 |
|---|---|---|---|
| 1 | C51 | Khan Younis | 86.2 |
| 2 | C13 | Beit Hanoun | 58.7 |
| 3 | C11 | Beit Lahia | 7.0 |
| 4 | C98 | Al Rimal | 3.7 |

## Legend

**Typhoid**

**Incidence per 100,000**

- 3.7 - 5.0
- 5.1 - 15.0
- 15.1 - 86.2
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
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**Date: 4/22/2015**


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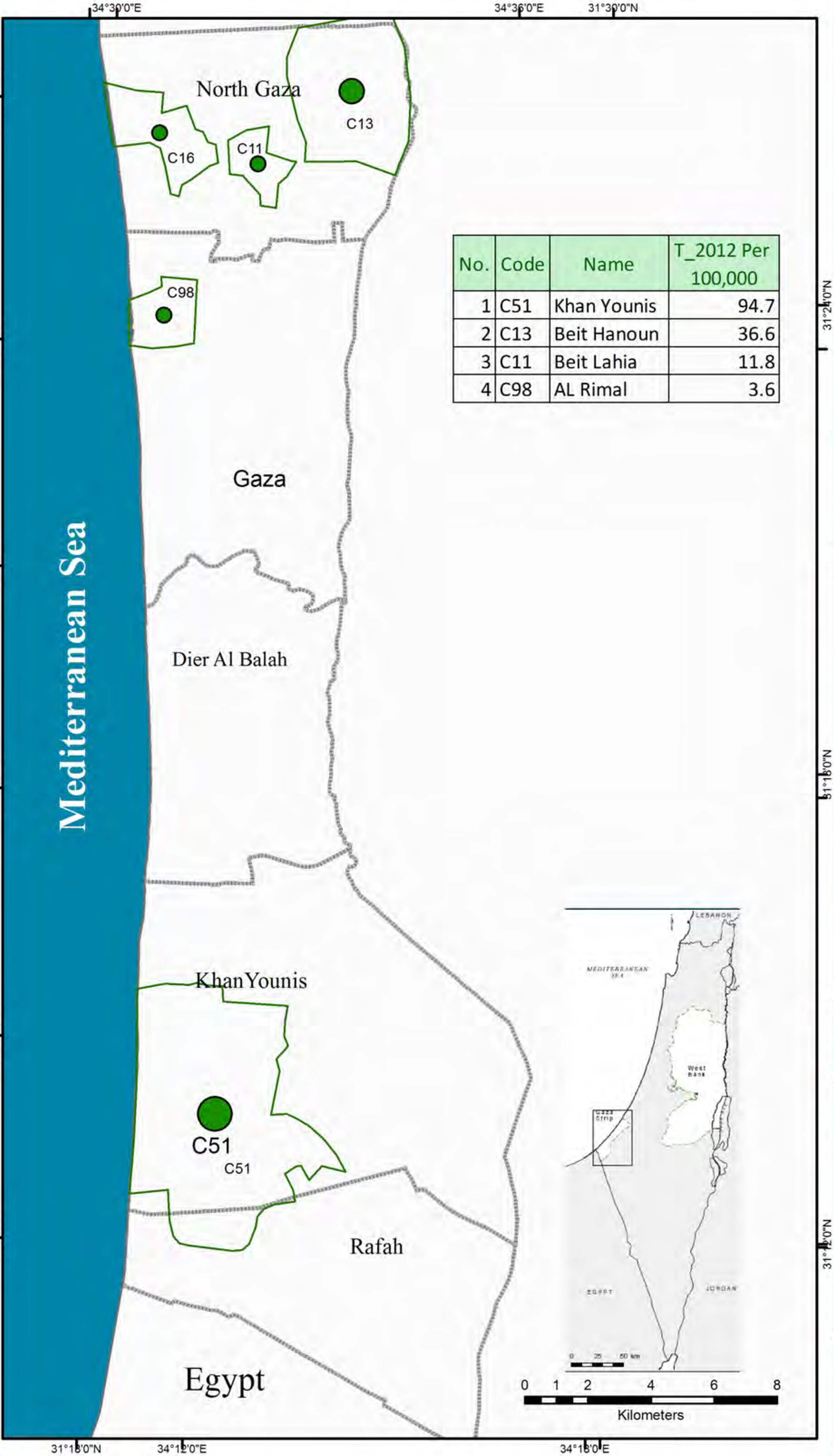
# Typhoid incidence rate in Gaza Strip - MOH 2012

Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Typhoid**

**Incidence per 100,000**

- 3.6 - 11.8
- 11.9 - 36.6
- 36.7 - 94.7
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

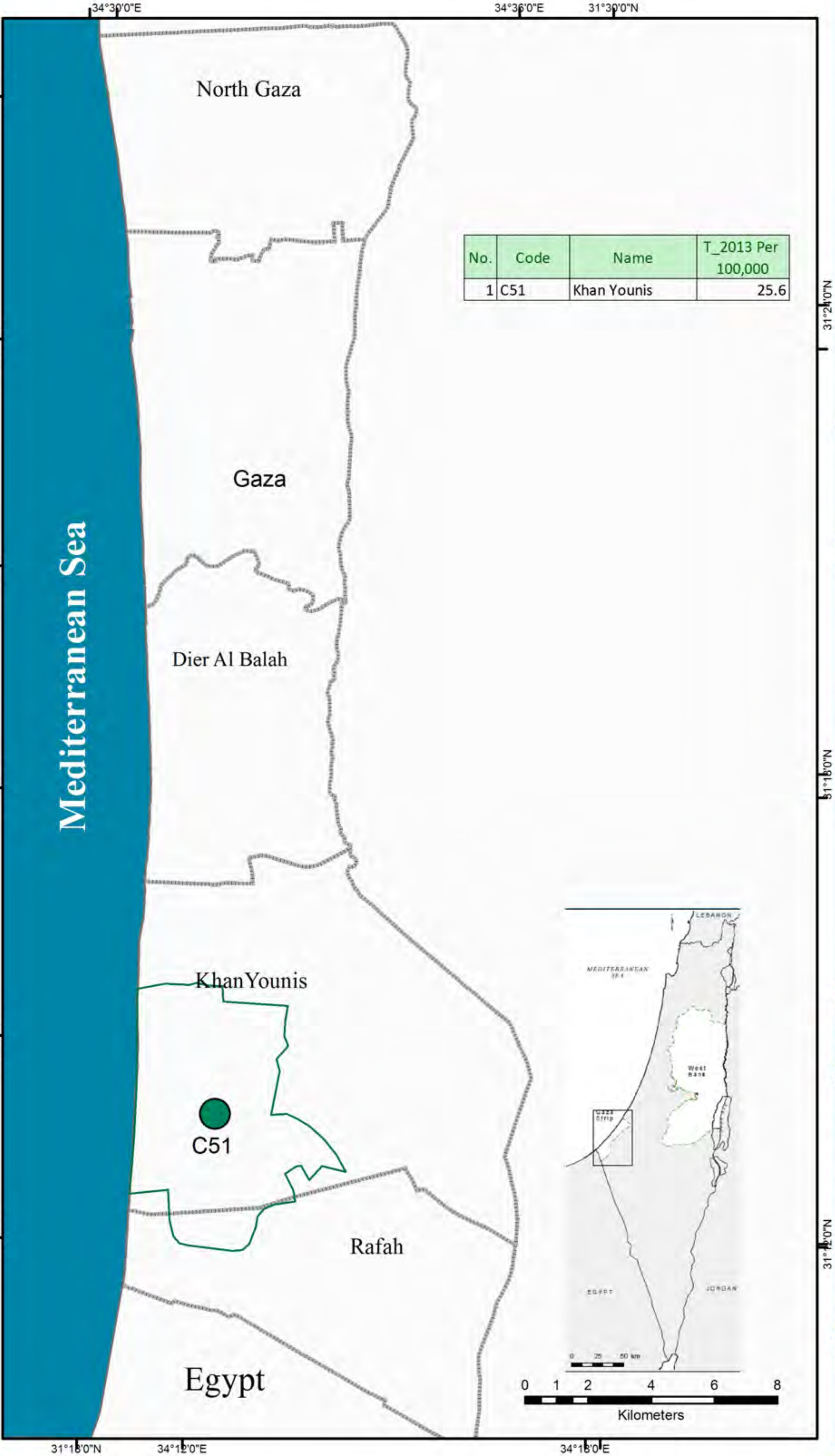
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# Typhoid incidence rate in Gaza Strip - MOH 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2013 Per 100,000 |
|---|---|---|---|
| 1 | C51 | Khan Younis | 25.6 |

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PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Typhoid**

**Incidence per 100,000**

- 1 - 30
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
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**Date: 4/22/2015**


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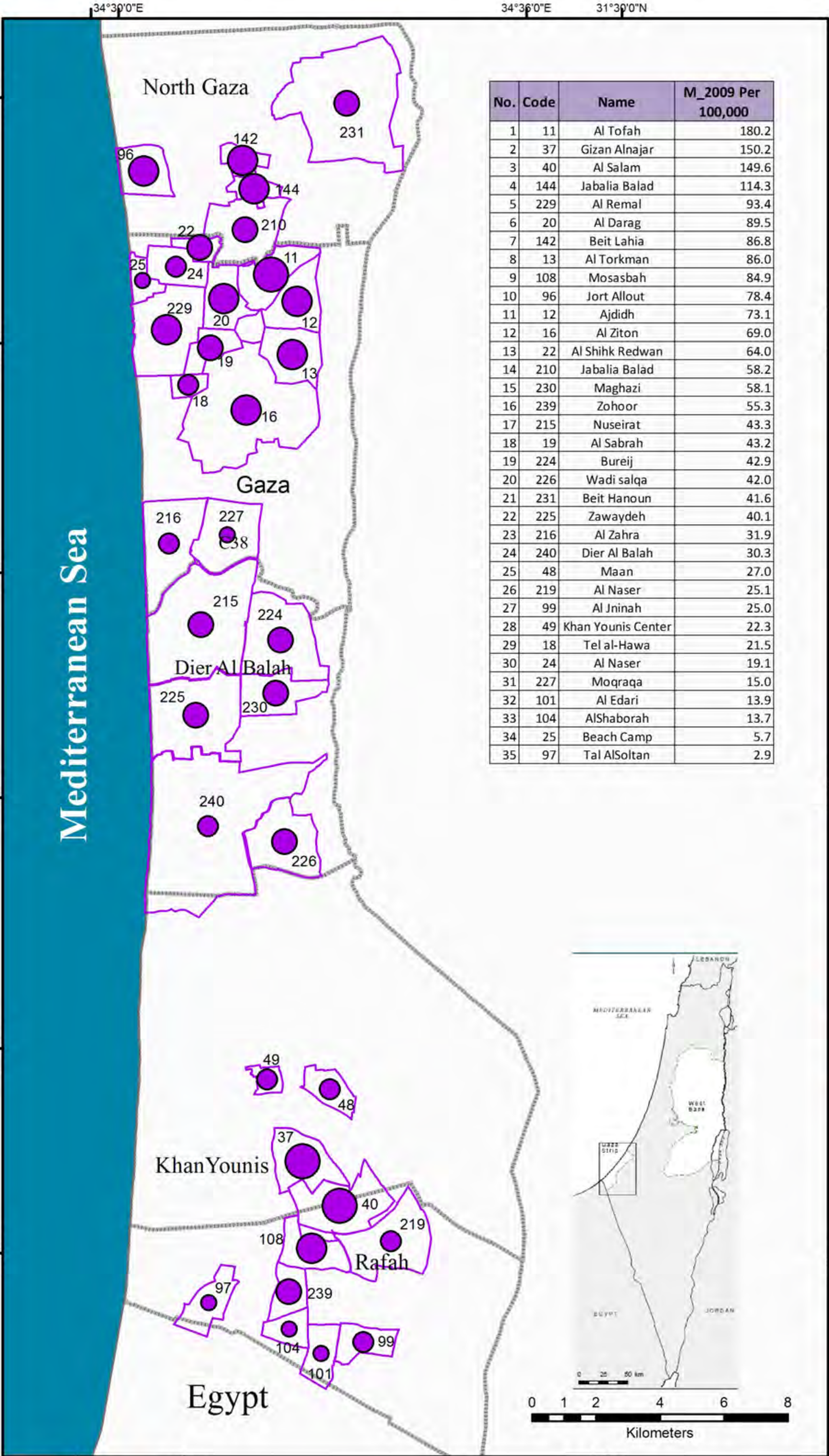
# Meningitis incidence rate in Gaza Strip - MOH 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | M_2009 Per 100,000 |
|---|---|---|---|
| 1 | 11 | Al Tofah | 180.2 |
| 2 | 37 | Gizan Alnajar | 150.2 |
| 3 | 40 | Al Salam | 149.6 |
| 4 | 144 | Jabalia Balad | 114.3 |
| 5 | 229 | Al Remal | 93.4 |
| 6 | 20 | Al Darag | 89.5 |
| 7 | 142 | Beit Lahia | 86.8 |
| 8 | 13 | Al Torkman | 86.0 |
| 9 | 108 | Mosasbah | 84.9 |
| 10 | 96 | Jort Allout | 78.4 |
| 11 | 12 | Ajdidh | 73.1 |
| 12 | 16 | Al Ziton | 69.0 |
| 13 | 22 | Al Shihk Redwan | 64.0 |
| 14 | 210 | Jabalia Balad | 58.2 |
| 15 | 230 | Maghazi | 58.1 |
| 16 | 239 | Zohoor | 55.3 |
| 17 | 215 | Nuseirat | 43.3 |
| 18 | 19 | Al Sabrah | 43.2 |
| 19 | 224 | Bureij | 42.9 |
| 20 | 226 | Wadi salqa | 42.0 |
| 21 | 231 | Beit Hanoun | 41.6 |
| 22 | 225 | Zawaydeh | 40.1 |
| 23 | 216 | Al Zahra | 31.9 |
| 24 | 240 | Dier Al Balah | 30.3 |
| 25 | 48 | Maan | 27.0 |
| 26 | 219 | Al Naser | 25.1 |
| 27 | 99 | Al Jninah | 25.0 |
| 28 | 49 | Khan Younis Center | 22.3 |
| 29 | 18 | Tel al-Hawa | 21.5 |
| 30 | 24 | Al Naser | 19.1 |
| 31 | 227 | Moqraqa | 15.0 |
| 32 | 101 | Al Edari | 13.9 |
| 33 | 104 | AlShaborah | 13.7 |
| 34 | 25 | Beach Camp | 5.7 |
| 35 | 97 | Tal AlSoltan | 2.9 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Meningitis**
**Incidence per 100,000**

- 2.9 - 15.0
- 15.1 - 31.9
- 32.0 - 64.0
- 64.1 - 114.3
- 114.4 - 180.2
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
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latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
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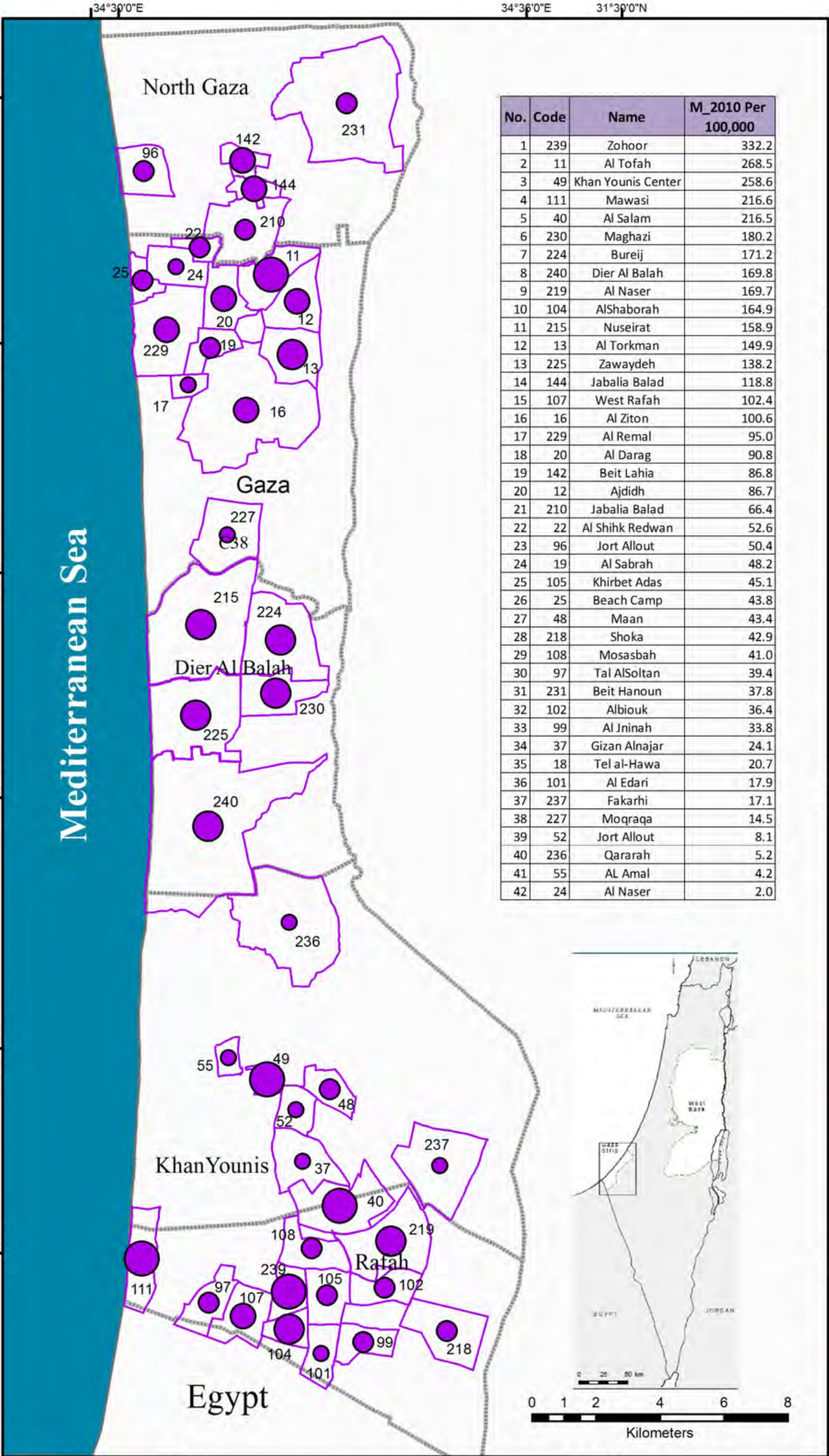
# Meningitis incidence rate in Gaza Strip - MOH 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | M_2010 Per 100,000 |
|---|---|---|---|
| 1 | 239 | Zohoor | 332.2 |
| 2 | 11 | Al Tofah | 268.5 |
| 3 | 49 | Khan Younis Center | 258.6 |
| 4 | 111 | Mawasi | 216.6 |
| 5 | 40 | Al Salam | 216.5 |
| 6 | 230 | Maghazi | 180.2 |
| 7 | 224 | Bureij | 171.2 |
| 8 | 240 | Dier Al Balah | 169.8 |
| 9 | 219 | Al Naser | 169.7 |
| 10 | 104 | AlShaborah | 164.9 |
| 11 | 215 | Nuseirat | 158.9 |
| 12 | 13 | Al Torkman | 149.9 |
| 13 | 225 | Zawaydeh | 138.2 |
| 14 | 144 | Jabalia Balad | 118.8 |
| 15 | 107 | West Rafah | 102.4 |
| 16 | 16 | Al Ziton | 100.6 |
| 17 | 229 | Al Remal | 95.0 |
| 18 | 20 | Al Darag | 90.8 |
| 19 | 142 | Beit Lahia | 86.8 |
| 20 | 12 | Ajdidh | 86.7 |
| 21 | 210 | Jabalia Balad | 66.4 |
| 22 | 22 | Al Shihk Redwan | 52.6 |
| 23 | 96 | Jort Allout | 50.4 |
| 24 | 19 | Al Sabrah | 48.2 |
| 25 | 105 | Khirbet Adas | 45.1 |
| 26 | 25 | Beach Camp | 43.8 |
| 27 | 48 | Maan | 43.4 |
| 28 | 218 | Shoka | 42.9 |
| 29 | 108 | Mosasbah | 41.0 |
| 30 | 97 | Tal AlSoltan | 39.4 |
| 31 | 231 | Beit Hanoun | 37.8 |
| 32 | 102 | Albiouk | 36.4 |
| 33 | 99 | Al Jninah | 33.8 |
| 34 | 37 | Gizan Alnajar | 24.1 |
| 35 | 18 | Tel al-Hawa | 20.7 |
| 36 | 101 | Al Edari | 17.9 |
| 37 | 237 | Fakarhi | 17.1 |
| 38 | 227 | Moqraqa | 14.5 |
| 39 | 52 | Jort Allout | 8.1 |
| 40 | 236 | Qararah | 5.2 |
| 41 | 55 | AL Amal | 4.2 |
| 42 | 24 | Al Naser | 2.0 |

PALESTINIAN WATER AUTHORITY

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## Legend

**Meningitis Incidence per 100,000**

- 2.0 - 24.1
- 24.2 - 66.4
- 66.5 - 118.8
- 118.9 - 180.2
- 180.3 - 332.2
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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**Date: 4/22/2015**

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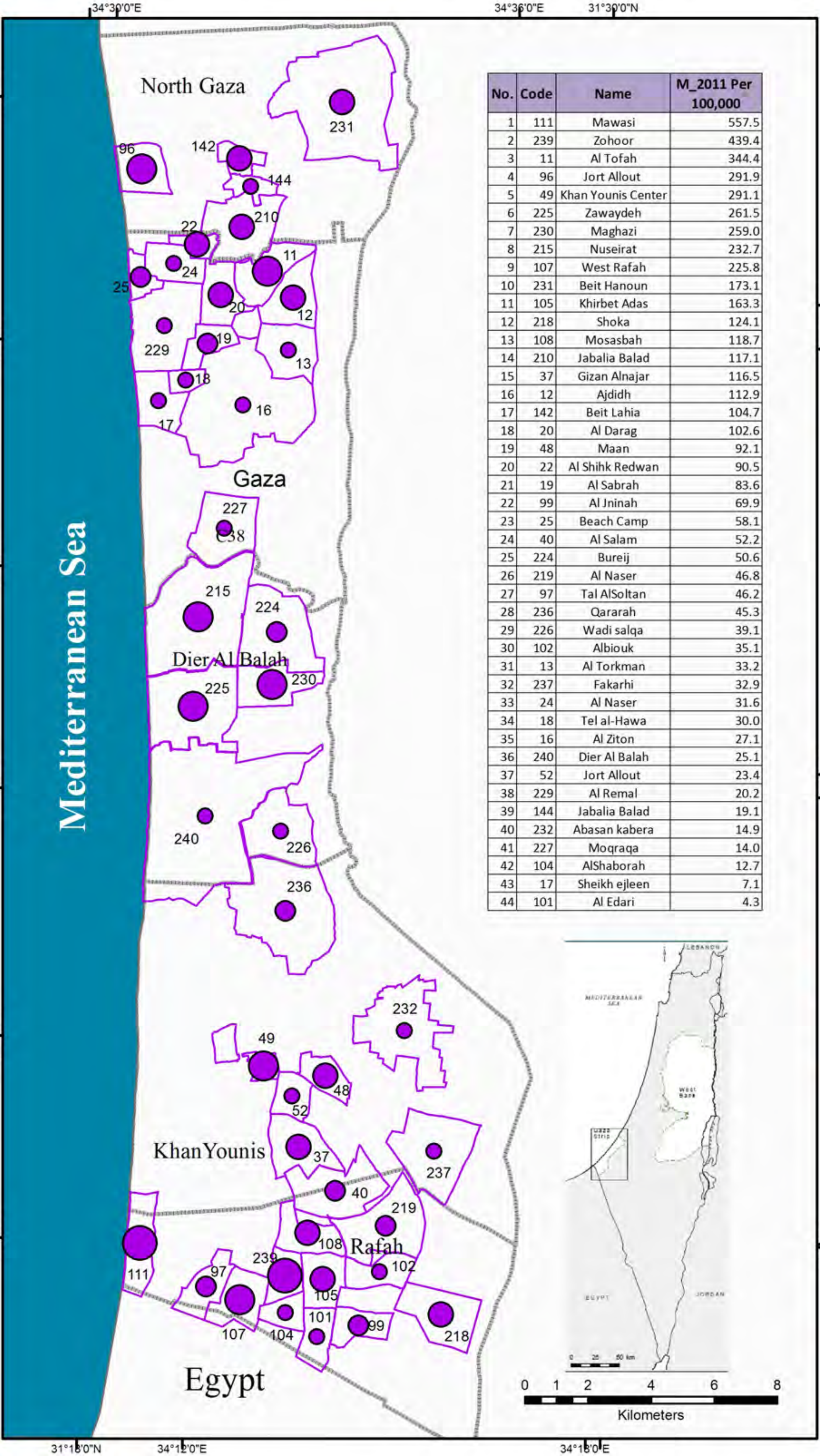
# Meningitis incidence rate in Gaza Strip - MOH 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | M_2011 Per 100,000 |
|---|---|---|---|
| 1 | 111 | Mawasi | 557.5 |
| 2 | 239 | Zohoor | 439.4 |
| 3 | 11 | Al Tofah | 344.4 |
| 4 | 96 | Jort Allout | 291.9 |
| 5 | 49 | Khan Younis Center | 291.1 |
| 6 | 225 | Zawaydeh | 261.5 |
| 7 | 230 | Maghazi | 259.0 |
| 8 | 215 | Nuseirat | 232.7 |
| 9 | 107 | West Rafah | 225.8 |
| 10 | 231 | Beit Hanoun | 173.1 |
| 11 | 105 | Khirbet Adas | 163.3 |
| 12 | 218 | Shoka | 124.1 |
| 13 | 108 | Mosasbah | 118.7 |
| 14 | 210 | Jabalia Balad | 117.1 |
| 15 | 37 | Gizan Alnajar | 116.5 |
| 16 | 12 | Ajdidh | 112.9 |
| 17 | 142 | Beit Lahia | 104.7 |
| 18 | 20 | Al Darag | 102.6 |
| 19 | 48 | Maan | 92.1 |
| 20 | 22 | Al Shihk Redwan | 90.5 |
| 21 | 19 | Al Sabrah | 83.6 |
| 22 | 99 | Al Jninah | 69.9 |
| 23 | 25 | Beach Camp | 58.1 |
| 24 | 40 | Al Salam | 52.2 |
| 25 | 224 | Bureij | 50.6 |
| 26 | 219 | Al Naser | 46.8 |
| 27 | 97 | Tal AlSoltan | 46.2 |
| 28 | 236 | Qararah | 45.3 |
| 29 | 226 | Wadi salqa | 39.1 |
| 30 | 102 | Albiouk | 35.1 |
| 31 | 13 | Al Torkman | 33.2 |
| 32 | 237 | Fakarhi | 32.9 |
| 33 | 24 | Al Naser | 31.6 |
| 34 | 18 | Tel al-Hawa | 30.0 |
| 35 | 16 | Al Ziton | 27.1 |
| 36 | 240 | Dier Al Balah | 25.1 |
| 37 | 52 | Jort Allout | 23.4 |
| 38 | 229 | Al Remal | 20.2 |
| 39 | 144 | Jabalia Balad | 19.1 |
| 40 | 232 | Abasan kabera | 14.9 |
| 41 | 227 | Moqraqa | 14.0 |
| 42 | 104 | AlShaborah | 12.7 |
| 43 | 17 | Sheikh ejleen | 7.1 |
| 44 | 101 | Al Edari | 4.3 |

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PALESTINIAN WATER AUTHORITY

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## Legend

**Meningitis**

**Incidence per 100,000**

- 4.3 - 39.1
- 39.2 - 83.6
- 83.7 - 173.1
- 173.2 - 344.4
- 344.5 - 557.5
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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# Meningitis incidence rate in Gaza Strip - MOH 2012

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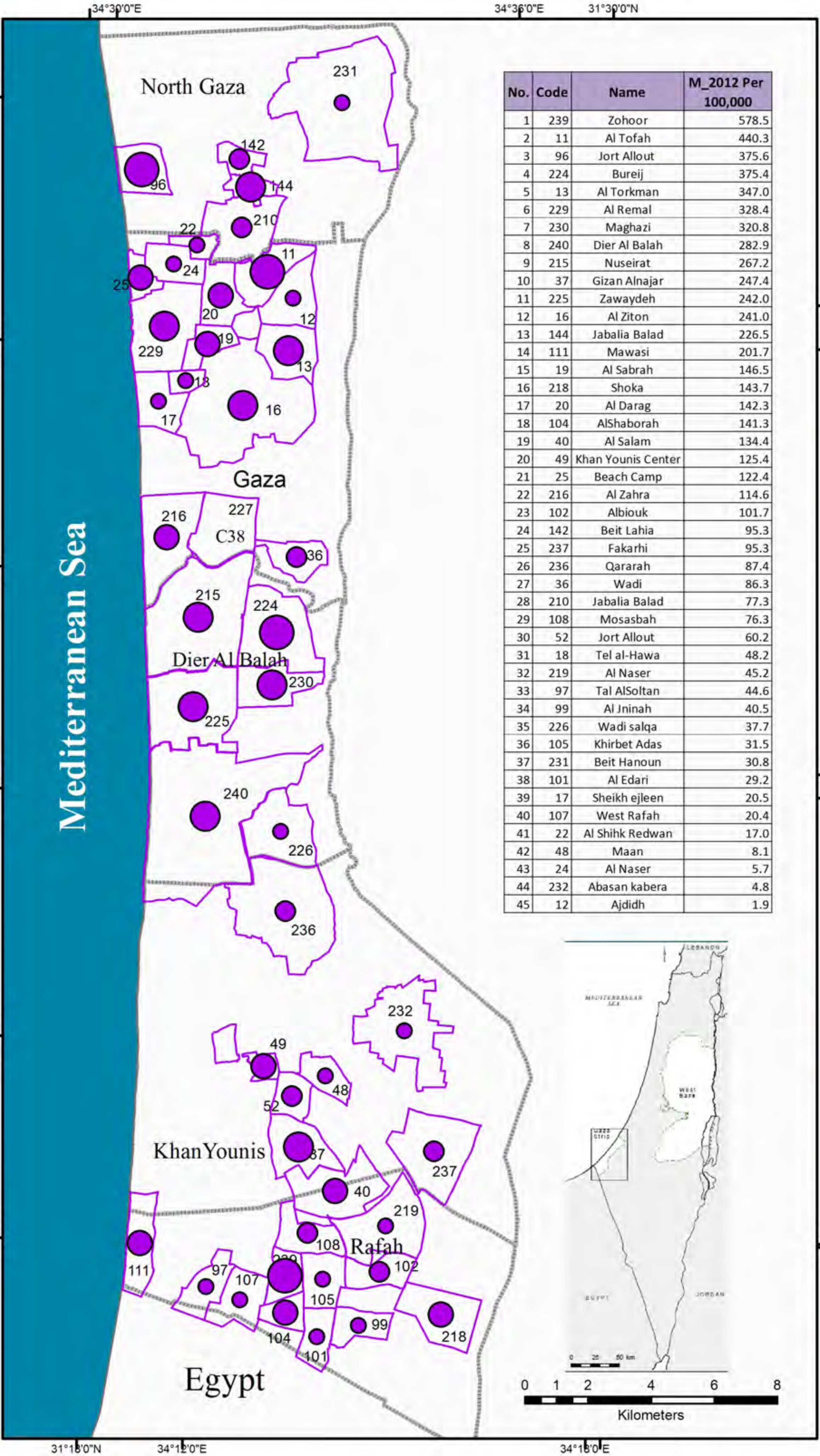


| No. | Code | Name | M_2012 Per 100,000 |
|---|---|---|---|
| 1 | 239 | Zohoor | 578.5 |
| 2 | 11 | Al Tofah | 440.3 |
| 3 | 96 | Jort Allout | 375.6 |
| 4 | 224 | Bureij | 375.4 |
| 5 | 13 | Al Torkman | 347.0 |
| 6 | 229 | Al Remal | 328.4 |
| 7 | 230 | Maghazi | 320.8 |
| 8 | 240 | Dier Al Balah | 282.9 |
| 9 | 215 | Nuseirat | 267.2 |
| 10 | 37 | Gizan Alnajar | 247.4 |
| 11 | 225 | Zawaydeh | 242.0 |
| 12 | 16 | Al Ziton | 241.0 |
| 13 | 144 | Jabalia Balad | 226.5 |
| 14 | 111 | Mawasi | 201.7 |
| 15 | 19 | Al Sabrah | 146.5 |
| 16 | 218 | Shoka | 143.7 |
| 17 | 20 | Al Darag | 142.3 |
| 18 | 104 | AlShaborah | 141.3 |
| 19 | 40 | Al Salam | 134.4 |
| 20 | 49 | Khan Younis Center | 125.4 |
| 21 | 25 | Beach Camp | 122.4 |
| 22 | 216 | Al Zahra | 114.6 |
| 23 | 102 | Albiouk | 101.7 |
| 24 | 142 | Beit Lahia | 95.3 |
| 25 | 237 | Fakarhi | 95.3 |
| 26 | 236 | Qararah | 87.4 |
| 27 | 36 | Wadi | 86.3 |
| 28 | 210 | Jabalia Balad | 77.3 |
| 29 | 108 | Mosasbah | 76.3 |
| 30 | 52 | Jort Allout | 60.2 |
| 31 | 18 | Tel al-Hawa | 48.2 |
| 32 | 219 | Al Naser | 45.2 |
| 33 | 97 | Tal AlSoltan | 44.6 |
| 34 | 99 | Al Jninah | 40.5 |
| 35 | 226 | Wadi salqa | 37.7 |
| 36 | 105 | Khirbet Adas | 31.5 |
| 37 | 231 | Beit Hanoun | 30.8 |
| 38 | 101 | Al Edari | 29.2 |
| 39 | 17 | Sheikh ejleen | 20.5 |
| 40 | 107 | West Rafah | 20.4 |
| 41 | 22 | Al Shihk Redwan | 17.0 |
| 42 | 48 | Maan | 8.1 |
| 43 | 24 | Al Naser | 5.7 |
| 44 | 232 | Abasan kabera | 4.8 |
| 45 | 12 | Ajdidh | 1.9 |

## Legend

**Meningitis**

**Incidence per 100,000**

- 1.9 - 48.2
- 48.3 - 101.7
- 101.8 - 201.7
- 201.8 - 347.0
- 347.1 - 578.5
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
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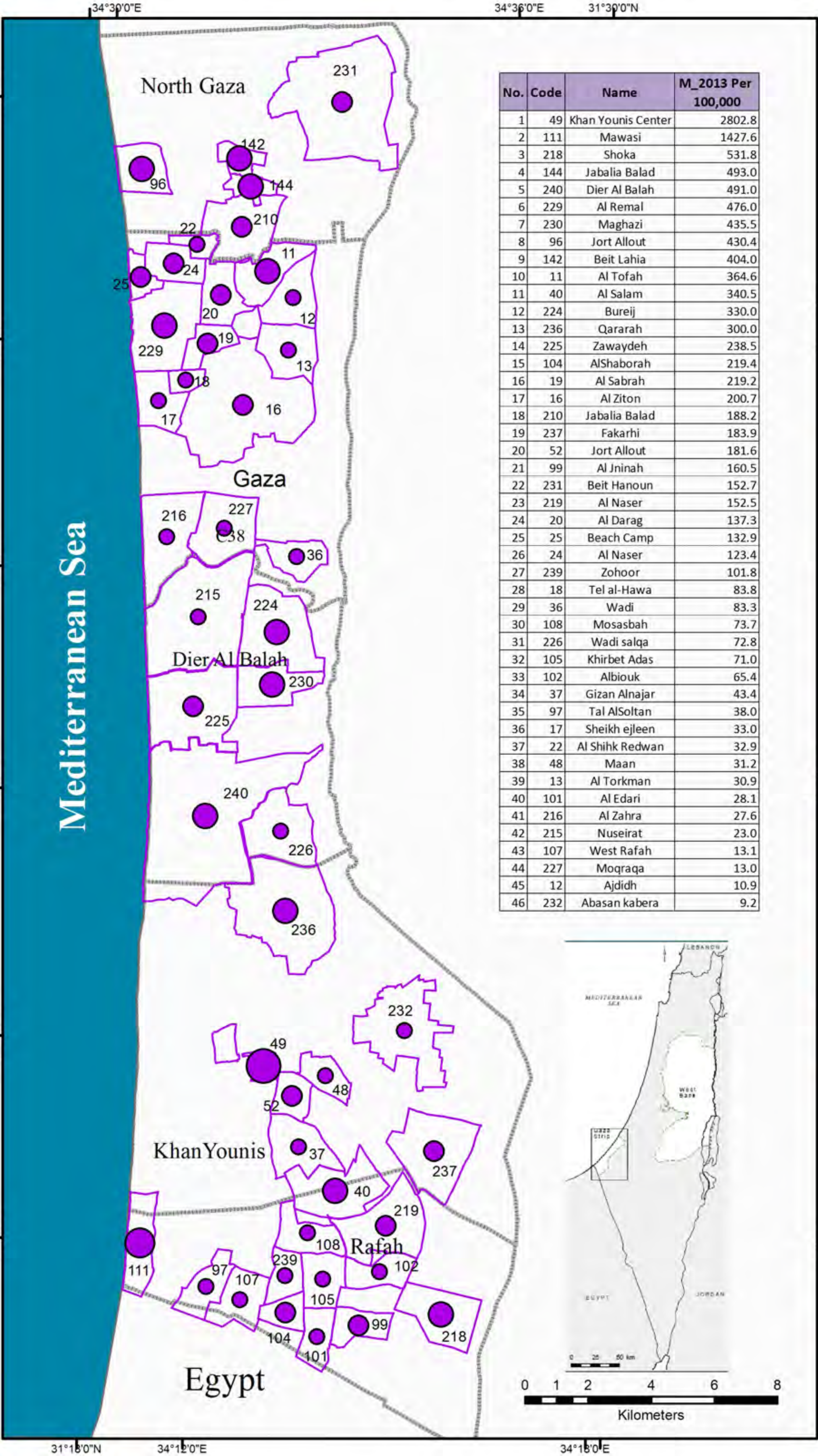
# Meningitis incidence rate in Gaza Strip - MOH 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | M_2013 Per 100,000 |
|---|---|---|---|
| 1 | 49 | Khan Younis Center | 2802.8 |
| 2 | 111 | Mawasi | 1427.6 |
| 3 | 218 | Shoka | 531.8 |
| 4 | 144 | Jabalia Balad | 493.0 |
| 5 | 240 | Dier Al Balah | 491.0 |
| 6 | 229 | Al Remal | 476.0 |
| 7 | 230 | Maghazi | 435.5 |
| 8 | 96 | Jort Allout | 430.4 |
| 9 | 142 | Beit Lahia | 404.0 |
| 10 | 11 | Al Tofah | 364.6 |
| 11 | 40 | Al Salam | 340.5 |
| 12 | 224 | Bureij | 330.0 |
| 13 | 236 | Qararah | 300.0 |
| 14 | 225 | Zawaydeh | 238.5 |
| 15 | 104 | AlShaborah | 219.4 |
| 16 | 19 | Al Sabrah | 219.2 |
| 17 | 16 | Al Ziton | 200.7 |
| 18 | 210 | Jabalia Balad | 188.2 |
| 19 | 237 | Fakarhi | 183.9 |
| 20 | 52 | Jort Allout | 181.6 |
| 21 | 99 | Al Jninah | 160.5 |
| 22 | 231 | Beit Hanoun | 152.7 |
| 23 | 219 | Al Naser | 152.5 |
| 24 | 20 | Al Darag | 137.3 |
| 25 | 25 | Beach Camp | 132.9 |
| 26 | 24 | Al Naser | 123.4 |
| 27 | 239 | Zohoor | 101.8 |
| 28 | 18 | Tel al-Hawa | 83.8 |
| 29 | 36 | Wadi | 83.3 |
| 30 | 108 | Mosasbah | 73.7 |
| 31 | 226 | Wadi salqa | 72.8 |
| 32 | 105 | Khirbet Adas | 71.0 |
| 33 | 102 | Albiouk | 65.4 |
| 34 | 37 | Gizan Alnajar | 43.4 |
| 35 | 97 | Tal AlSoltan | 38.0 |
| 36 | 17 | Sheikh ejleen | 33.0 |
| 37 | 22 | Al Shihk Redwan | 32.9 |
| 38 | 48 | Maan | 31.2 |
| 39 | 13 | Al Torkman | 30.9 |
| 40 | 101 | Al Edari | 28.1 |
| 41 | 216 | Al Zahra | 27.6 |
| 42 | 215 | Nuseirat | 23.0 |
| 43 | 107 | West Rafah | 13.1 |
| 44 | 227 | Moqraqa | 13.0 |
| 45 | 12 | Ajdidh | 10.9 |
| 46 | 232 | Abasan kabera | 9.2 |

PALESTINIAN WATER AUTHORITY

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## Legend

**Meningitis**

**Incidence per 100,000**

- 9.2 - 101.8
- 101.9 - 238.5
- 238.6 - 531.8
- 531.9 - 1,427.6
- 1,427.7 - 2,802.8
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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**Date: 4/22/2015**

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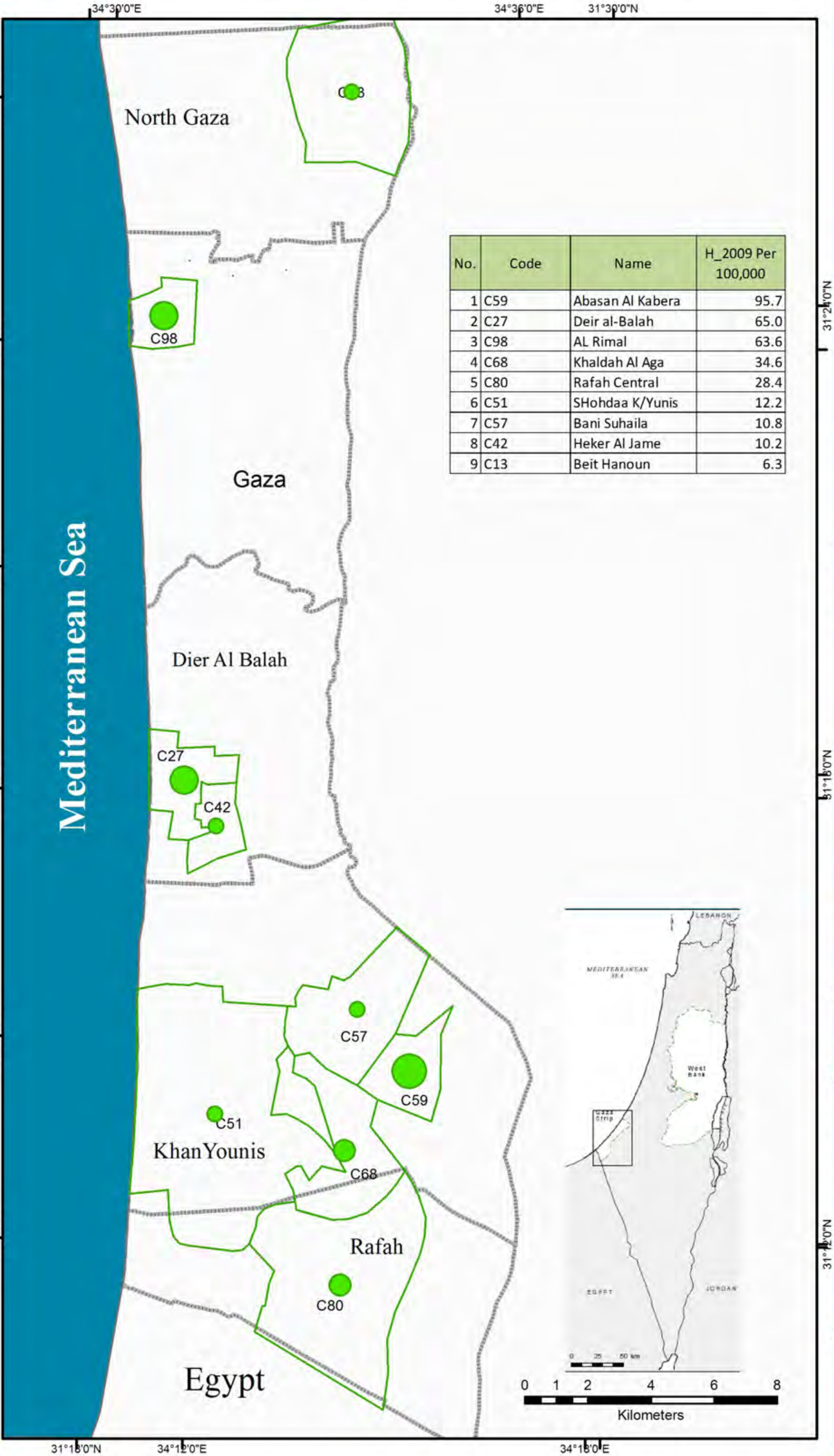
# Hepatitis (A) incidence rate in Gaza Strip - MOH 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | H_2009 Per 100,000 |
|---|---|---|---|
| 1 | C59 | Abasan Al Kabera | 95.7 |
| 2 | C27 | Deir al-Balah | 65.0 |
| 3 | C98 | AL Rimal | 63.6 |
| 4 | C68 | Khaldah Al Aga | 34.6 |
| 5 | C80 | Rafah Central | 28.4 |
| 6 | C51 | SHohdaa K/Yunis | 12.2 |
| 7 | C57 | Bani Suhaila | 10.8 |
| 8 | C42 | Heker Al Jame | 10.2 |
| 9 | C13 | Beit Hanoun | 6.3 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 6.3 - 12.2
- 12.3 - 34.6
- 34.7 - 65.0
- 65.1 - 95.7
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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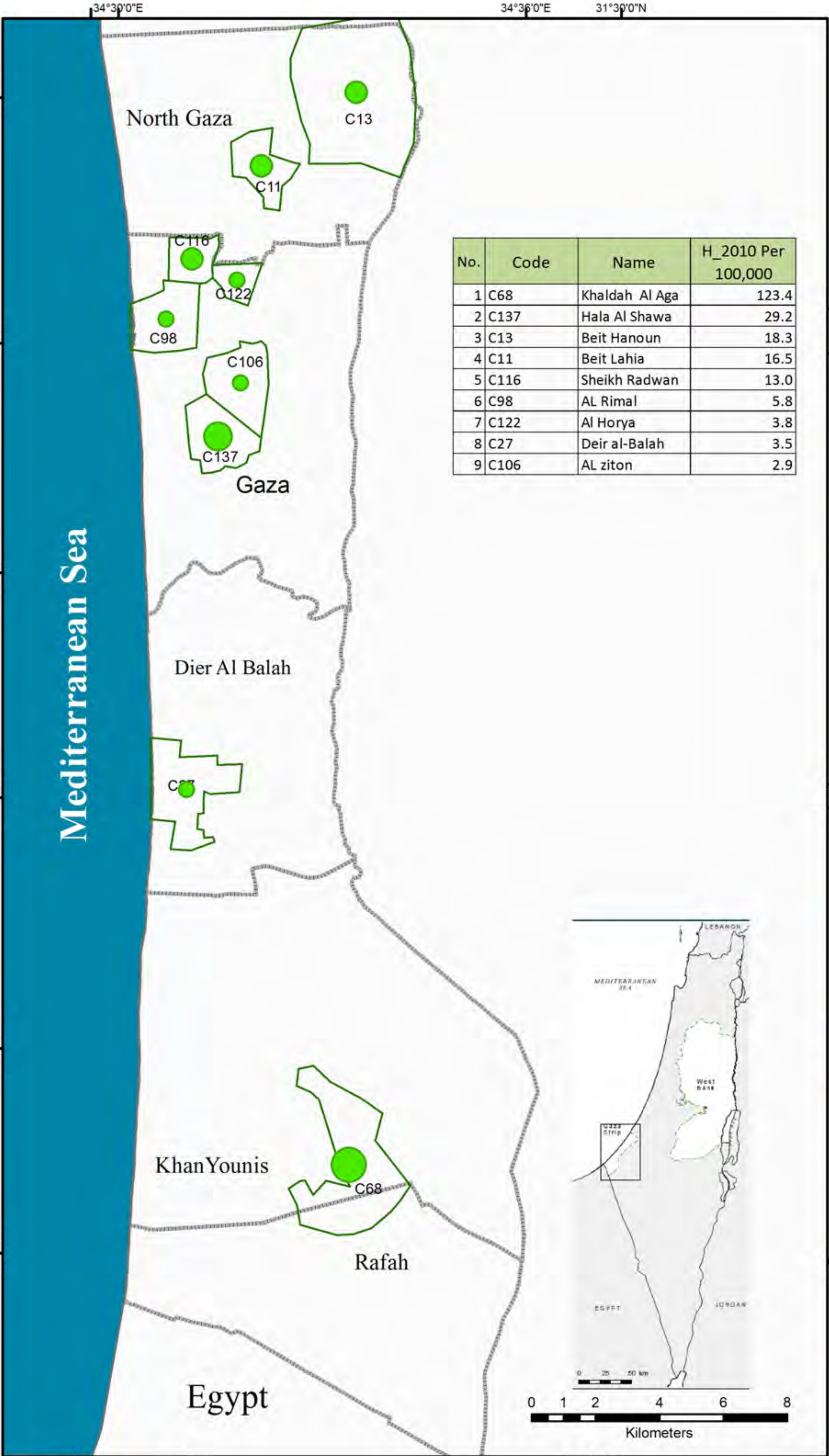
# Hepatitis (A) incidence rate in Gaza Strip - MOH 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | H_2010 Per 100,000 |
|---|---|---|---|
| 1 | C68 | Khaldah Al Aga | 123.4 |
| 2 | C137 | Hala Al Shawa | 29.2 |
| 3 | C13 | Beit Hanoun | 18.3 |
| 4 | C11 | Beit Lahia | 16.5 |
| 5 | C116 | Sheikh Radwan | 13.0 |
| 6 | C98 | AL Rimal | 5.8 |
| 7 | C122 | Al Horya | 3.8 |
| 8 | C27 | Deir al-Balah | 3.5 |
| 9 | C106 | AL ziton | 2.9 |

سلطة المياه الفلسطينية
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N E S W

## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 2.9 - 5.8
- 5.9 - 18.3
- 18.4 - 29.2
- 29.3 - 123.4
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

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# Hepatitis (A) incidence rate in Gaza Strip - MOH 2011

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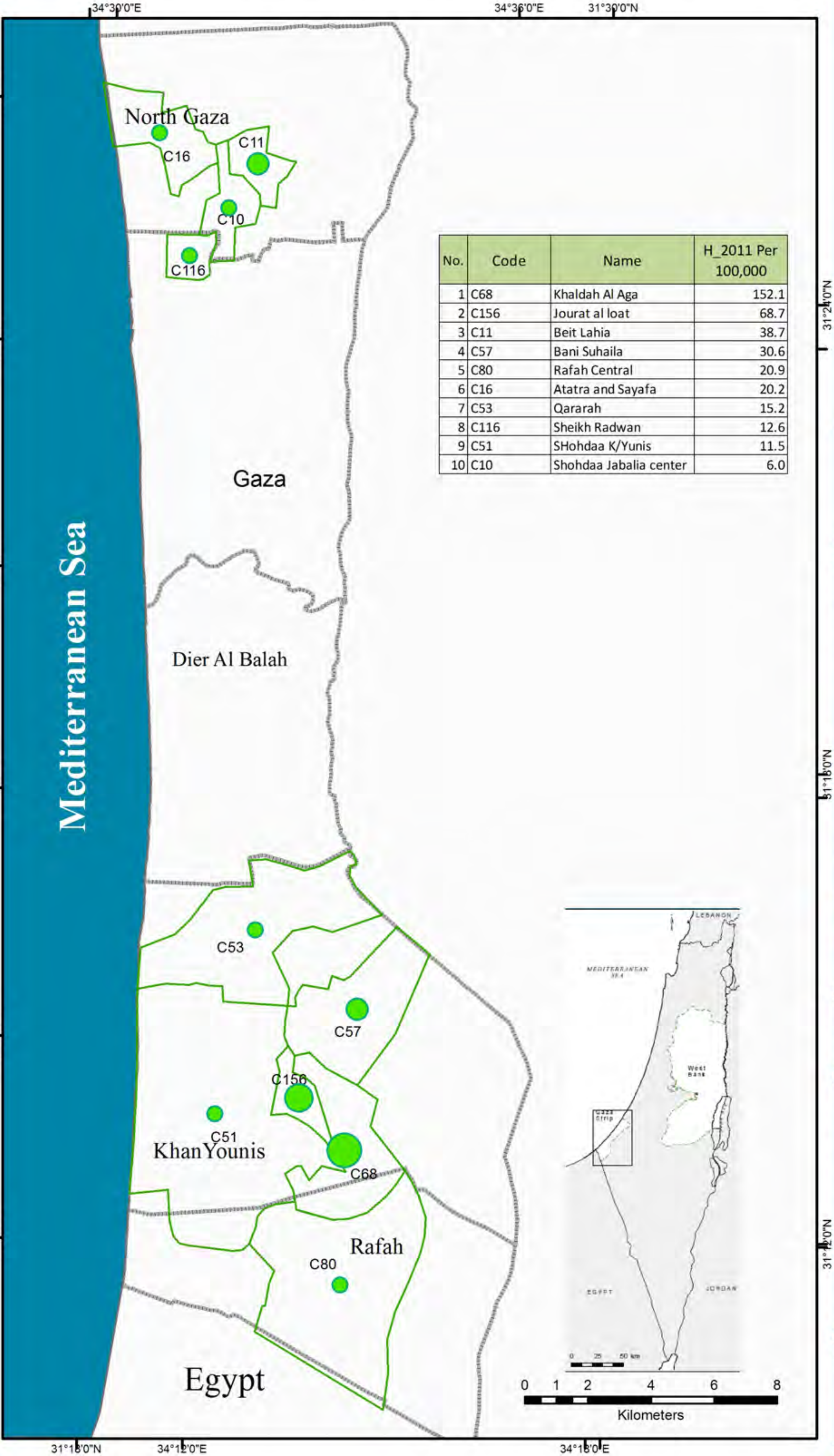


| No. | Code | Name | H_2011 Per 100,000 |
|---|---|---|---|
| 1 | C68 | Khaldah Al Aga | 152.1 |
| 2 | C156 | Jourat al loat | 68.7 |
| 3 | C11 | Beit Lahia | 38.7 |
| 4 | C57 | Bani Suhaila | 30.6 |
| 5 | C80 | Rafah Central | 20.9 |
| 6 | C16 | Atatra and Sayafa | 20.2 |
| 7 | C53 | Qararah | 15.2 |
| 8 | C116 | Sheikh Radwan | 12.6 |
| 9 | C51 | SHohdaa K/Yunis | 11.5 |
| 10 | C10 | Shohdaa Jabalia center | 6.0 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 6.0 - 20.9
- 21.0 - 38.7
- 38.8 - 68.7
- 68.8 - 152.1
- Catchment Area
- Governorate
- Sea

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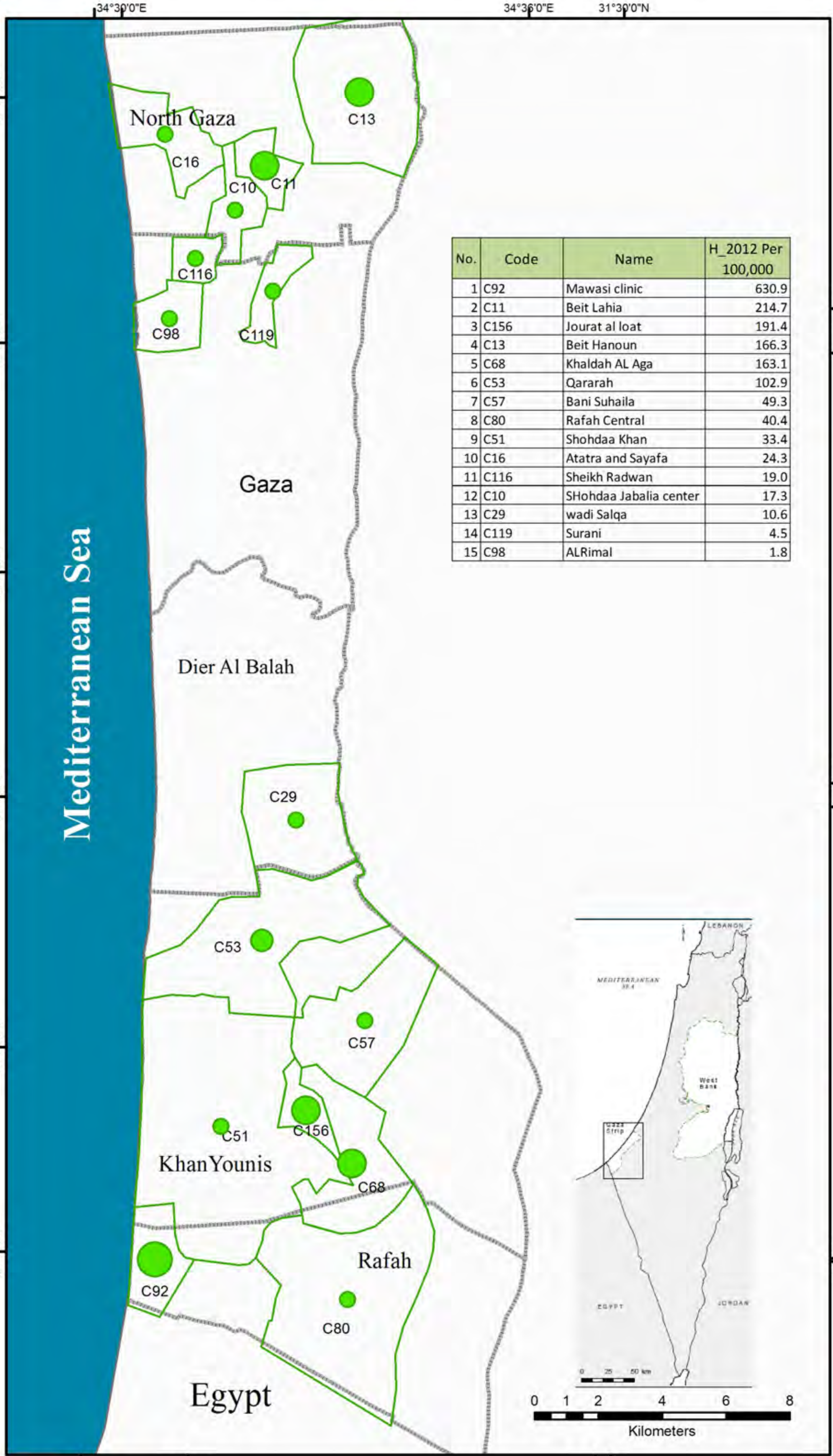



| No. | Code | Name | H_2012 Per 100,000 |
|---|---|---|---|
| 1 | C92 | Mawasi clinic | 630.9 |
| 2 | C11 | Beit Lahia | 214.7 |
| 3 | C156 | Jourat al loat | 191.4 |
| 4 | C13 | Beit Hanoun | 166.3 |
| 5 | C68 | Khaldah AL Aga | 163.1 |
| 6 | C53 | Qararah | 102.9 |
| 7 | C57 | Bani Suhaila | 49.3 |
| 8 | C80 | Rafah Central | 40.4 |
| 9 | C51 | Shohdaa Khan | 33.4 |
| 10 | C16 | Atatra and Sayafa | 24.3 |
| 11 | C116 | Sheikh Radwan | 19.0 |
| 12 | C10 | SHohdaa Jabalia center | 17.3 |
| 13 | C29 | wadi Salqa | 10.6 |
| 14 | C119 | Surani | 4.5 |
| 15 | C98 | ALRimal | 1.8 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 1.8 - 49.3
- 49.4 - 102.9
- 103.0 - 214.7
- 214.8 - 630.9
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

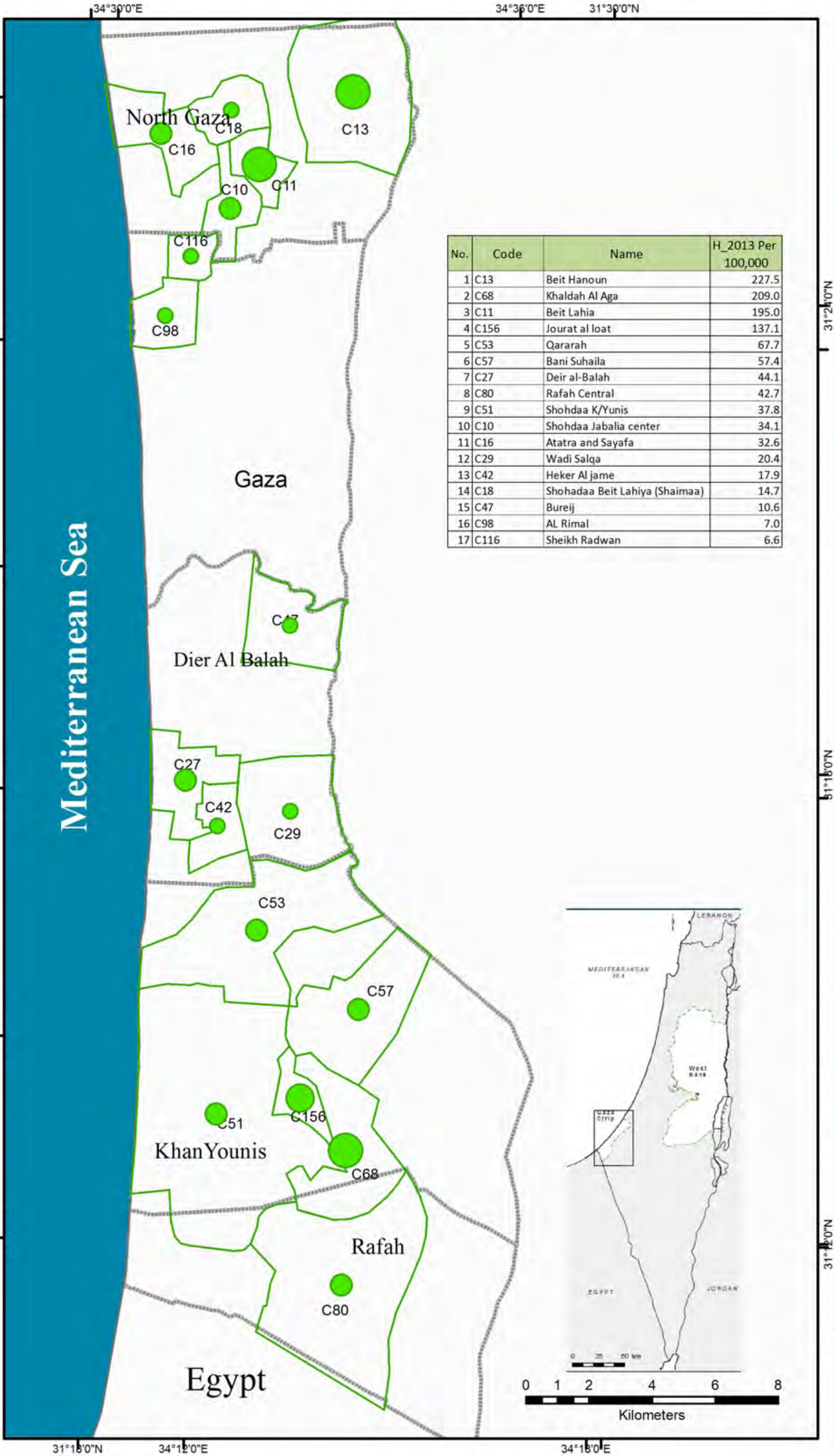
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Hepatitis (A) incidence rate in Gaza Strip - MOH 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | H_2013 Per 100,000 |
|---|---|---|---|
| 1 | C13 | Beit Hanoun | 227.5 |
| 2 | C68 | Khaldah Al Aga | 209.0 |
| 3 | C11 | Beit Lahia | 195.0 |
| 4 | C156 | Jourat al loat | 137.1 |
| 5 | C53 | Qararah | 67.7 |
| 6 | C57 | Bani Suhaila | 57.4 |
| 7 | C27 | Deir al-Balah | 44.1 |
| 8 | C80 | Rafah Central | 42.7 |
| 9 | C51 | Shohdaa K/Yunis | 37.8 |
| 10 | C10 | Shohdaa Jabalia center | 34.1 |
| 11 | C16 | Atatra and Sayafa | 32.6 |
| 12 | C29 | Wadi Salqa | 20.4 |
| 13 | C42 | Heker Al jame | 17.9 |
| 14 | C18 | Shohadaa Beit Lahiya (Shaimaa) | 14.7 |
| 15 | C47 | Bureij | 10.6 |
| 16 | C98 | AL Rimal | 7.0 |
| 17 | C116 | Sheikh Radwan | 6.6 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 6.6 - 20.4
- 20.5 - 67.7
- 67.8 - 137.1
- 137.2 - 227.5
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

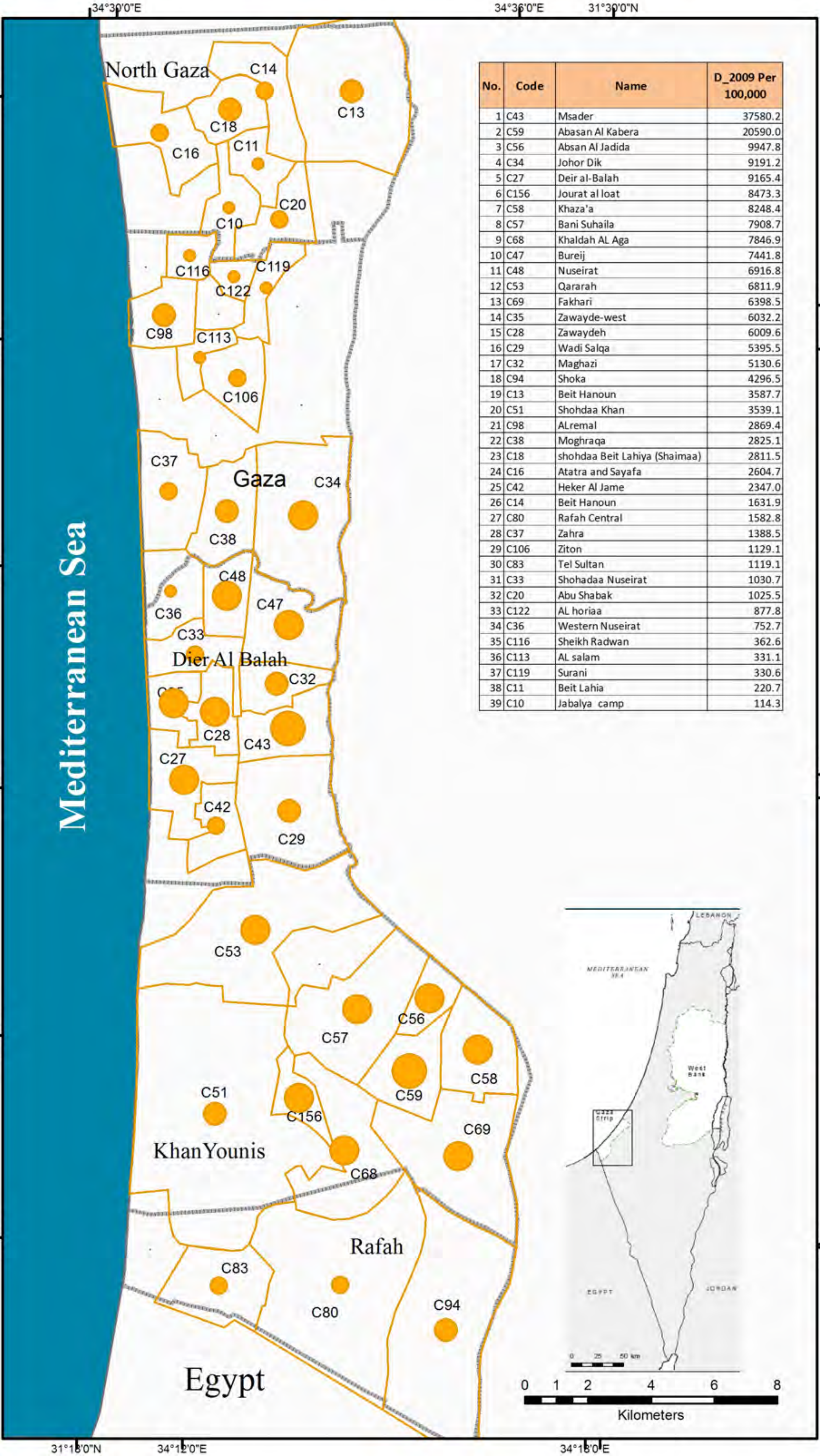
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# Diarrheal incidence rate in Gaza Strip - MOH 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2009 Per 100,000 |
|---|---|---|---|
| 1 | C43 | Msader | 37580.2 |
| 2 | C59 | Abasan Al Kabera | 20590.0 |
| 3 | C56 | Absan Al Jadida | 9947.8 |
| 4 | C34 | Johor Dik | 9191.2 |
| 5 | C27 | Deir al-Balah | 9165.4 |
| 6 | C156 | Jourat al loat | 8473.3 |
| 7 | C58 | Khaza'a | 8248.4 |
| 8 | C57 | Bani Suhaila | 7908.7 |
| 9 | C68 | Khaldah AL Aga | 7846.9 |
| 10 | C47 | Bureij | 7441.8 |
| 11 | C48 | Nuseirat | 6916.8 |
| 12 | C53 | Qararah | 6811.9 |
| 13 | C69 | Fakhari | 6398.5 |
| 14 | C35 | Zawayde-west | 6032.2 |
| 15 | C28 | Zawaydeh | 6009.6 |
| 16 | C29 | Wadi Salqa | 5395.5 |
| 17 | C32 | Maghazi | 5130.6 |
| 18 | C94 | Shoka | 4296.5 |
| 19 | C13 | Beit Hanoun | 3587.7 |
| 20 | C51 | Shohdaa Khan | 3539.1 |
| 21 | C98 | ALremal | 2869.4 |
| 22 | C38 | Moghraqa | 2825.1 |
| 23 | C18 | shohdaa Beit Lahiya (Shaimaa) | 2811.5 |
| 24 | C16 | Atatra and Sayafa | 2604.7 |
| 25 | C42 | Heker Al Jame | 2347.0 |
| 26 | C14 | Beit Hanoun | 1631.9 |
| 27 | C80 | Rafah Central | 1582.8 |
| 28 | C37 | Zahra | 1388.5 |
| 29 | C106 | Ziton | 1129.1 |
| 30 | C83 | Tel Sultan | 1119.1 |
| 31 | C33 | Shohadaa Nuseirat | 1030.7 |
| 32 | C20 | Abu Shabak | 1025.5 |
| 33 | C122 | AL horiaa | 877.8 |
| 34 | C36 | Western Nuseirat | 752.7 |
| 35 | C116 | Sheikh Radwan | 362.6 |
| 36 | C113 | AL salam | 331.1 |
| 37 | C119 | Surani | 330.6 |
| 38 | C11 | Beit Lahia | 220.7 |
| 39 | C10 | Jabalya camp | 114.3 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Diarrheal**

- 114.3 - 877.8
- 877.9 - 2,604.7
- 2,604.8 - 5,395.5
- 5,395.6 - 9,947.8
- 9,947.9 - 37,580.2

Catchment Area

Governorate

Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

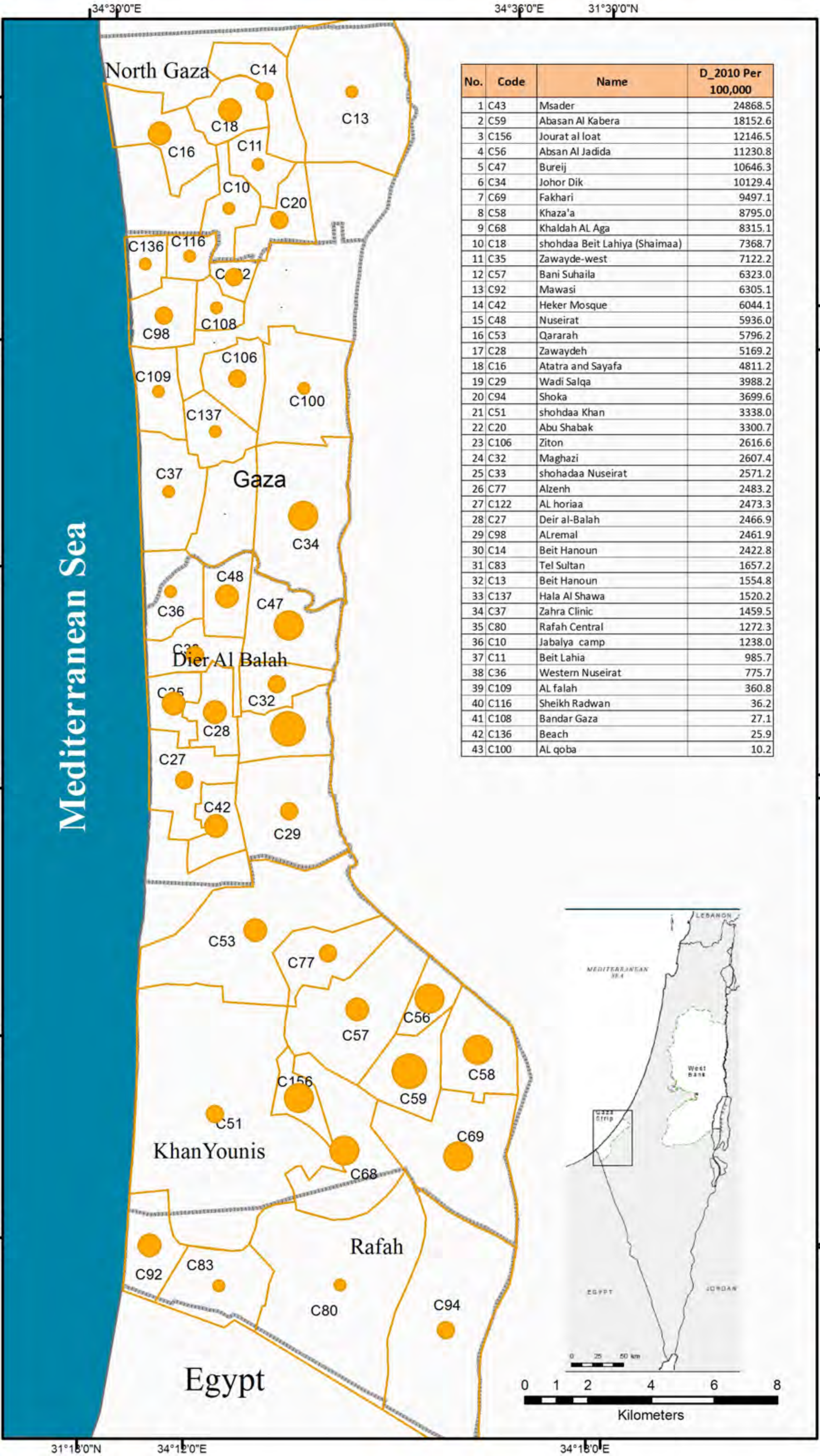
**Date: 4/22/2015**

**Funded by:**

Austrian Development Agency

# Diarrheal incidence rate in Gaza Strip - MOH 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2010 Per 100,000 |
|---|---|---|---|
| 1 | C43 | Msader | 24868.5 |
| 2 | C59 | Abasan Al Kabera | 18152.6 |
| 3 | C156 | Jourat al loat | 12146.5 |
| 4 | C56 | Absan Al Jadida | 11230.8 |
| 5 | C47 | Bureij | 10646.3 |
| 6 | C34 | Johor Dik | 10129.4 |
| 7 | C69 | Fakhari | 9497.1 |
| 8 | C58 | Khaza'a | 8795.0 |
| 9 | C68 | Khaldah AL Aga | 8315.1 |
| 10 | C18 | shohdaa Beit Lahiya (Shaimaa) | 7368.7 |
| 11 | C35 | Zawayde-west | 7122.2 |
| 12 | C57 | Bani Suhaila | 6323.0 |
| 13 | C92 | Mawasi | 6305.1 |
| 14 | C42 | Heker Mosque | 6044.1 |
| 15 | C48 | Nuseirat | 5936.0 |
| 16 | C53 | Qararah | 5796.2 |
| 17 | C28 | Zawaydeh | 5169.2 |
| 18 | C16 | Atatra and Sayafa | 4811.2 |
| 19 | C29 | Wadi Salqa | 3988.2 |
| 20 | C94 | Shoka | 3699.6 |
| 21 | C51 | shohdaa Khan | 3338.0 |
| 22 | C20 | Abu Shabak | 3300.7 |
| 23 | C106 | Ziton | 2616.6 |
| 24 | C32 | Maghazi | 2607.4 |
| 25 | C33 | shohadaa Nuseirat | 2571.2 |
| 26 | C77 | Alzenh | 2483.2 |
| 27 | C122 | AL horiaa | 2473.3 |
| 28 | C27 | Deir al-Balah | 2466.9 |
| 29 | C98 | ALremal | 2461.9 |
| 30 | C14 | Beit Hanoun | 2422.8 |
| 31 | C83 | Tel Sultan | 1657.2 |
| 32 | C13 | Beit Hanoun | 1554.8 |
| 33 | C137 | Hala Al Shawa | 1520.2 |
| 34 | C37 | Zahra Clinic | 1459.5 |
| 35 | C80 | Rafah Central | 1272.3 |
| 36 | C10 | Jabalya camp | 1238.0 |
| 37 | C11 | Beit Lahia | 985.7 |
| 38 | C36 | Western Nuseirat | 775.7 |
| 39 | C109 | AL falah | 360.8 |
| 40 | C116 | Sheikh Radwan | 36.2 |
| 41 | C108 | Bandar Gaza | 27.1 |
| 42 | C136 | Beach | 25.9 |
| 43 | C100 | AL qoba | 10.2 |

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## Legend

**Diarrheal Incidence per 100,000**

- 10.2 - 1,657.2
- 1,657.3 - 3,988.2
- 3,988.3 - 7,368.7
- 7,368.8 - 12,146.5
- 12,146.6 - 24,868.5
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

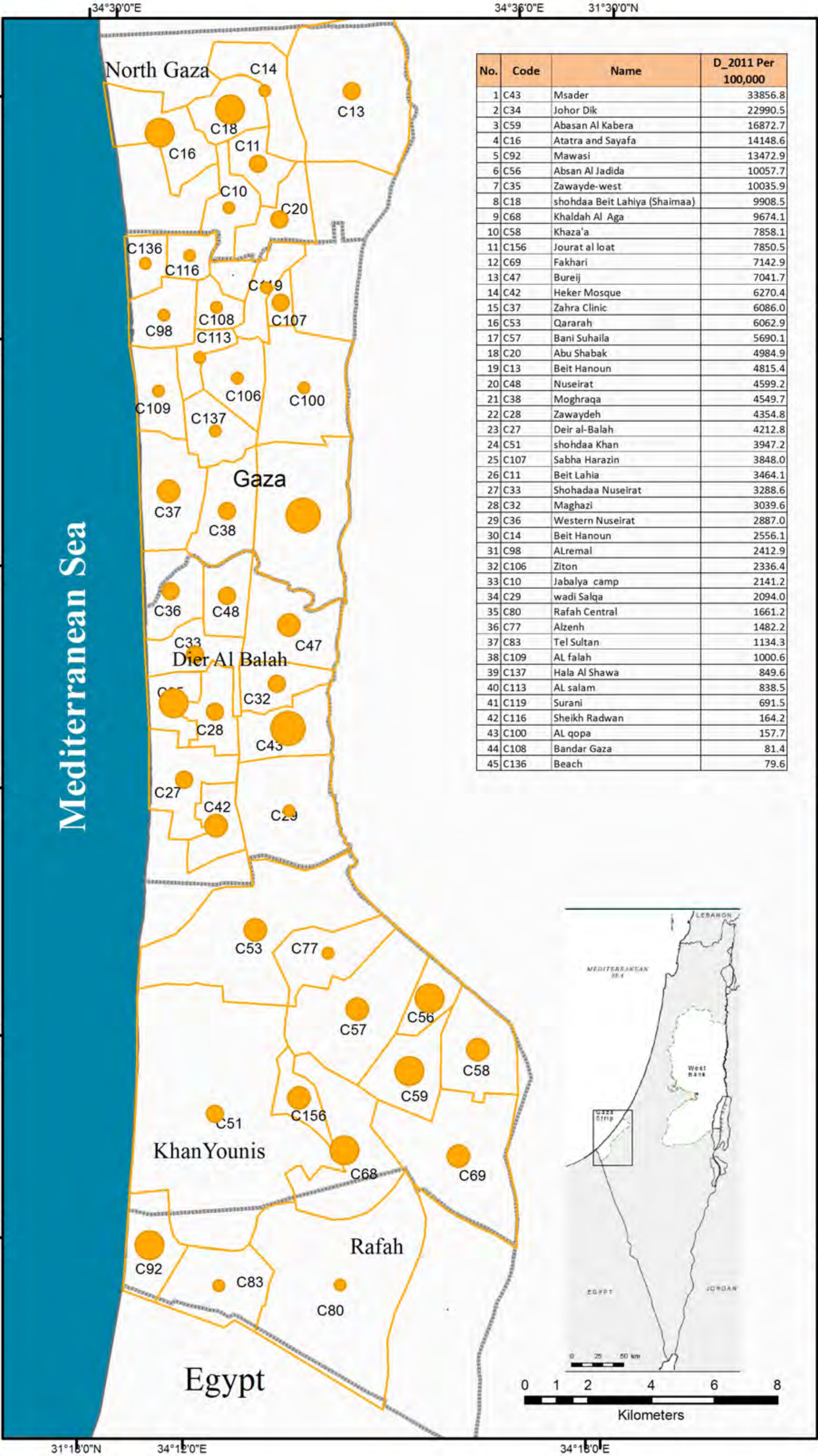
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# Diarrheal incidence rate in Gaza Strip - MOH 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2011 Per 100,000 |
|---|---|---|---|
| 1 | C43 | Msader | 33856.8 |
| 2 | C34 | Johor Dik | 22990.5 |
| 3 | C59 | Abasan Al Kabera | 16872.7 |
| 4 | C16 | Atatra and Sayafa | 14148.6 |
| 5 | C92 | Mawasi | 13472.9 |
| 6 | C56 | Absan Al Jadida | 10057.7 |
| 7 | C35 | Zawayde-west | 10035.9 |
| 8 | C18 | shohdaa Beit Lahiya (Shaimaa) | 9908.5 |
| 9 | C68 | Khaldah Al Aga | 9674.1 |
| 10 | C58 | Khaza'a | 7858.1 |
| 11 | C156 | Jourat al loat | 7850.5 |
| 12 | C69 | Fakhari | 7142.9 |
| 13 | C47 | Bureij | 7041.7 |
| 14 | C42 | Heker Mosque | 6270.4 |
| 15 | C37 | Zahra Clinic | 6086.0 |
| 16 | C53 | Qararah | 6062.9 |
| 17 | C57 | Bani Suhaila | 5690.1 |
| 18 | C20 | Abu Shabak | 4984.9 |
| 19 | C13 | Beit Hanoun | 4815.4 |
| 20 | C48 | Nuseirat | 4599.2 |
| 21 | C38 | Moghraqa | 4549.7 |
| 22 | C28 | Zawaydeh | 4354.8 |
| 23 | C27 | Deir al-Balah | 4212.8 |
| 24 | C51 | shohdaa Khan | 3947.2 |
| 25 | C107 | Sabha Harazin | 3848.0 |
| 26 | C11 | Beit Lahia | 3464.1 |
| 27 | C33 | Shohadaa Nuseirat | 3288.6 |
| 28 | C32 | Maghazi | 3039.6 |
| 29 | C36 | Western Nuseirat | 2887.0 |
| 30 | C14 | Beit Hanoun | 2556.1 |
| 31 | C98 | ALremal | 2412.9 |
| 32 | C106 | Ziton | 2336.4 |
| 33 | C10 | Jabalya camp | 2141.2 |
| 34 | C29 | wadi Salqa | 2094.0 |
| 35 | C80 | Rafah Central | 1661.2 |
| 36 | C77 | Alzenh | 1482.2 |
| 37 | C83 | Tel Sultan | 1134.3 |
| 38 | C109 | AL falah | 1000.6 |
| 39 | C137 | Hala Al Shawa | 849.6 |
| 40 | C113 | AL salam | 838.5 |
| 41 | C119 | Surani | 691.5 |
| 42 | C116 | Sheikh Radwan | 164.2 |
| 43 | C100 | AL qopa | 157.7 |
| 44 | C108 | Bandar Gaza | 81.4 |
| 45 | C136 | Beach | 79.6 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

## Legend

**Diarrheal**

**Incidence per 100,000**

- 79.6 - 2,556.1
- 2,556.2 - 4,984.9
- 4,985.0 - 7,858.1
- 7,858.2 - 16,872.7
- 16,872.8 - 33,856.8
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

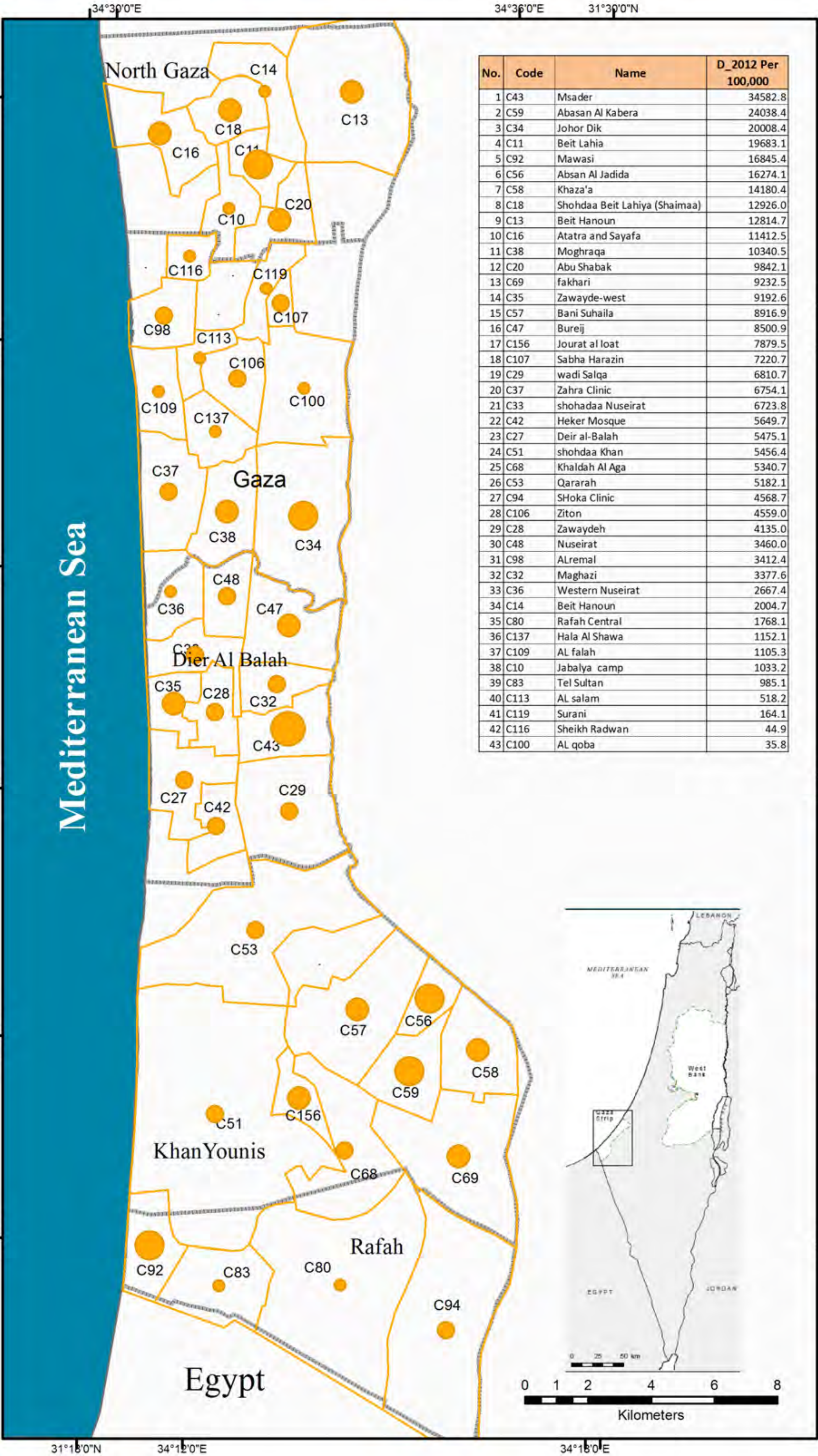
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Diarrheal incidence rate in Gaza Strip - MOH 2012

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2012 Per 100,000 |
|---|---|---|---|
| 1 | C43 | Msader | 34582.8 |
| 2 | C59 | Abasan Al Kabera | 24038.4 |
| 3 | C34 | Johor Dik | 20008.4 |
| 4 | C11 | Beit Lahia | 19683.1 |
| 5 | C92 | Mawasi | 16845.4 |
| 6 | C56 | Absan Al Jadida | 16274.1 |
| 7 | C58 | Khaza'a | 14180.4 |
| 8 | C18 | Shohdaa Beit Lahiya (Shaimaa) | 12926.0 |
| 9 | C13 | Beit Hanoun | 12814.7 |
| 10 | C16 | Atatra and Sayafa | 11412.5 |
| 11 | C38 | Moghraqa | 10340.5 |
| 12 | C20 | Abu Shabak | 9842.1 |
| 13 | C69 | fakhari | 9232.5 |
| 14 | C35 | Zawayde-west | 9192.6 |
| 15 | C57 | Bani Suhaila | 8916.9 |
| 16 | C47 | Bureij | 8500.9 |
| 17 | C156 | Jourat al loat | 7879.5 |
| 18 | C107 | Sabha Harazin | 7220.7 |
| 19 | C29 | wadi Salqa | 6810.7 |
| 20 | C37 | Zahra Clinic | 6754.1 |
| 21 | C33 | shohadaa Nuseirat | 6723.8 |
| 22 | C42 | Heker Mosque | 5649.7 |
| 23 | C27 | Deir al-Balah | 5475.1 |
| 24 | C51 | shohdaa Khan | 5456.4 |
| 25 | C68 | Khaldah Al Aga | 5340.7 |
| 26 | C53 | Qararah | 5182.1 |
| 27 | C94 | SHoka Clinic | 4568.7 |
| 28 | C106 | Ziton | 4559.0 |
| 29 | C28 | Zawaydeh | 4135.0 |
| 30 | C48 | Nuseirat | 3460.0 |
| 31 | C98 | ALremal | 3412.4 |
| 32 | C32 | Maghazi | 3377.6 |
| 33 | C36 | Western Nuseirat | 2667.4 |
| 34 | C14 | Beit Hanoun | 2004.7 |
| 35 | C80 | Rafah Central | 1768.1 |
| 36 | C137 | Hala Al Shawa | 1152.1 |
| 37 | C109 | AL falah | 1105.3 |
| 38 | C10 | Jabalya camp | 1033.2 |
| 39 | C83 | Tel Sultan | 985.1 |
| 40 | C113 | AL salam | 518.2 |
| 41 | C119 | Surani | 164.1 |
| 42 | C116 | Sheikh Radwan | 44.9 |
| 43 | C100 | AL qoba | 35.8 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

## Legend

**Diarrheal**

**Incidence per 100,000**

- 35.8 - 2,667.4
- 2,667.5 - 7,220.7
- 7,220.8 - 14,180.4
- 14,180.5 - 24,038.4
- 24,038.5 - 34,582.8
- Catchment Area
- Governorate
- Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

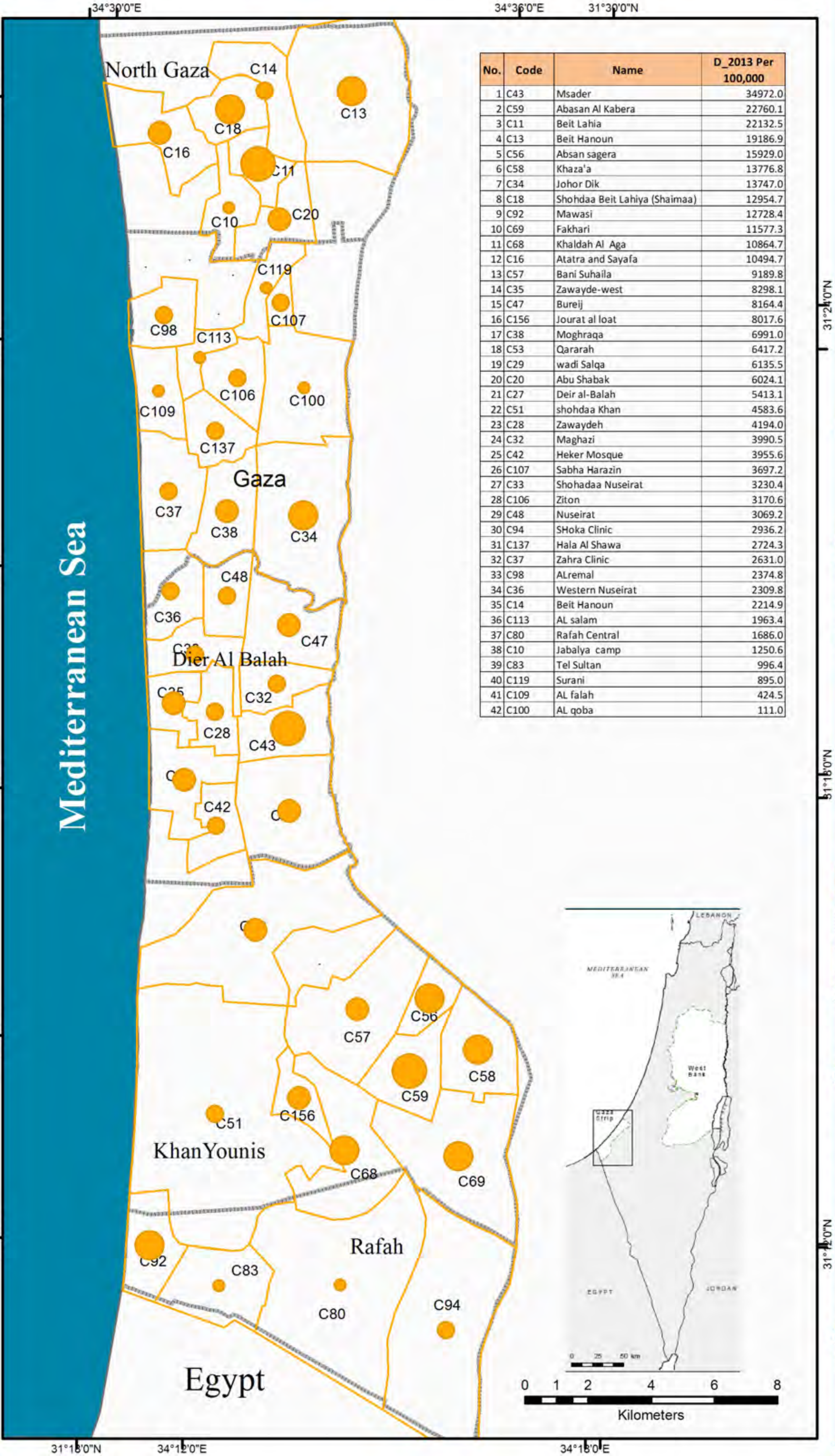
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Diarrheal incidence rate in Gaza Strip - MOH 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2013 Per 100,000 |
|---|---|---|---|
| 1 | C43 | Msader | 34972.0 |
| 2 | C59 | Abasan Al Kabera | 22760.1 |
| 3 | C11 | Beit Lahia | 22132.5 |
| 4 | C13 | Beit Hanoun | 19186.9 |
| 5 | C56 | Absan sagera | 15929.0 |
| 6 | C58 | Khaza'a | 13776.8 |
| 7 | C34 | Johor Dik | 13747.0 |
| 8 | C18 | Shohdaa Beit Lahiya (Shaimaa) | 12954.7 |
| 9 | C92 | Mawasi | 12728.4 |
| 10 | C69 | Fakhari | 11577.3 |
| 11 | C68 | Khaldah Al Aga | 10864.7 |
| 12 | C16 | Atatra and Sayafa | 10494.7 |
| 13 | C57 | Bani Suhaila | 9189.8 |
| 14 | C35 | Zawayde-west | 8298.1 |
| 15 | C47 | Bureij | 8164.4 |
| 16 | C156 | Jourat al loat | 8017.6 |
| 17 | C38 | Moghraqa | 6991.0 |
| 18 | C53 | Qararah | 6417.2 |
| 19 | C29 | wadi Salqa | 6135.5 |
| 20 | C20 | Abu Shabak | 6024.1 |
| 21 | C27 | Deir al-Balah | 5413.1 |
| 22 | C51 | shohdaa Khan | 4583.6 |
| 23 | C28 | Zawaydeh | 4194.0 |
| 24 | C32 | Maghazi | 3990.5 |
| 25 | C42 | Heker Mosque | 3955.6 |
| 26 | C107 | Sabha Harazin | 3697.2 |
| 27 | C33 | Shohadaa Nuseirat | 3230.4 |
| 28 | C106 | Ziton | 3170.6 |
| 29 | C48 | Nuseirat | 3069.2 |
| 30 | C94 | SHoka Clinic | 2936.2 |
| 31 | C137 | Hala Al Shawa | 2724.3 |
| 32 | C37 | Zahra Clinic | 2631.0 |
| 33 | C98 | ALremal | 2374.8 |
| 34 | C36 | Western Nuseirat | 2309.8 |
| 35 | C14 | Beit Hanoun | 2214.9 |
| 36 | C113 | AL salam | 1963.4 |
| 37 | C80 | Rafah Central | 1686.0 |
| 38 | C10 | Jabalya camp | 1250.6 |
| 39 | C83 | Tel Sultan | 996.4 |
| 40 | C119 | Surani | 895.0 |
| 41 | C109 | AL falah | 424.5 |
| 42 | C100 | AL qoba | 111.0 |

سلطة المياه الفلسطينية

PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

## Legend

**Diarrheal Incidence per 100,000**

- 111.0 - 1,963.4
- 1,963.5 - 4,583.6
- 4,583.7 - 10,494.7
- 10,494.8 - 19,186.9
- 19,187.0 - 34,972.0

Catchment Area

Governorate

Sea

Source:
Palestinian Ministry of Health
Date of Data : 2009-2013

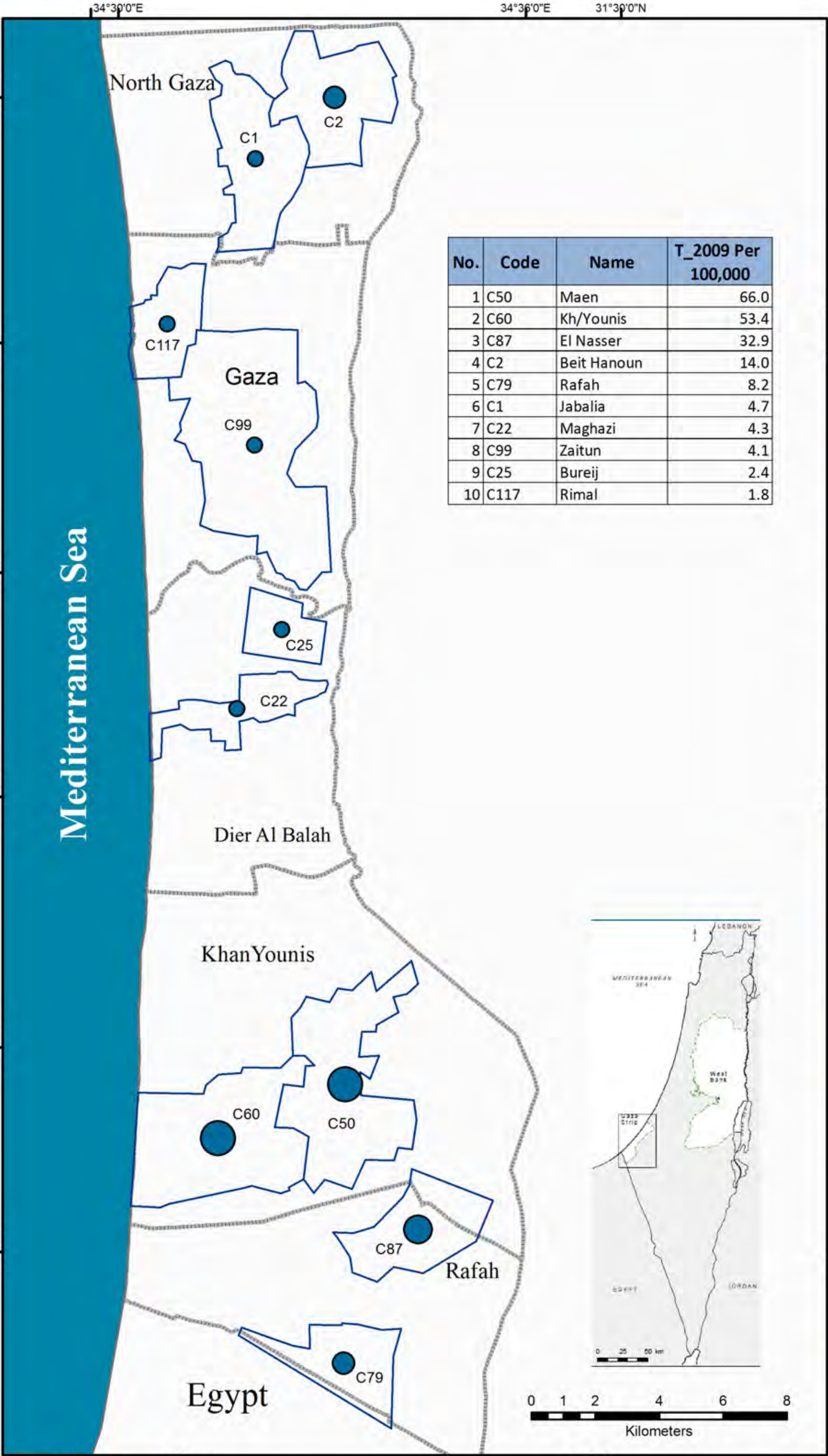
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# Typhoid incidence rate in Gaza Strip - UNRWA 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2009 Per 100,000 |
|---|---|---|---|
| 1 | C50 | Maen | 66.0 |
| 2 | C60 | Kh/Younis | 53.4 |
| 3 | C87 | El Nasser | 32.9 |
| 4 | C2 | Beit Hanoun | 14.0 |
| 5 | C79 | Rafah | 8.2 |
| 6 | C1 | Jabalia | 4.7 |
| 7 | C22 | Maghazi | 4.3 |
| 8 | C99 | Zaitun | 4.1 |
| 9 | C25 | Bureij | 2.4 |
| 10 | C117 | Rimal | 1.8 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Typhoid**

**Incidence per 100,000**

- 1.8 - 4.7
- 4.8 - 14.0
- 14.1 - 32.9
- 33.0 - 66.0
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

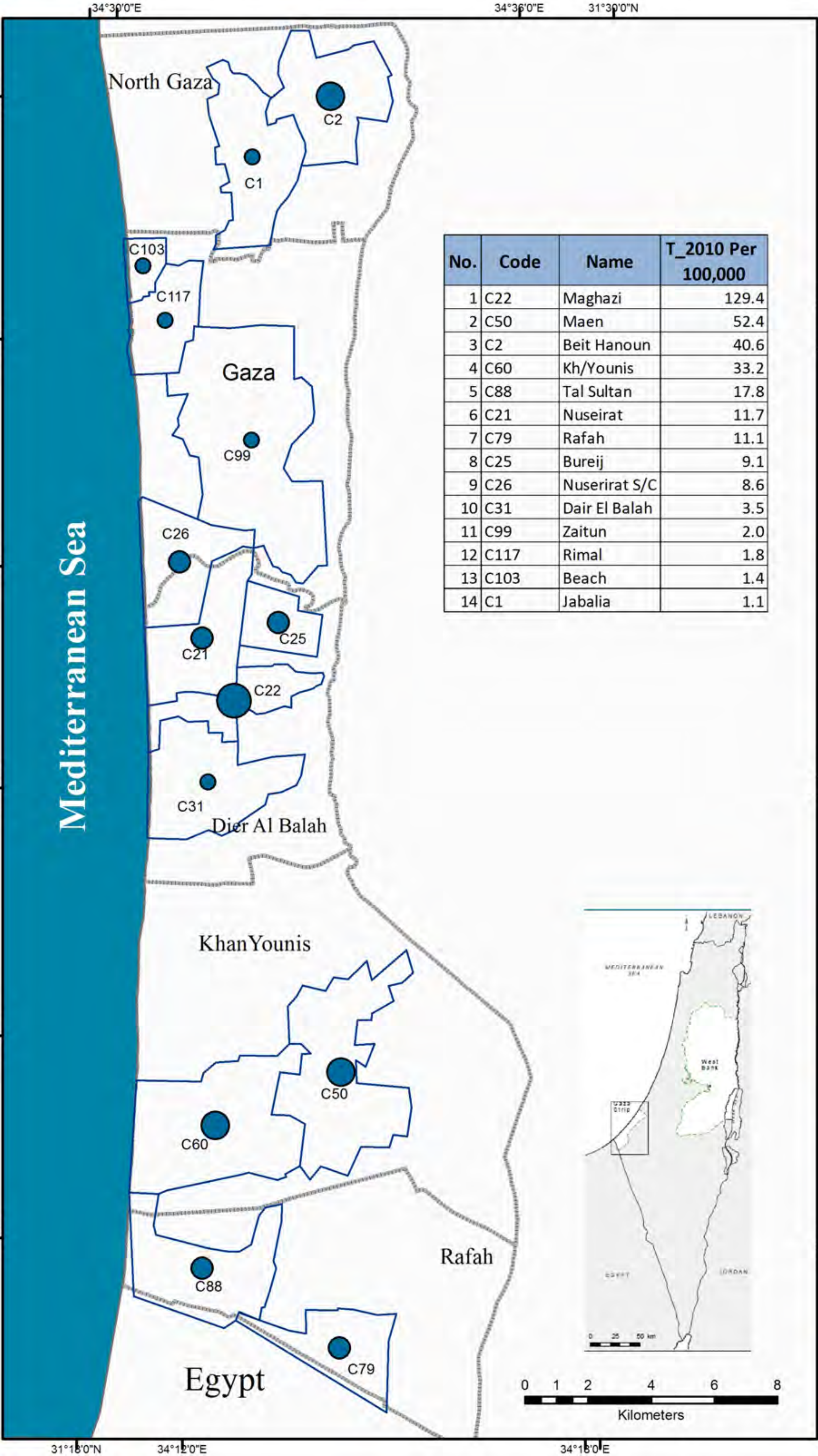
**Date: 4/22/2015**


**Funded by:**

Austrian
Development Agency

# Typhoid incidence rate in Gaza Strip - UNRWA 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2010 Per 100,000 |
|---|---|---|---|
| 1 | C22 | Maghazi | 129.4 |
| 2 | C50 | Maen | 52.4 |
| 3 | C2 | Beit Hanoun | 40.6 |
| 4 | C60 | Kh/Younis | 33.2 |
| 5 | C88 | Tal Sultan | 17.8 |
| 6 | C21 | Nuseirat | 11.7 |
| 7 | C79 | Rafah | 11.1 |
| 8 | C25 | Bureij | 9.1 |
| 9 | C26 | Nuserirat S/C | 8.6 |
| 10 | C31 | Dair El Balah | 3.5 |
| 11 | C99 | Zaitun | 2.0 |
| 12 | C117 | Rimal | 1.8 |
| 13 | C103 | Beach | 1.4 |
| 14 | C1 | Jabalia | 1.1 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Typhoid**

**Incidence per 100,000**

- 1.1 - 3.5
- 3.6 - 17.8
- 17.9 - 52.4
- 52.5 - 129.4
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

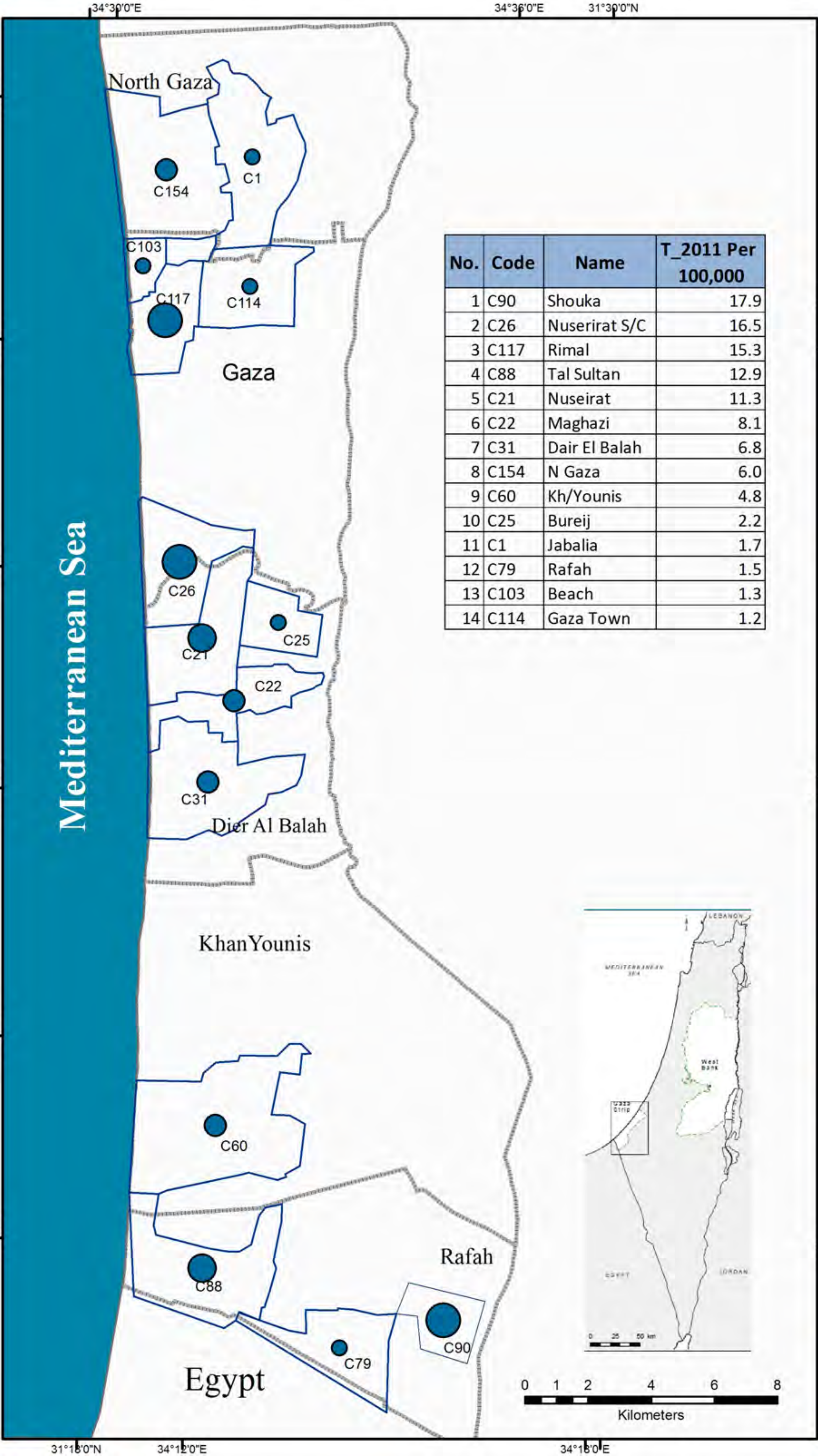
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian
Development Agency

# Typhoid incidence rate in Gaza Strip - UNRWA 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2011 Per 100,000 |
|---|---|---|---|
| 1 | C90 | Shouka | 17.9 |
| 2 | C26 | Nuserirat S/C | 16.5 |
| 3 | C117 | Rimal | 15.3 |
| 4 | C88 | Tal Sultan | 12.9 |
| 5 | C21 | Nuseirat | 11.3 |
| 6 | C22 | Maghazi | 8.1 |
| 7 | C31 | Dair El Balah | 6.8 |
| 8 | C154 | N Gaza | 6.0 |
| 9 | C60 | Kh/Younis | 4.8 |
| 10 | C25 | Bureij | 2.2 |
| 11 | C1 | Jabalia | 1.7 |
| 12 | C79 | Rafah | 1.5 |
| 13 | C103 | Beach | 1.3 |
| 14 | C114 | Gaza Town | 1.2 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Typhoid**

**Incidence per 100,000**

- 1.2 - 2.2
- 2.3 - 8.1
- 8.2 - 12.9
- 13.0 - 17.9
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

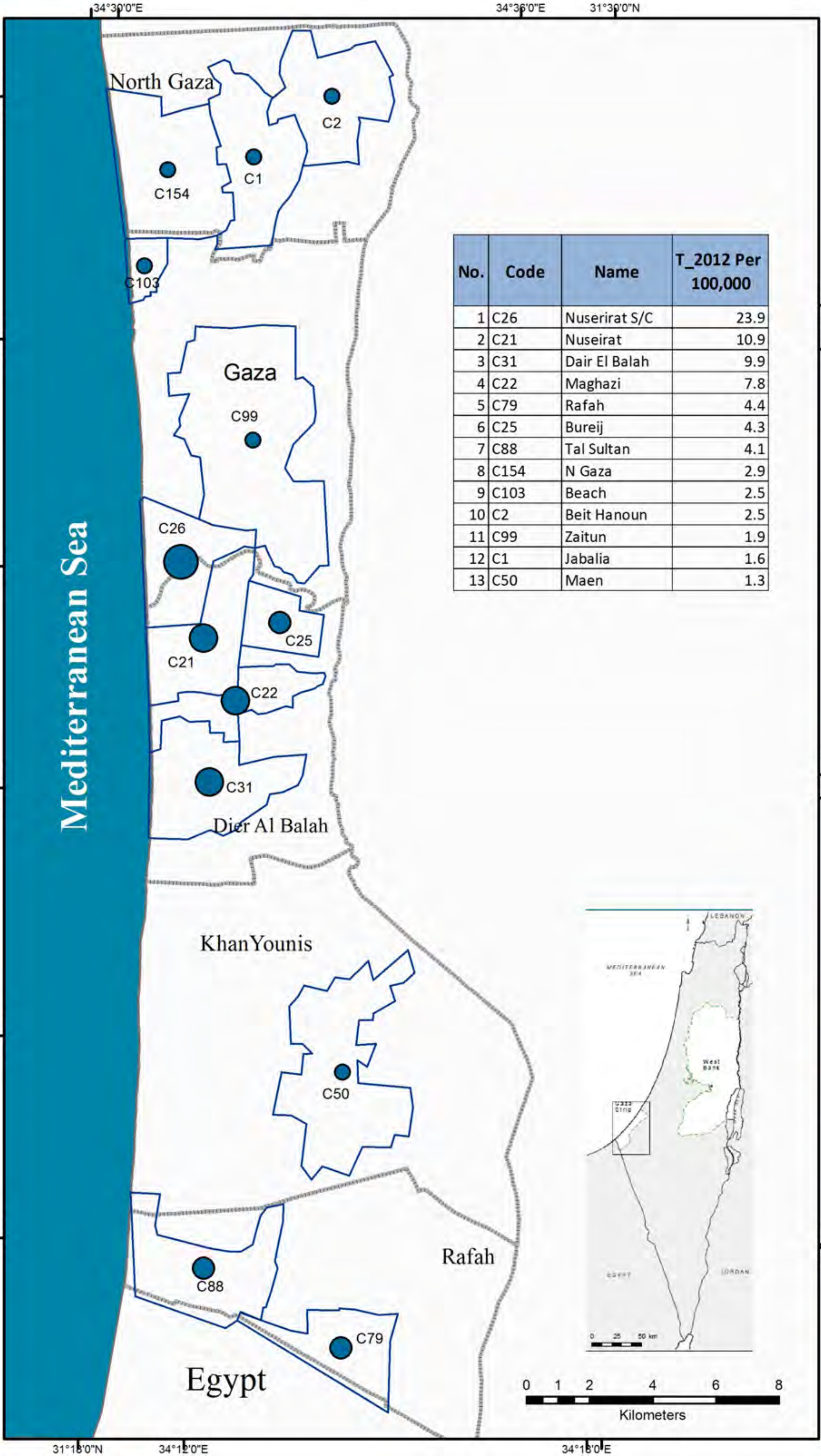
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian
Development Agency

# Typhoid incidence rate in Gaza Strip - UNRWA 2012

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2012 Per 100,000 |
|---|---|---|---|
| 1 | C26 | Nuserirat S/C | 23.9 |
| 2 | C21 | Nuseirat | 10.9 |
| 3 | C31 | Dair El Balah | 9.9 |
| 4 | C22 | Maghazi | 7.8 |
| 5 | C79 | Rafah | 4.4 |
| 6 | C25 | Bureij | 4.3 |
| 7 | C88 | Tal Sultan | 4.1 |
| 8 | C154 | N Gaza | 2.9 |
| 9 | C103 | Beach | 2.5 |
| 10 | C2 | Beit Hanoun | 2.5 |
| 11 | C99 | Zaitun | 1.9 |
| 12 | C1 | Jabalia | 1.6 |
| 13 | C50 | Maen | 1.3 |

## Legend

**Typhoid**

**Incidence per 100,000**

- 1.3 - 2.9
- 3.0 - 4.4
- 4.5 - 10.9
- 11.0 - 23.9
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

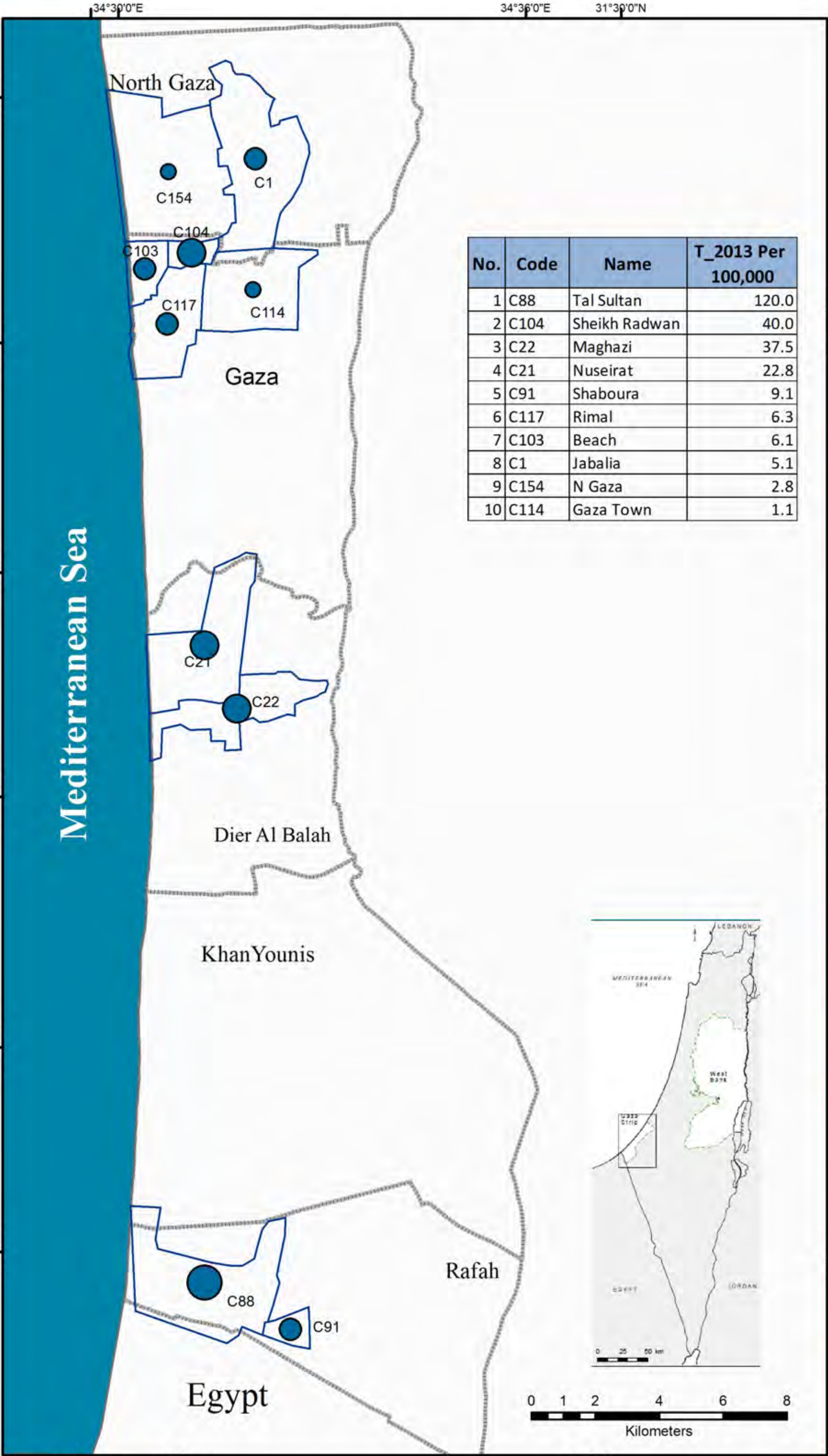
**Date: 4/22/2015**


**Funded by:**

Austrian
Development Agency

# Typhoid incidence rate in Gaza Strip - UNRWA 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | T_2013 Per 100,000 |
|---|---|---|---|
| 1 | C88 | Tal Sultan | 120.0 |
| 2 | C104 | Sheikh Radwan | 40.0 |
| 3 | C22 | Maghazi | 37.5 |
| 4 | C21 | Nuseirat | 22.8 |
| 5 | C91 | Shaboura | 9.1 |
| 6 | C117 | Rimal | 6.3 |
| 7 | C103 | Beach | 6.1 |
| 8 | C1 | Jabalia | 5.1 |
| 9 | C154 | N Gaza | 2.8 |
| 10 | C114 | Gaza Town | 1.1 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Typhoid**

**Incidence per 100,000**

- 1.1 - 2.8
- 2.9 - 9.1
- 9.2 - 40.0
- 40.1 - 120.0

Catchment Area
Governorate
Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian
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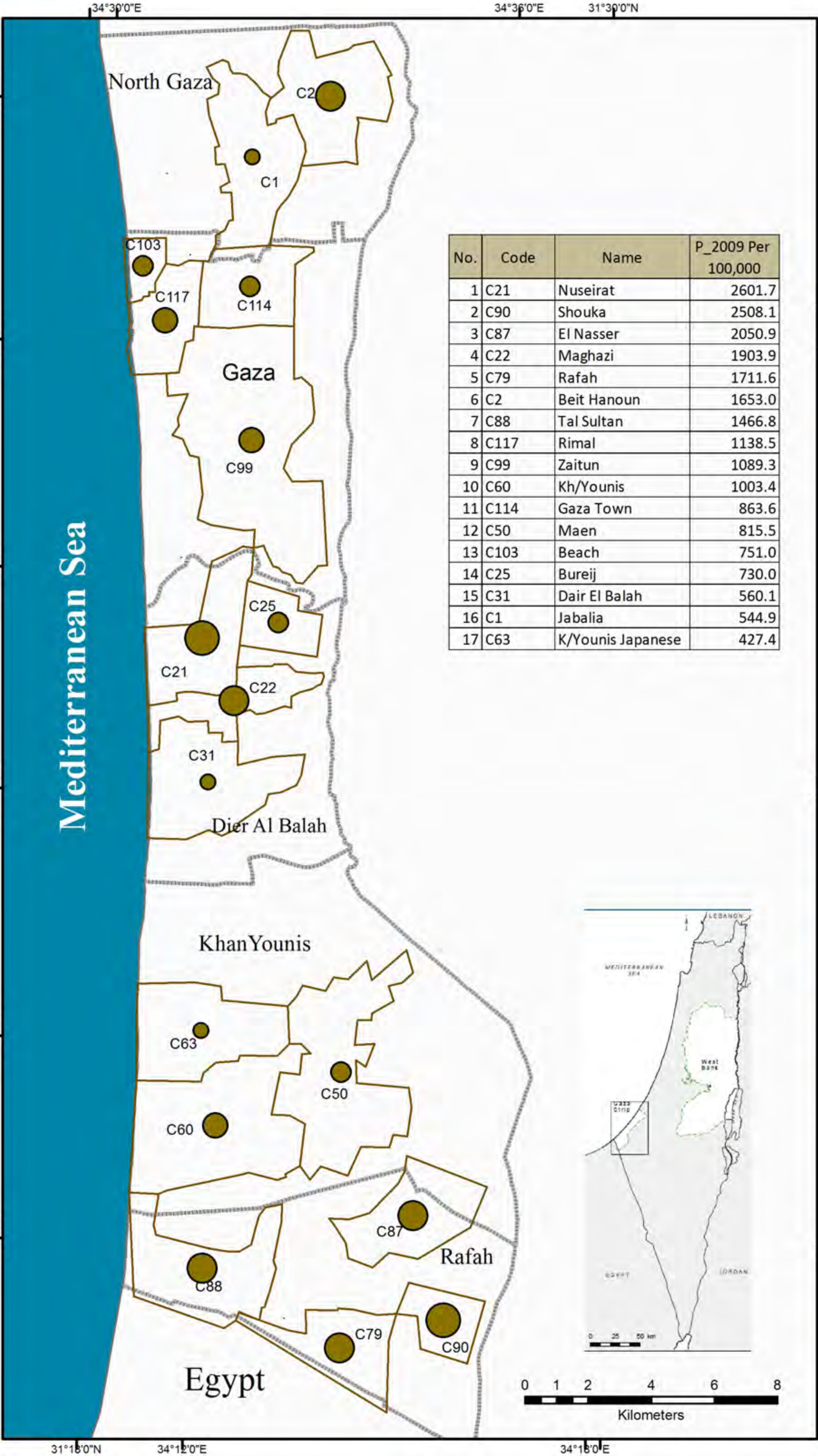
# Parasitic infestations incidence rate in Gaza Strip - UNRWA 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | P_2009 Per 100,000 |
|---|---|---|---|
| 1 | C21 | Nuseirat | 2601.7 |
| 2 | C90 | Shouka | 2508.1 |
| 3 | C87 | El Nasser | 2050.9 |
| 4 | C22 | Maghazi | 1903.9 |
| 5 | C79 | Rafah | 1711.6 |
| 6 | C2 | Beit Hanoun | 1653.0 |
| 7 | C88 | Tal Sultan | 1466.8 |
| 8 | C117 | Rimal | 1138.5 |
| 9 | C99 | Zaitun | 1089.3 |
| 10 | C60 | Kh/Younis | 1003.4 |
| 11 | C114 | Gaza Town | 863.6 |
| 12 | C50 | Maen | 815.5 |
| 13 | C103 | Beach | 751.0 |
| 14 | C25 | Bureij | 730.0 |
| 15 | C31 | Dair El Balah | 560.1 |
| 16 | C1 | Jabalia | 544.9 |
| 17 | C63 | K/Younis Japanese | 427.4 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Parasitic Incidence per 100,000**

- 427.4 - 560.1
- 560.2 - 863.6
- 863.7 - 1,138.5
- 1,138.6 - 2,050.9
- 2,051.0 - 2,601.7
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
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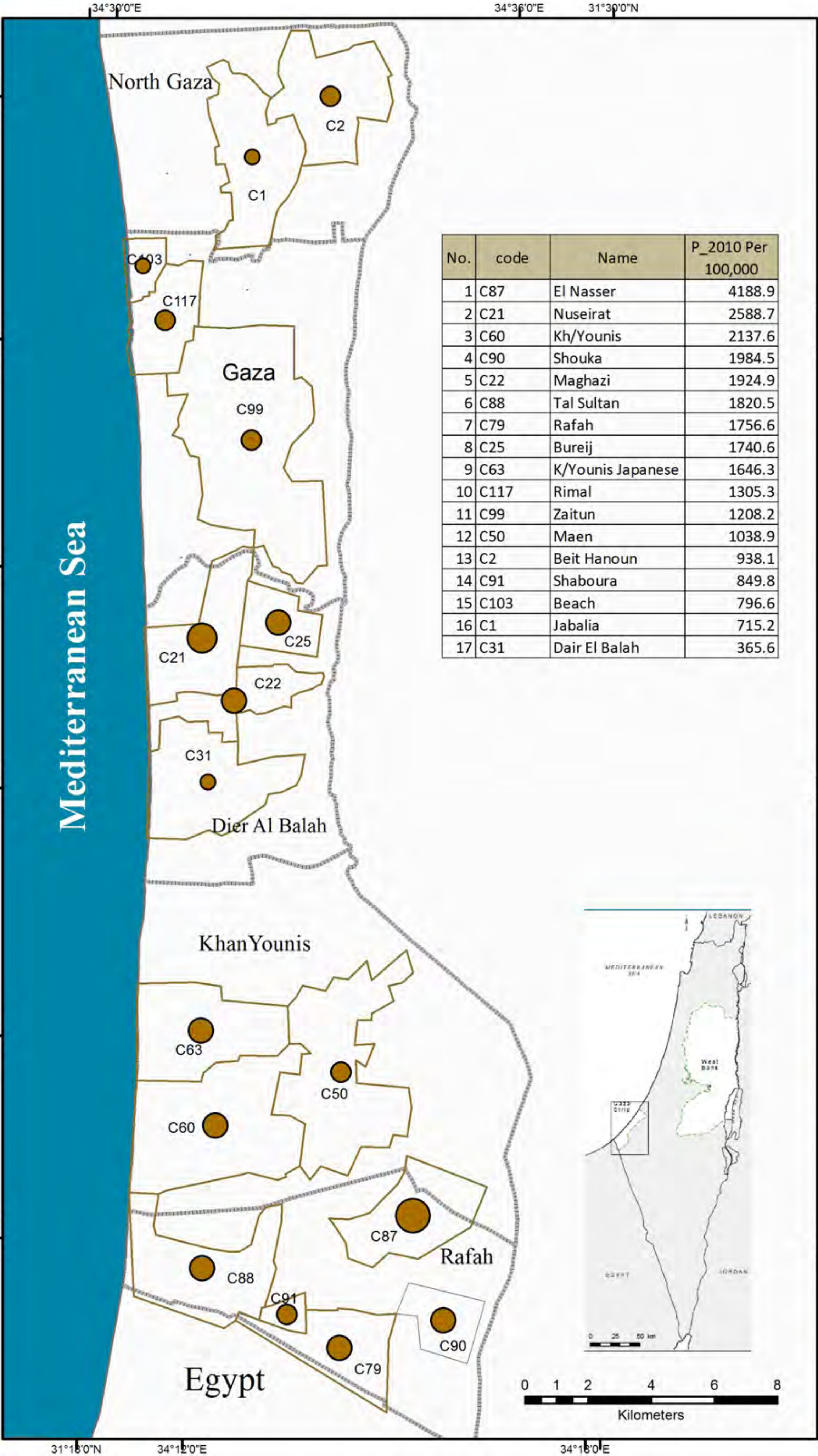
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Parasitic infestations incidence rate in Gaza Strip - UNRWA 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | P_2010 Per 100,000 |
|---|---|---|---|
| 1 | C87 | El Nasser | 4188.9 |
| 2 | C21 | Nuseirat | 2588.7 |
| 3 | C60 | Kh/Younis | 2137.6 |
| 4 | C90 | Shouka | 1984.5 |
| 5 | C22 | Maghazi | 1924.9 |
| 6 | C88 | Tal Sultan | 1820.5 |
| 7 | C79 | Rafah | 1756.6 |
| 8 | C25 | Bureij | 1740.6 |
| 9 | C63 | K/Younis Japanese | 1646.3 |
| 10 | C117 | Rimal | 1305.3 |
| 11 | C99 | Zaitun | 1208.2 |
| 12 | C50 | Maen | 1038.9 |
| 13 | C2 | Beit Hanoun | 938.1 |
| 14 | C91 | Shaboura | 849.8 |
| 15 | C103 | Beach | 796.6 |
| 16 | C1 | Jabalia | 715.2 |
| 17 | C31 | Dair El Balah | 365.6 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Parasitic Incidence per 100,000**

- 365.6 - 800.0
- 800.1 - 1,305.3
- 1,305.4 - 2,137.6
- 2,137.7 - 2,588.7
- 2,588.8 - 4,188.9
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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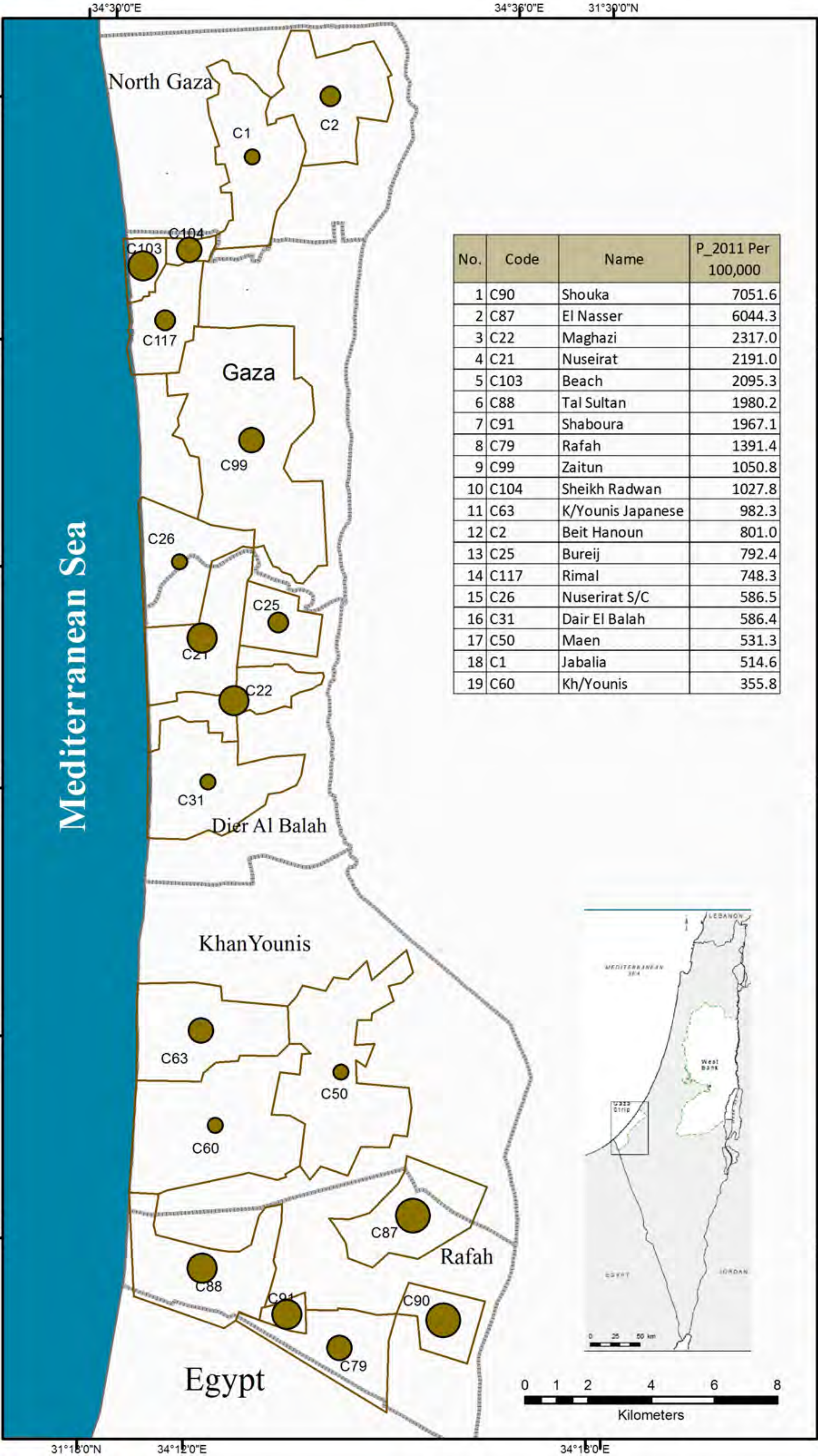
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Parasitic infestations incidence rate in Gaza Strip - UNRWA 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | P_2011 Per 100,000 |
|---|---|---|---|
| 1 | C90 | Shouka | 7051.6 |
| 2 | C87 | El Nasser | 6044.3 |
| 3 | C22 | Maghazi | 2317.0 |
| 4 | C21 | Nuseirat | 2191.0 |
| 5 | C103 | Beach | 2095.3 |
| 6 | C88 | Tal Sultan | 1980.2 |
| 7 | C91 | Shaboura | 1967.1 |
| 8 | C79 | Rafah | 1391.4 |
| 9 | C99 | Zaitun | 1050.8 |
| 10 | C104 | Sheikh Radwan | 1027.8 |
| 11 | C63 | K/Younis Japanese | 982.3 |
| 12 | C2 | Beit Hanoun | 801.0 |
| 13 | C25 | Bureij | 792.4 |
| 14 | C117 | Rimal | 748.3 |
| 15 | C26 | Nuserirat S/C | 586.5 |
| 16 | C31 | Dair El Balah | 586.4 |
| 17 | C50 | Maen | 531.3 |
| 18 | C1 | Jabalia | 514.6 |
| 19 | C60 | Kh/Younis | 355.8 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Parasitic Incidence per 100,000**

- 355.8 - 586.5
- 586.6 - 801.0
- 801.1 - 1,391.4
- 1,391.5 - 2,317.0
- 2,317.1 - 7,051.6

Catchment Area

Governorate

Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
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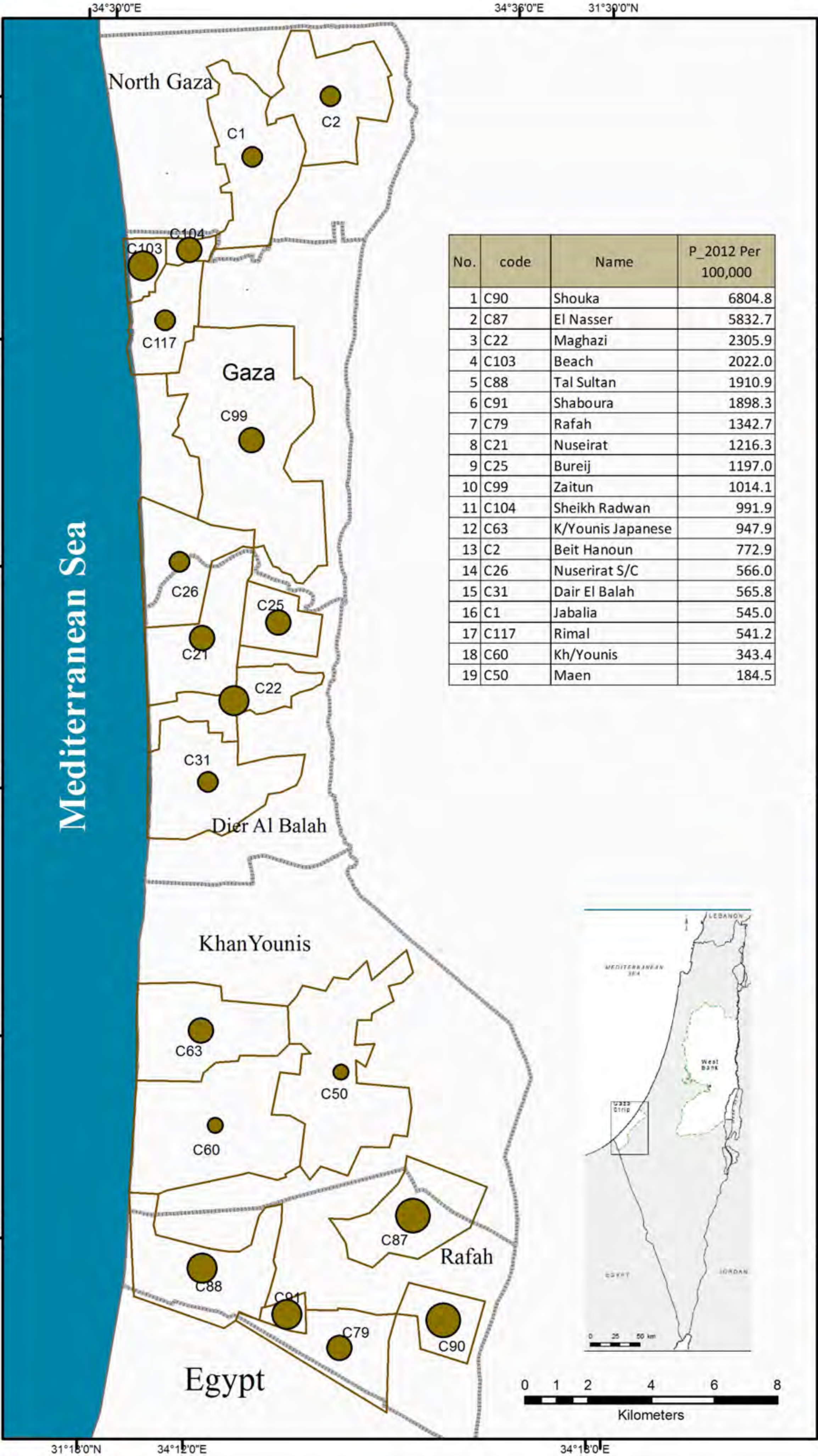
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Parasitic infestations incidence rate in Gaza Strip - UNRWA 2012

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | P_2012 Per 100,000 |
|---|---|---|---|
| 1 | C90 | Shouka | 6804.8 |
| 2 | C87 | El Nasser | 5832.7 |
| 3 | C22 | Maghazi | 2305.9 |
| 4 | C103 | Beach | 2022.0 |
| 5 | C88 | Tal Sultan | 1910.9 |
| 6 | C91 | Shaboura | 1898.3 |
| 7 | C79 | Rafah | 1342.7 |
| 8 | C21 | Nuseirat | 1216.3 |
| 9 | C25 | Bureij | 1197.0 |
| 10 | C99 | Zaitun | 1014.1 |
| 11 | C104 | Sheikh Radwan | 991.9 |
| 12 | C63 | K/Younis Japanese | 947.9 |
| 13 | C2 | Beit Hanoun | 772.9 |
| 14 | C26 | Nuserirat S/C | 566.0 |
| 15 | C31 | Dair El Balah | 565.8 |
| 16 | C1 | Jabalia | 545.0 |
| 17 | C117 | Rimal | 541.2 |
| 18 | C60 | Kh/Younis | 343.4 |
| 19 | C50 | Maen | 184.5 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Parasitic Incidence per 100,000**

- 184.5 - 343.4
- 343.5 - 772.9
- 773.0 - 1,342.7
- 1,342.8 - 2,305.9
- 2,306.0 - 6,804.8

Catchment Area

Governorate

Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

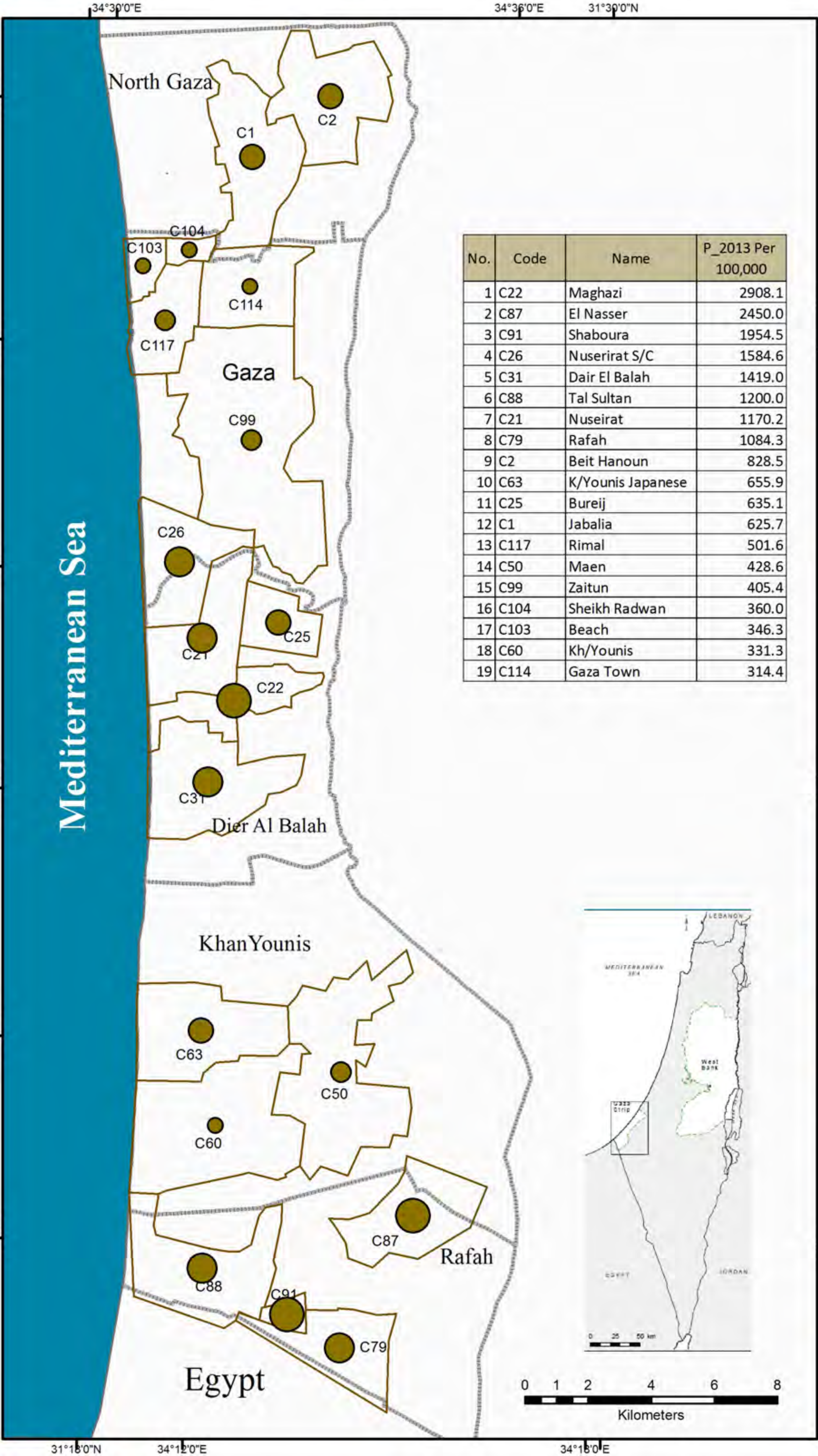
**Date: 4/22/2015**

**Funded by:**

Austrian Development Agency

# Parasitic infestations incidence rate in Gaza Strip - UNRWA 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | P_2013 Per 100,000 |
|---|---|---|---|
| 1 | C22 | Maghazi | 2908.1 |
| 2 | C87 | El Nasser | 2450.0 |
| 3 | C91 | Shaboura | 1954.5 |
| 4 | C26 | Nuserirat S/C | 1584.6 |
| 5 | C31 | Dair El Balah | 1419.0 |
| 6 | C88 | Tal Sultan | 1200.0 |
| 7 | C21 | Nuseirat | 1170.2 |
| 8 | C79 | Rafah | 1084.3 |
| 9 | C2 | Beit Hanoun | 828.5 |
| 10 | C63 | K/Younis Japanese | 655.9 |
| 11 | C25 | Bureij | 635.1 |
| 12 | C1 | Jabalia | 625.7 |
| 13 | C117 | Rimal | 501.6 |
| 14 | C50 | Maen | 428.6 |
| 15 | C99 | Zaitun | 405.4 |
| 16 | C104 | Sheikh Radwan | 360.0 |
| 17 | C103 | Beach | 346.3 |
| 18 | C60 | Kh/Younis | 331.3 |
| 19 | C114 | Gaza Town | 314.4 |

PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

## Legend

**Parasitic Incidence per 100,000**

- 314.4 - 360.0
- 360.1 - 501.6
- 501.7 - 828.5
- 828.6 - 1,584.6
- 1,584.7 - 2,908.1
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

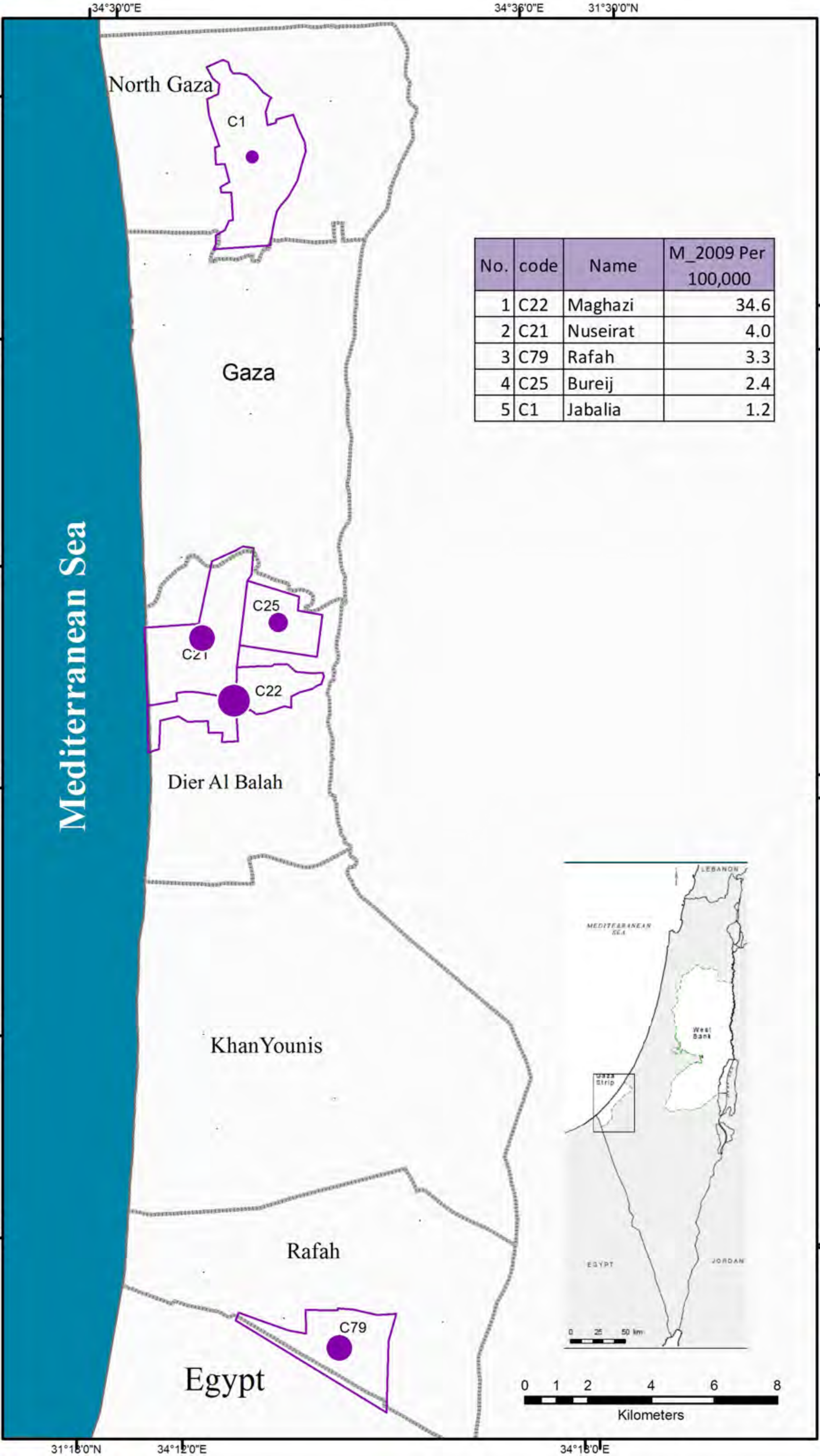
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Meningitis incidence rate in Gaza Strip - UNRWA 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | M_2009 Per 100,000 |
|---|---|---|---|
| 1 | C22 | Maghazi | 34.6 |
| 2 | C21 | Nuseirat | 4.0 |
| 3 | C79 | Rafah | 3.3 |
| 4 | C25 | Bureij | 2.4 |
| 5 | C1 | Jabalia | 1.2 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Meningitis**
**Incidence per 100,000**

- 1 - 1.2
- 1.3 - 2.4
- 2.5 - 4.0
- 4.1 - 34.6
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

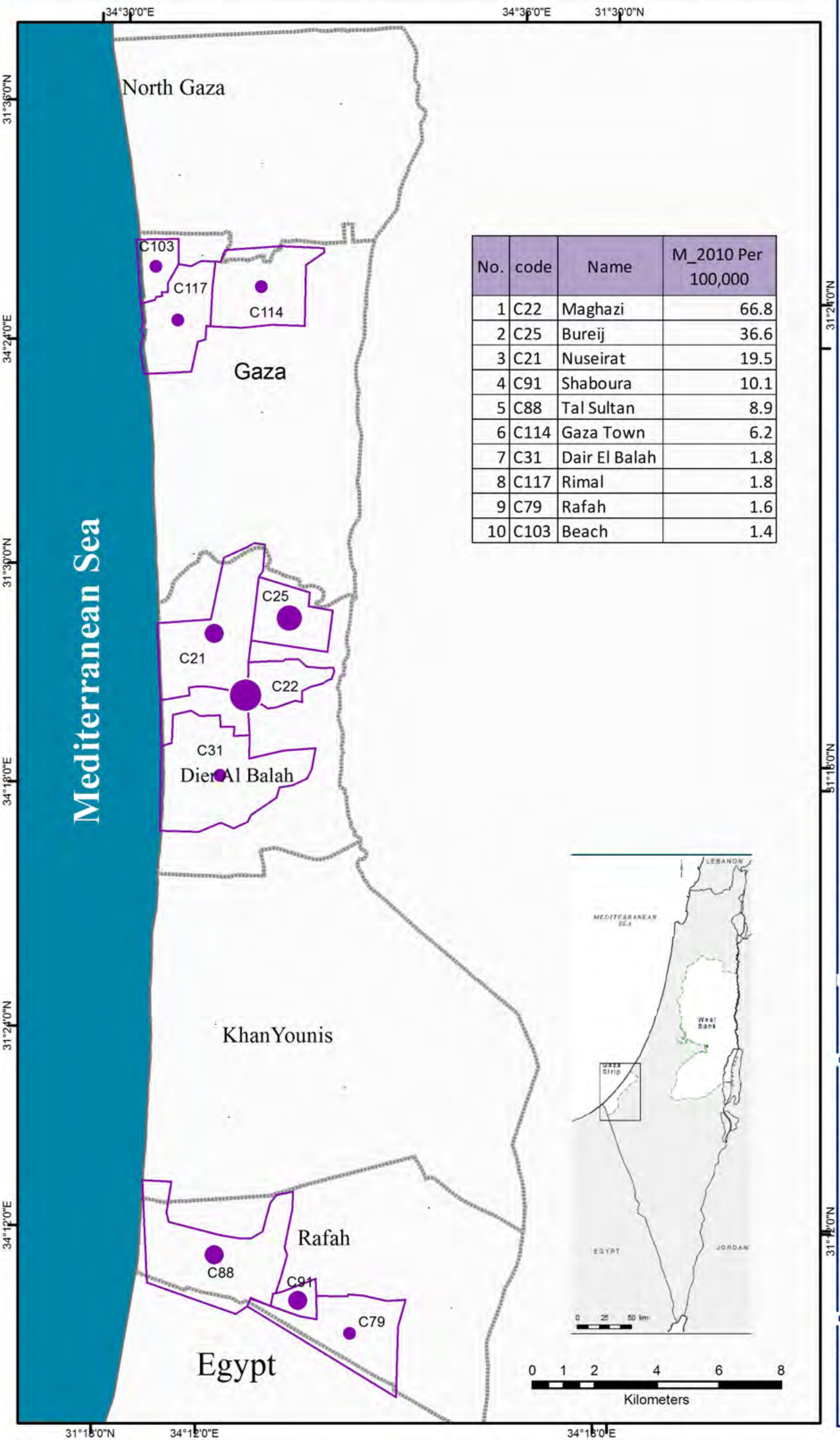
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Meningitis incidence rate in Gaza Strip - UNRWA 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | M_2010 Per 100,000 |
|---|---|---|---|
| 1 | C22 | Maghazi | 66.8 |
| 2 | C25 | Bureij | 36.6 |
| 3 | C21 | Nuseirat | 19.5 |
| 4 | C91 | Shaboura | 10.1 |
| 5 | C88 | Tal Sultan | 8.9 |
| 6 | C114 | Gaza Town | 6.2 |
| 7 | C31 | Dair El Balah | 1.8 |
| 8 | C117 | Rimal | 1.8 |
| 9 | C79 | Rafah | 1.6 |
| 10 | C103 | Beach | 1.4 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

## Legend

**Meningitis**

**Incidence per 100,000**

- 1.4 - 6.2
- 6.3 - 19.5
- 19.6 - 36.6
- 36.7 - 66.8
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

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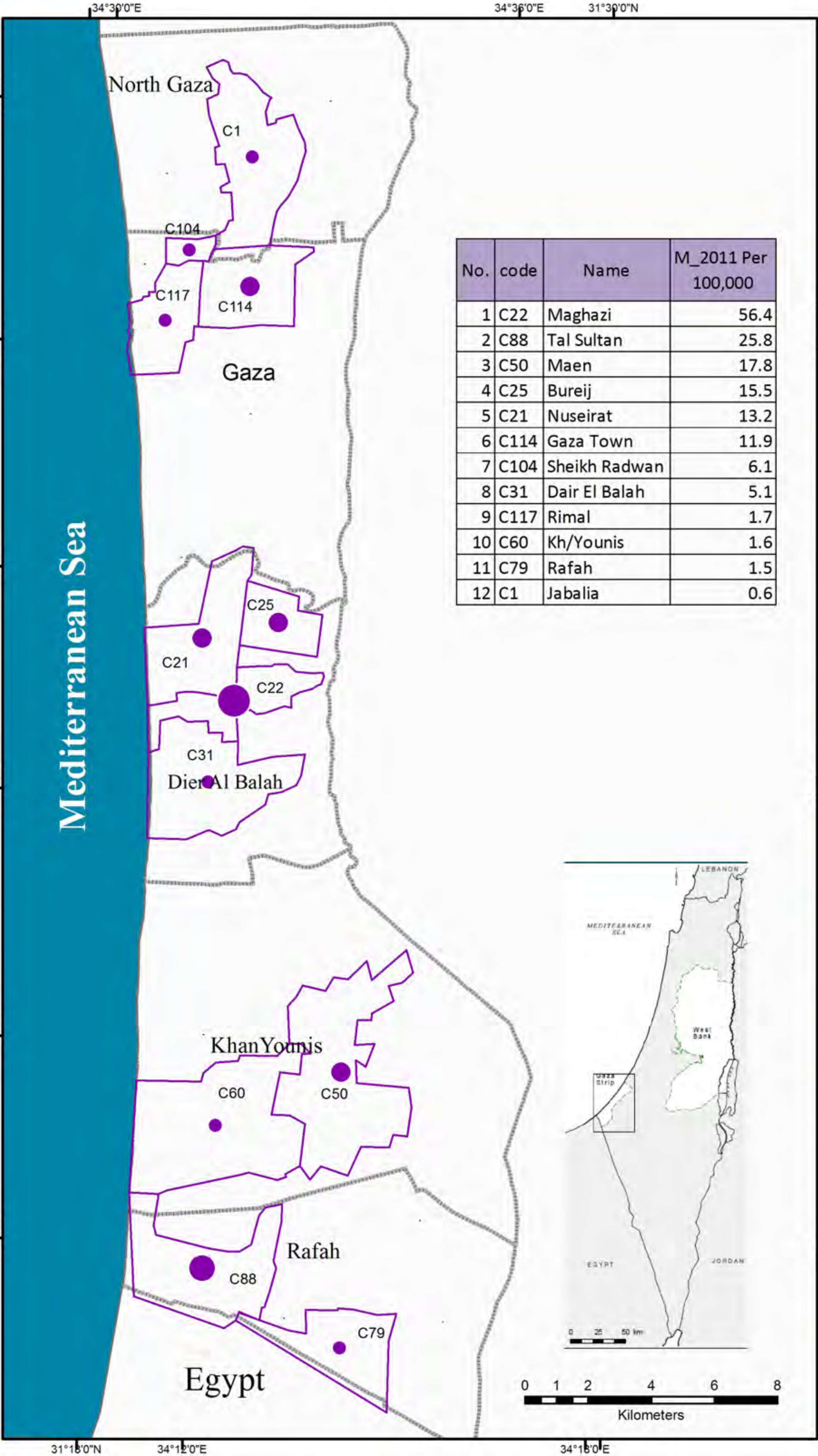
# Meningitis incidence rate in Gaza Strip - UNRWA 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | M_2011 Per 100,000 |
|---|---|---|---|
| 1 | C22 | Maghazi | 56.4 |
| 2 | C88 | Tal Sultan | 25.8 |
| 3 | C50 | Maen | 17.8 |
| 4 | C25 | Bureij | 15.5 |
| 5 | C21 | Nuseirat | 13.2 |
| 6 | C114 | Gaza Town | 11.9 |
| 7 | C104 | Sheikh Radwan | 6.1 |
| 8 | C31 | Dair El Balah | 5.1 |
| 9 | C117 | Rimal | 1.7 |
| 10 | C60 | Kh/Younis | 1.6 |
| 11 | C79 | Rafah | 1.5 |
| 12 | C1 | Jabalia | 0.6 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ
ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Meningitis**
**Incidence per 100,000**

- 0.6 - 6.1
- 6.2 - 17.8
- 17.9 - 25.8
- 25.9 - 56.4
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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central meridian: 35.2121
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latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

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Austrian
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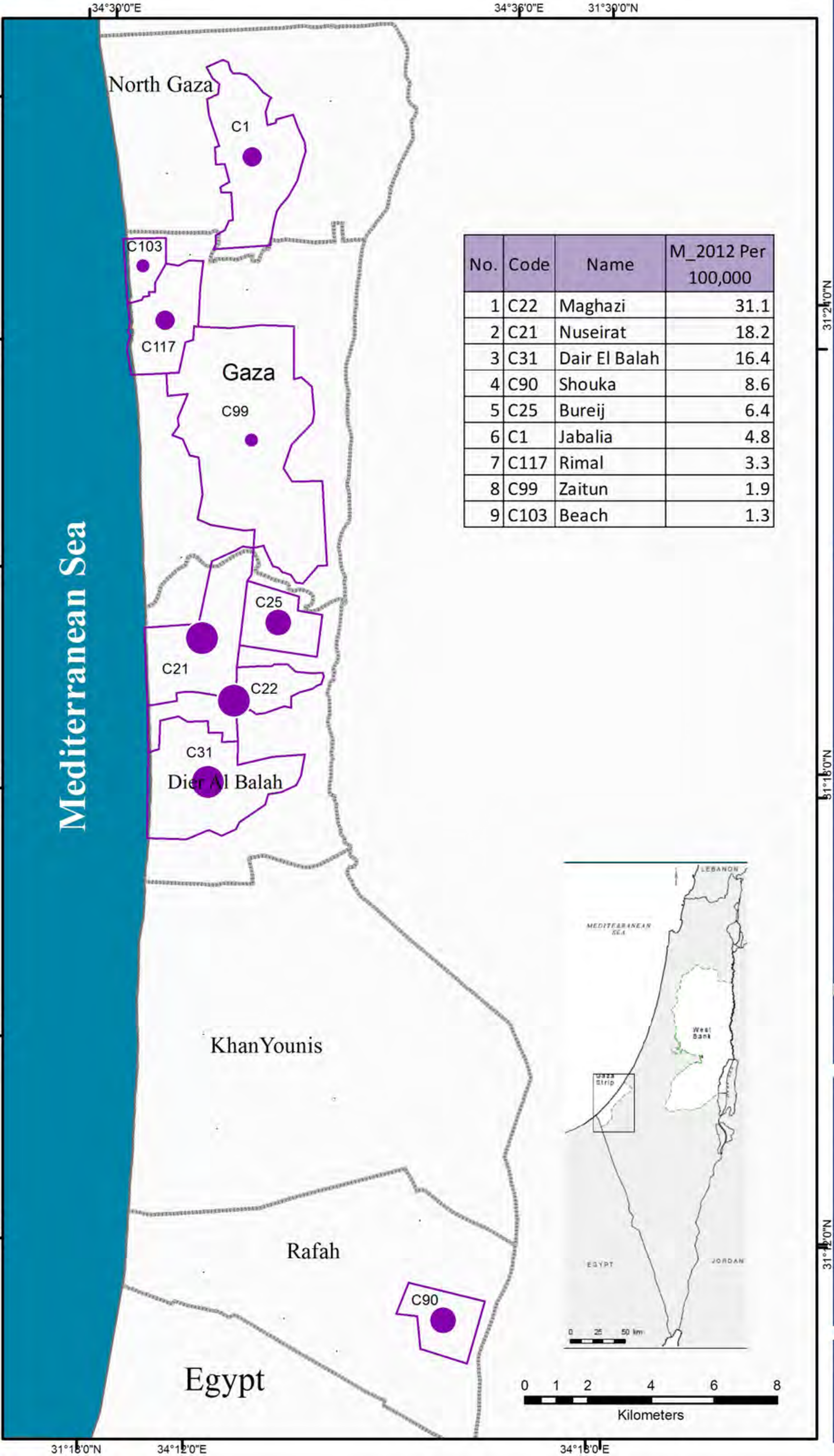
# Meningitis incidence rate in Gaza Strip - UNRWA 2012

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | M_2012 Per 100,000 |
|---|---|---|---|
| 1 | C22 | Maghazi | 31.1 |
| 2 | C21 | Nuseirat | 18.2 |
| 3 | C31 | Dair El Balah | 16.4 |
| 4 | C90 | Shouka | 8.6 |
| 5 | C25 | Bureij | 6.4 |
| 6 | C1 | Jabalia | 4.8 |
| 7 | C117 | Rimal | 3.3 |
| 8 | C99 | Zaitun | 1.9 |
| 9 | C103 | Beach | 1.3 |

سلطة الميـــاه الفلسطينية
PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

N E S W

## Legend

**Meningitis Incidence per 100,000**

- 1.3 - 1.9
- 2.0 - 4.8
- 4.9 - 8.6
- 8.7 - 31.1
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
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Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
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scale factor: 1.0000
latitude of origin: 31.7341
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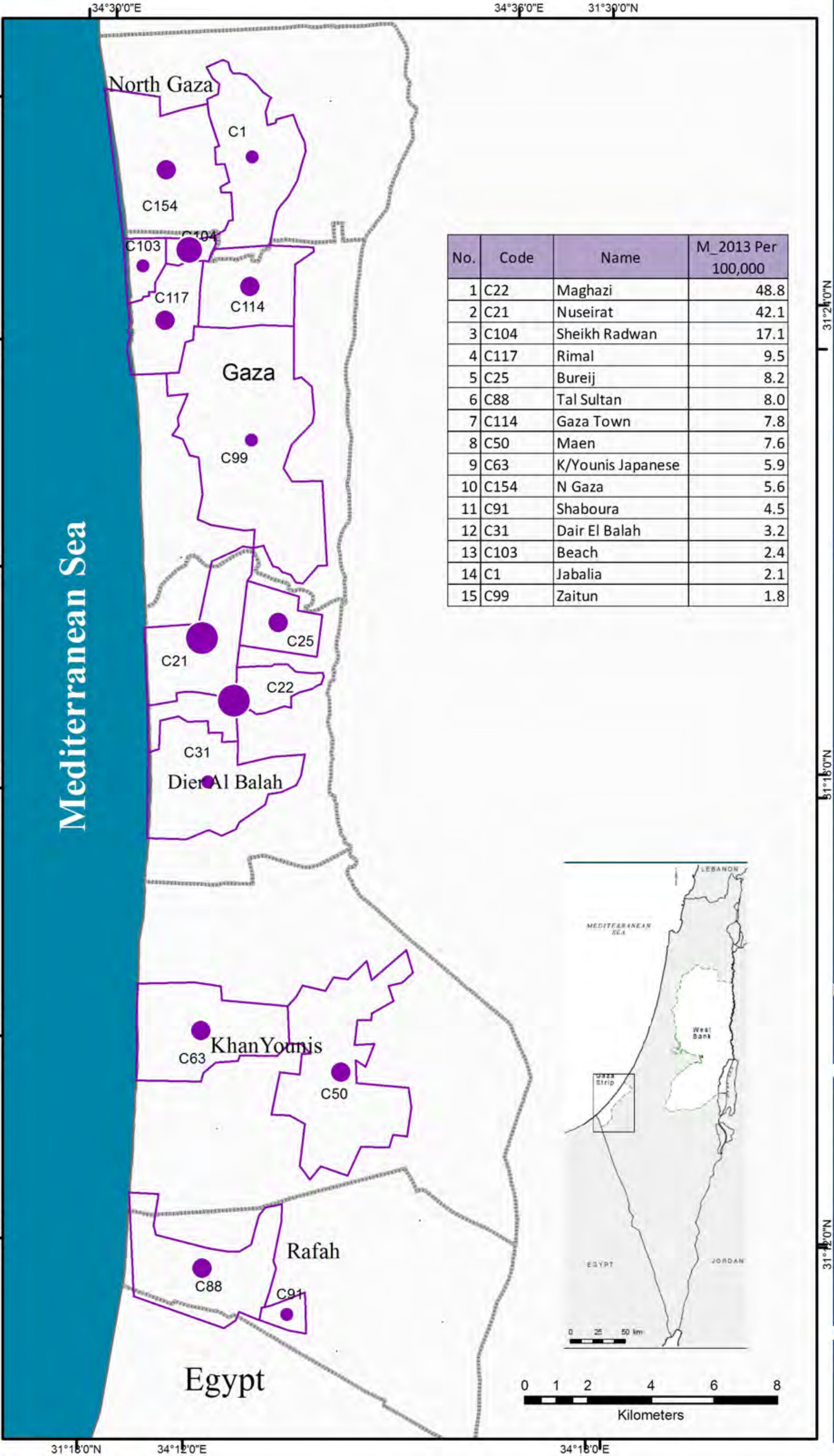
# Meningitis incidence rate in Gaza Strip - UNRWA 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | M_2013 Per 100,000 |
|---|---|---|---|
| 1 | C22 | Maghazi | 48.8 |
| 2 | C21 | Nuseirat | 42.1 |
| 3 | C104 | Sheikh Radwan | 17.1 |
| 4 | C117 | Rimal | 9.5 |
| 5 | C25 | Bureij | 8.2 |
| 6 | C88 | Tal Sultan | 8.0 |
| 7 | C114 | Gaza Town | 7.8 |
| 8 | C50 | Maen | 7.6 |
| 9 | C63 | K/Younis Japanese | 5.9 |
| 10 | C154 | N Gaza | 5.6 |
| 11 | C91 | Shaboura | 4.5 |
| 12 | C31 | Dair El Balah | 3.2 |
| 13 | C103 | Beach | 2.4 |
| 14 | C1 | Jabalia | 2.1 |
| 15 | C99 | Zaitun | 1.8 |

سلطة المياه الفلسطينية
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## Legend

**Meningitis Incidence per 100,000**

- 1.8 - 4.5
- 4.6 - 9.5
- 9.6 - 17.1
- 17.2 - 48.8
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

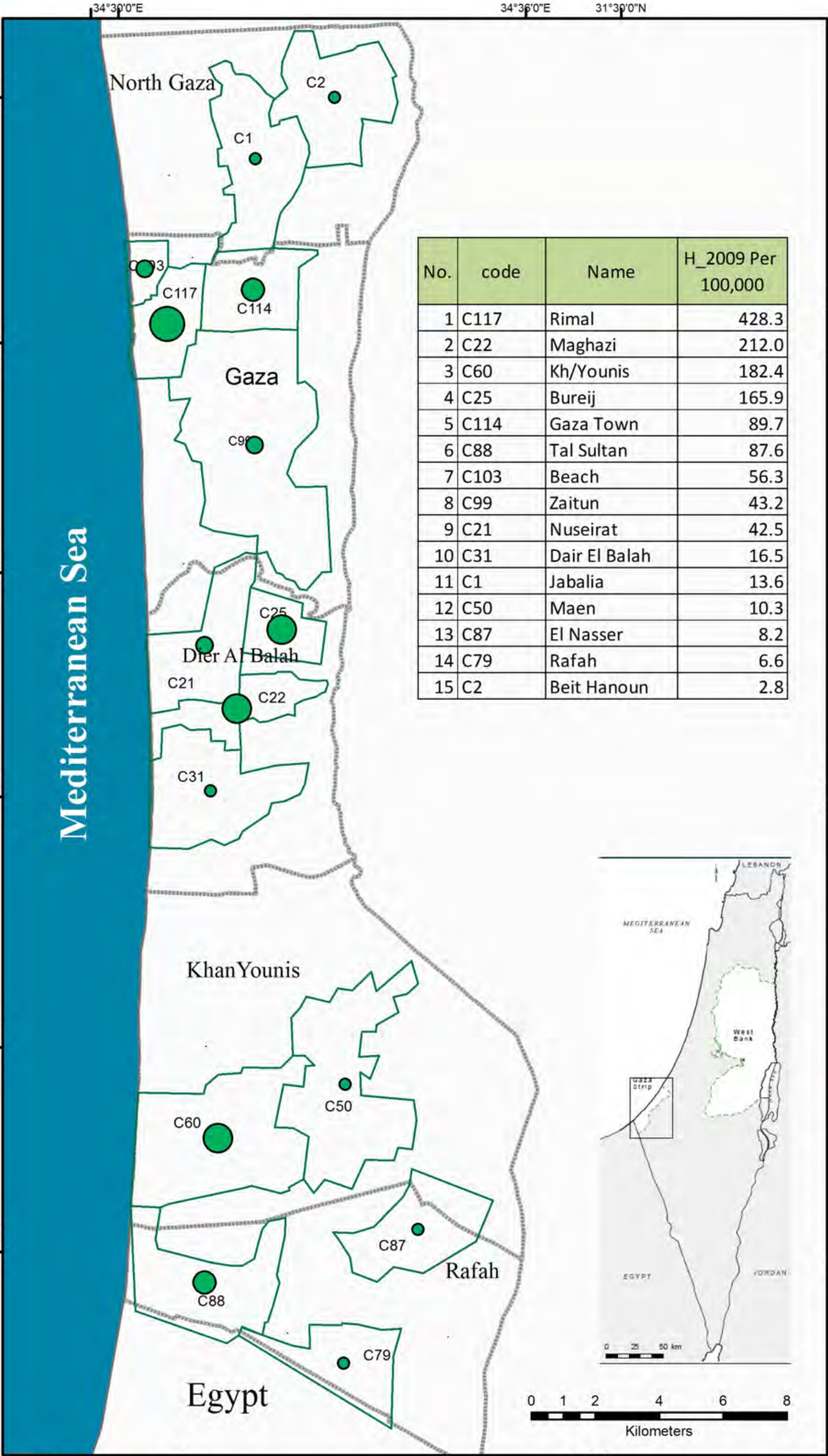
Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


**Funded by:**
Austrian Development Agency

# Hepatitis (A) incidence rate in Gaza Strip - UNRWA 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | H_2009 Per 100,000 |
|---|---|---|---|
| 1 | C117 | Rimal | 428.3 |
| 2 | C22 | Maghazi | 212.0 |
| 3 | C60 | Kh/Younis | 182.4 |
| 4 | C25 | Bureij | 165.9 |
| 5 | C114 | Gaza Town | 89.7 |
| 6 | C88 | Tal Sultan | 87.6 |
| 7 | C103 | Beach | 56.3 |
| 8 | C99 | Zaitun | 43.2 |
| 9 | C21 | Nuseirat | 42.5 |
| 10 | C31 | Dair El Balah | 16.5 |
| 11 | C1 | Jabalia | 13.6 |
| 12 | C50 | Maen | 10.3 |
| 13 | C87 | El Nasser | 8.2 |
| 14 | C79 | Rafah | 6.6 |
| 15 | C2 | Beit Hanoun | 2.8 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 2.8 - 16.5
- 16.6 - 56.3
- 56.4 - 89.7
- 89.8 - 212.0
- 212.1 - 428.3
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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**Date: 4/22/2015**

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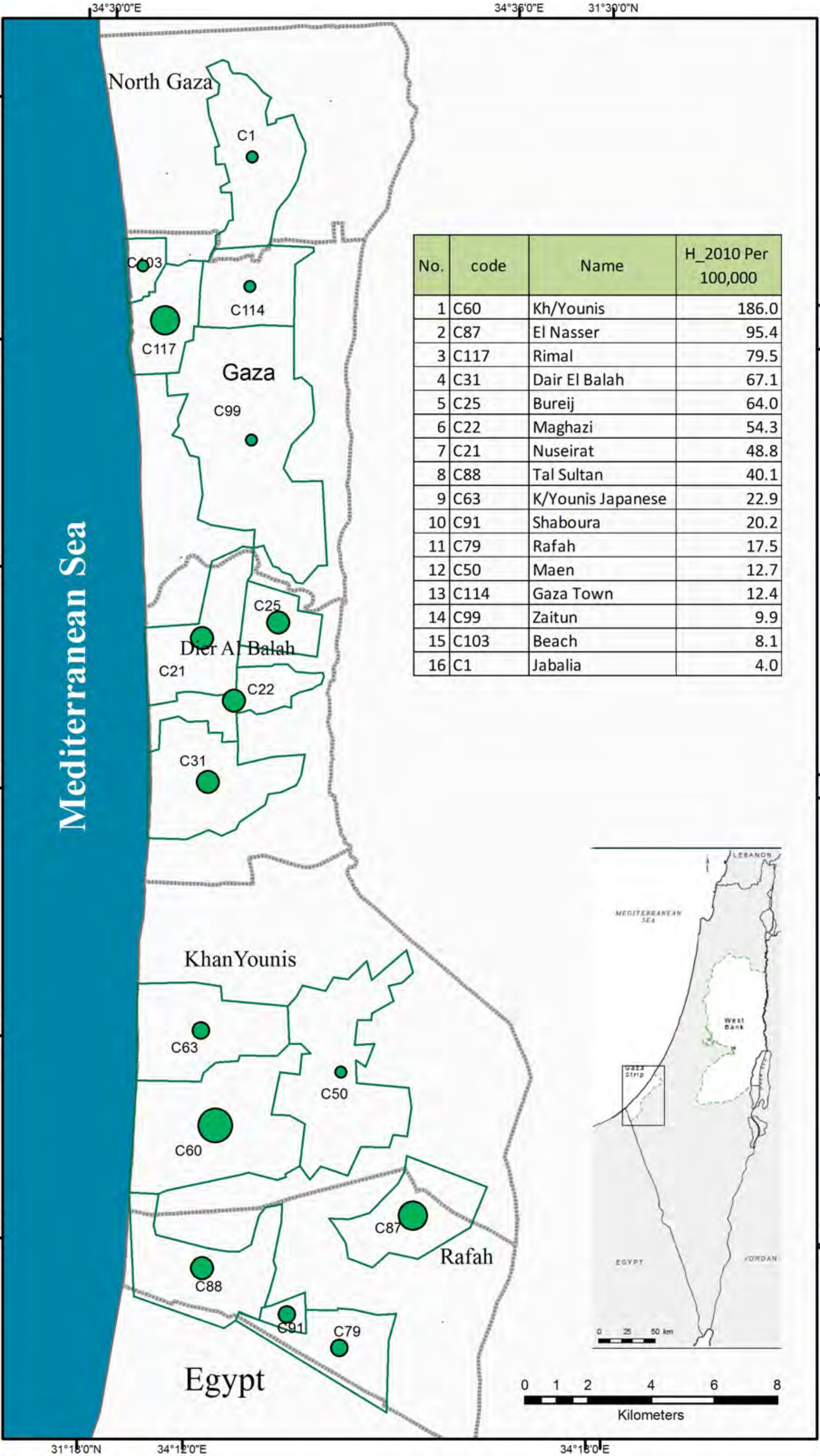
# Hepatitis (A) incidence rate in Gaza Strip - UNRWA 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | H_2010 Per 100,000 |
|---|---|---|---|
| 1 | C60 | Kh/Younis | 186.0 |
| 2 | C87 | El Nasser | 95.4 |
| 3 | C117 | Rimal | 79.5 |
| 4 | C31 | Dair El Balah | 67.1 |
| 5 | C25 | Bureij | 64.0 |
| 6 | C22 | Maghazi | 54.3 |
| 7 | C21 | Nuseirat | 48.8 |
| 8 | C88 | Tal Sultan | 40.1 |
| 9 | C63 | K/Younis Japanese | 22.9 |
| 10 | C91 | Shaboura | 20.2 |
| 11 | C79 | Rafah | 17.5 |
| 12 | C50 | Maen | 12.7 |
| 13 | C114 | Gaza Town | 12.4 |
| 14 | C99 | Zaitun | 9.9 |
| 15 | C103 | Beach | 8.1 |
| 16 | C1 | Jabalia | 4.0 |

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 4.0 - 12.7
- 12.8 - 22.9
- 23.0 - 67.1
- 67.2 - 95.4
- 95.5 - 186.0
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

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Palestine 1923 Palestine Grid
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latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

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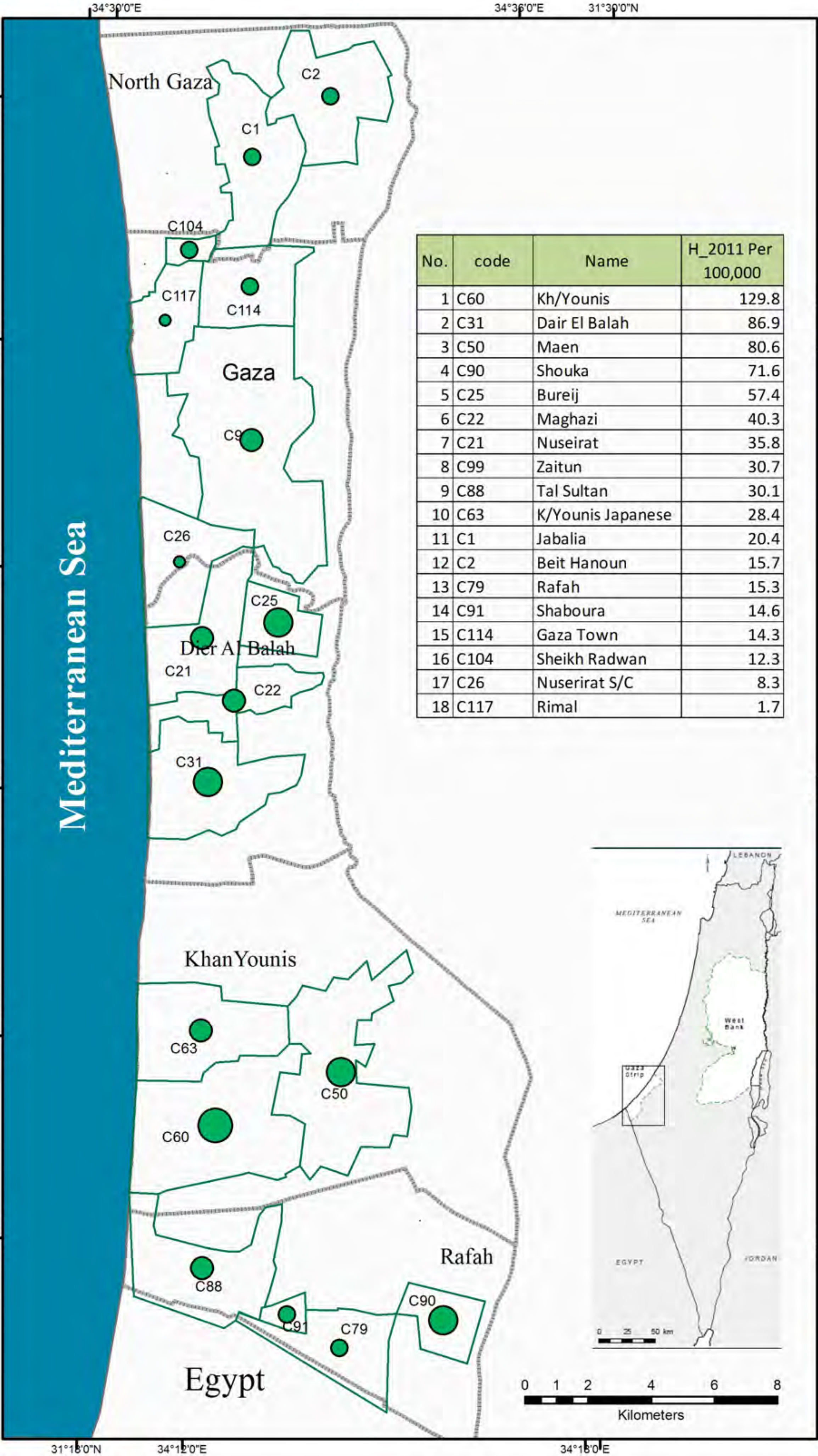
# Hepatitis (A) incidence rate in Gaza Strip - UNRWA 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | H_2011 Per 100,000 |
|---|---|---|---|
| 1 | C60 | Kh/Younis | 129.8 |
| 2 | C31 | Dair El Balah | 86.9 |
| 3 | C50 | Maen | 80.6 |
| 4 | C90 | Shouka | 71.6 |
| 5 | C25 | Bureij | 57.4 |
| 6 | C22 | Maghazi | 40.3 |
| 7 | C21 | Nuseirat | 35.8 |
| 8 | C99 | Zaitun | 30.7 |
| 9 | C88 | Tal Sultan | 30.1 |
| 10 | C63 | K/Younis Japanese | 28.4 |
| 11 | C1 | Jabalia | 20.4 |
| 12 | C2 | Beit Hanoun | 15.7 |
| 13 | C79 | Rafah | 15.3 |
| 14 | C91 | Shaboura | 14.6 |
| 15 | C114 | Gaza Town | 14.3 |
| 16 | C104 | Sheikh Radwan | 12.3 |
| 17 | C26 | Nuserirat S/C | 8.3 |
| 18 | C117 | Rimal | 1.7 |

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 1.7 - 8.3
- 8.4 - 20.4
- 20.5 - 40.3
- 40.4 - 86.9
- 87.0 - 129.8
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

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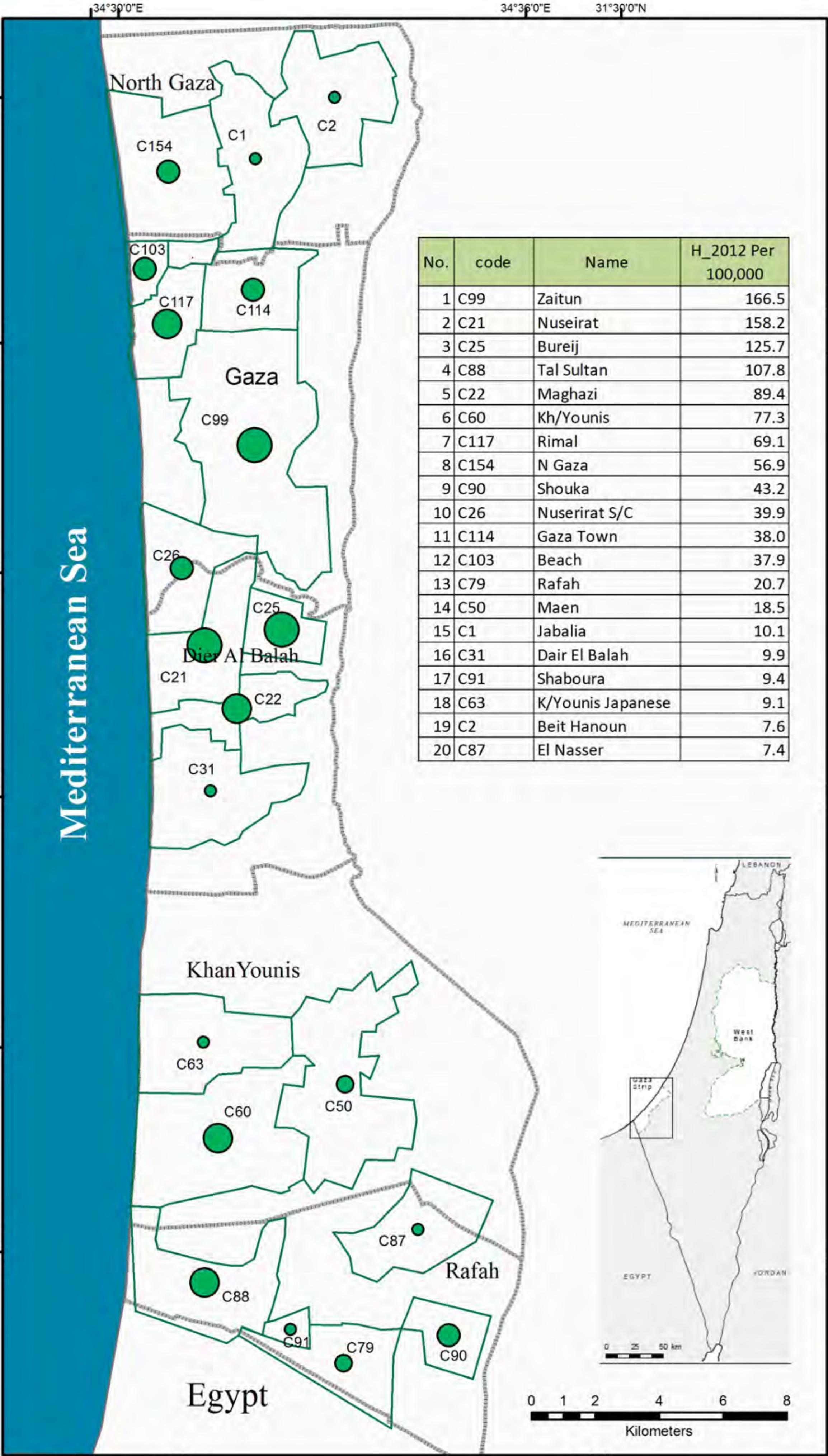
# Hepatitis (A) incidence rate in Gaza Strip - UNRWA 2012

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | H_2012 Per 100,000 |
|---|---|---|---|
| 1 | C99 | Zaitun | 166.5 |
| 2 | C21 | Nuseirat | 158.2 |
| 3 | C25 | Bureij | 125.7 |
| 4 | C88 | Tal Sultan | 107.8 |
| 5 | C22 | Maghazi | 89.4 |
| 6 | C60 | Kh/Younis | 77.3 |
| 7 | C117 | Rimal | 69.1 |
| 8 | C154 | N Gaza | 56.9 |
| 9 | C90 | Shouka | 43.2 |
| 10 | C26 | Nuserirat S/C | 39.9 |
| 11 | C114 | Gaza Town | 38.0 |
| 12 | C103 | Beach | 37.9 |
| 13 | C79 | Rafah | 20.7 |
| 14 | C50 | Maen | 18.5 |
| 15 | C1 | Jabalia | 10.1 |
| 16 | C31 | Dair El Balah | 9.9 |
| 17 | C91 | Shaboura | 9.4 |
| 18 | C63 | K/Younis Japanese | 9.1 |
| 19 | C2 | Beit Hanoun | 7.6 |
| 20 | C87 | El Nasser | 7.4 |

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 7.4 - 10.1
- 10.2 - 20.7
- 20.8 - 56.9
- 57.0 - 107.8
- 107.9 - 166.5
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

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false northing: 126,867.9090
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Units: Meter

**Date: 4/22/2015**

**Funded by:**
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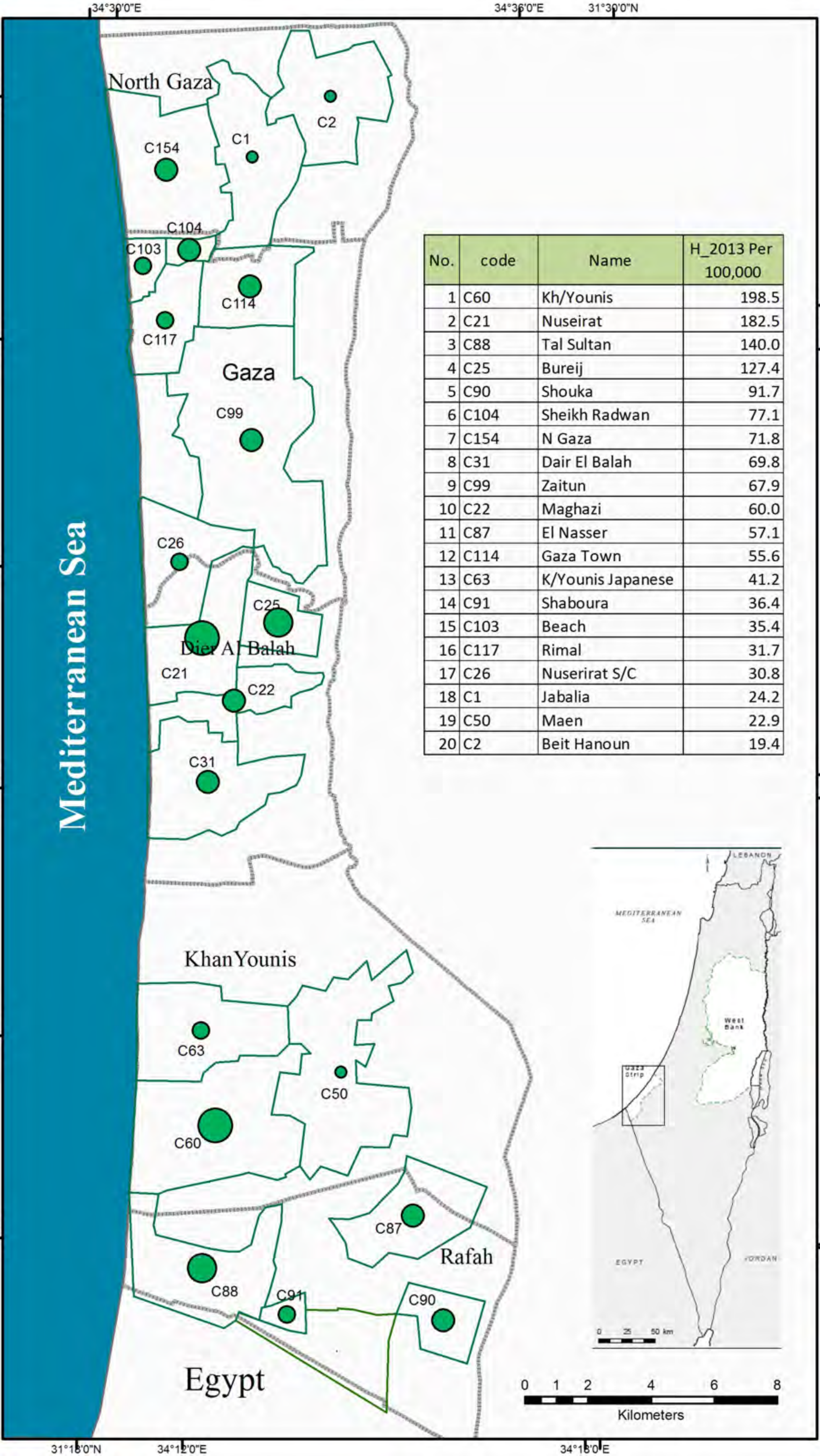
# Hepatitis (A) incidence rate in Gaza Strip - UNRWA 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | code | Name | H_2013 Per 100,000 |
|---|---|---|---|
| 1 | C60 | Kh/Younis | 198.5 |
| 2 | C21 | Nuseirat | 182.5 |
| 3 | C88 | Tal Sultan | 140.0 |
| 4 | C25 | Bureij | 127.4 |
| 5 | C90 | Shouka | 91.7 |
| 6 | C104 | Sheikh Radwan | 77.1 |
| 7 | C154 | N Gaza | 71.8 |
| 8 | C31 | Dair El Balah | 69.8 |
| 9 | C99 | Zaitun | 67.9 |
| 10 | C22 | Maghazi | 60.0 |
| 11 | C87 | El Nasser | 57.1 |
| 12 | C114 | Gaza Town | 55.6 |
| 13 | C63 | K/Younis Japanese | 41.2 |
| 14 | C91 | Shaboura | 36.4 |
| 15 | C103 | Beach | 35.4 |
| 16 | C117 | Rimal | 31.7 |
| 17 | C26 | Nuserirat S/C | 30.8 |
| 18 | C1 | Jabalia | 24.2 |
| 19 | C50 | Maen | 22.9 |
| 20 | C2 | Beit Hanoun | 19.4 |

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## Legend

**Hepatitis (A)**

**Incidence per 100,000**

- 19.4 - 24.2
- 24.3 - 41.2
- 41.3 - 91.7
- 91.8 - 140.0
- 140.1 - 198.5
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

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**Funded by:**
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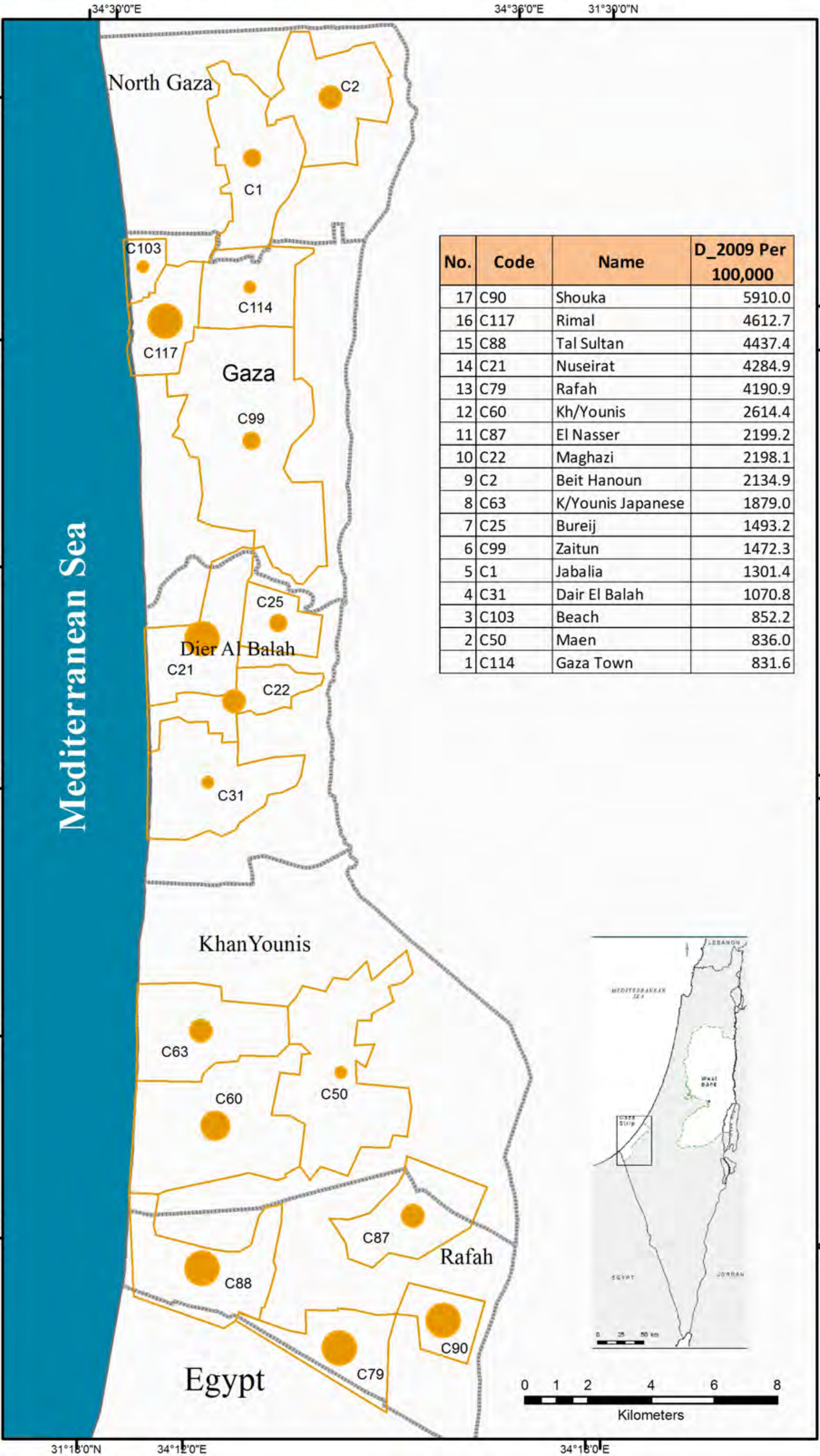
# Watery Diarrheal (Children below 3 yrs) incidence rate in Gaza Strip - UNRWA 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2009 Per 100,000 |
|---|---|---|---|
| 17 | C90 | Shouka | 5910.0 |
| 16 | C117 | Rimal | 4612.7 |
| 15 | C88 | Tal Sultan | 4437.4 |
| 14 | C21 | Nuseirat | 4284.9 |
| 13 | C79 | Rafah | 4190.9 |
| 12 | C60 | Kh/Younis | 2614.4 |
| 11 | C87 | El Nasser | 2199.2 |
| 10 | C22 | Maghazi | 2198.1 |
| 9 | C2 | Beit Hanoun | 2134.9 |
| 8 | C63 | K/Younis Japanese | 1879.0 |
| 7 | C25 | Bureij | 1493.2 |
| 6 | C99 | Zaitun | 1472.3 |
| 5 | C1 | Jabalia | 1301.4 |
| 4 | C31 | Dair El Balah | 1070.8 |
| 3 | C103 | Beach | 852.2 |
| 2 | C50 | Maen | 836.0 |
| 1 | C114 | Gaza Town | 831.6 |

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PALESTINIAN WATER AUTHORITY

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## Legend

**Diarrheal Incidence per 100,000**

- 831.6 - 1070.8
- 1070.9 - 1493.2
- 1493.3 - 2199.2
- 2199.3 - 2614.4
- 2614.5 - 5910.0
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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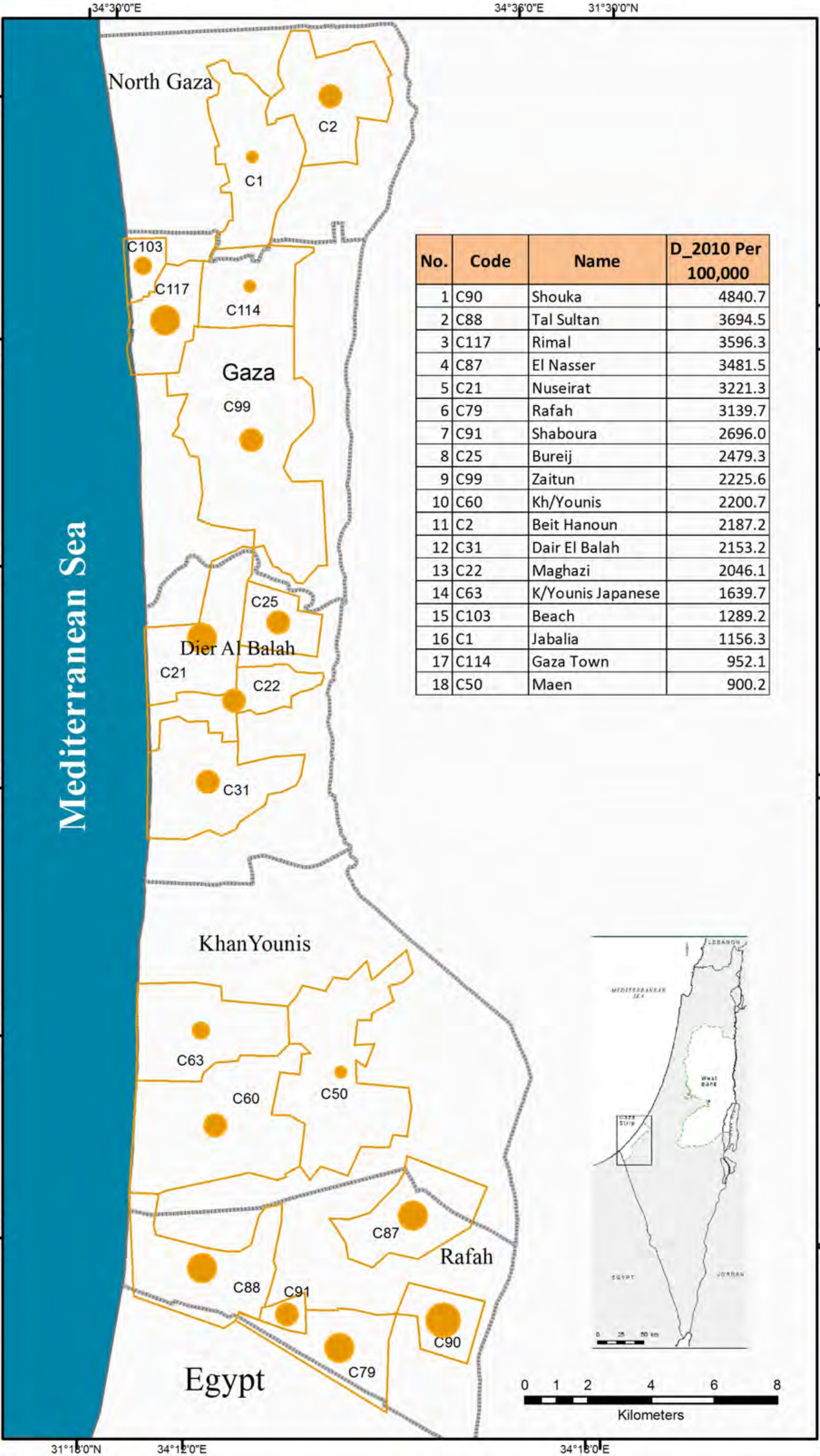
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian
Development Agency

# Watery Diarrheal (Children below 3 yrs) incidence rate in Gaza Strip - UNRWA 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2010 Per 100,000 |
|---|---|---|---|
| 1 | C90 | Shouka | 4840.7 |
| 2 | C88 | Tal Sultan | 3694.5 |
| 3 | C117 | Rimal | 3596.3 |
| 4 | C87 | El Nasser | 3481.5 |
| 5 | C21 | Nuseirat | 3221.3 |
| 6 | C79 | Rafah | 3139.7 |
| 7 | C91 | Shaboura | 2696.0 |
| 8 | C25 | Bureij | 2479.3 |
| 9 | C99 | Zaitun | 2225.6 |
| 10 | C60 | Kh/Younis | 2200.7 |
| 11 | C2 | Beit Hanoun | 2187.2 |
| 12 | C31 | Dair El Balah | 2153.2 |
| 13 | C22 | Maghazi | 2046.1 |
| 14 | C63 | K/Younis Japanese | 1639.7 |
| 15 | C103 | Beach | 1289.2 |
| 16 | C1 | Jabalia | 1156.3 |
| 17 | C114 | Gaza Town | 952.1 |
| 18 | C50 | Maen | 900.2 |

PALESTINIAN WATER AUTHORITY

## Legend

**Diarrheal Incidence per 100,000**

- 900.2 - 1156.3
- 1156.4 - 1639.7
- 1639.8 - 2696.0
- 2696.1 - 3694.5
- 3694.6 - 4840.7
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

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# Watery Diarrheal (Children below 3 yrs) incidence rate in Gaza Strip - UNRWA 2011

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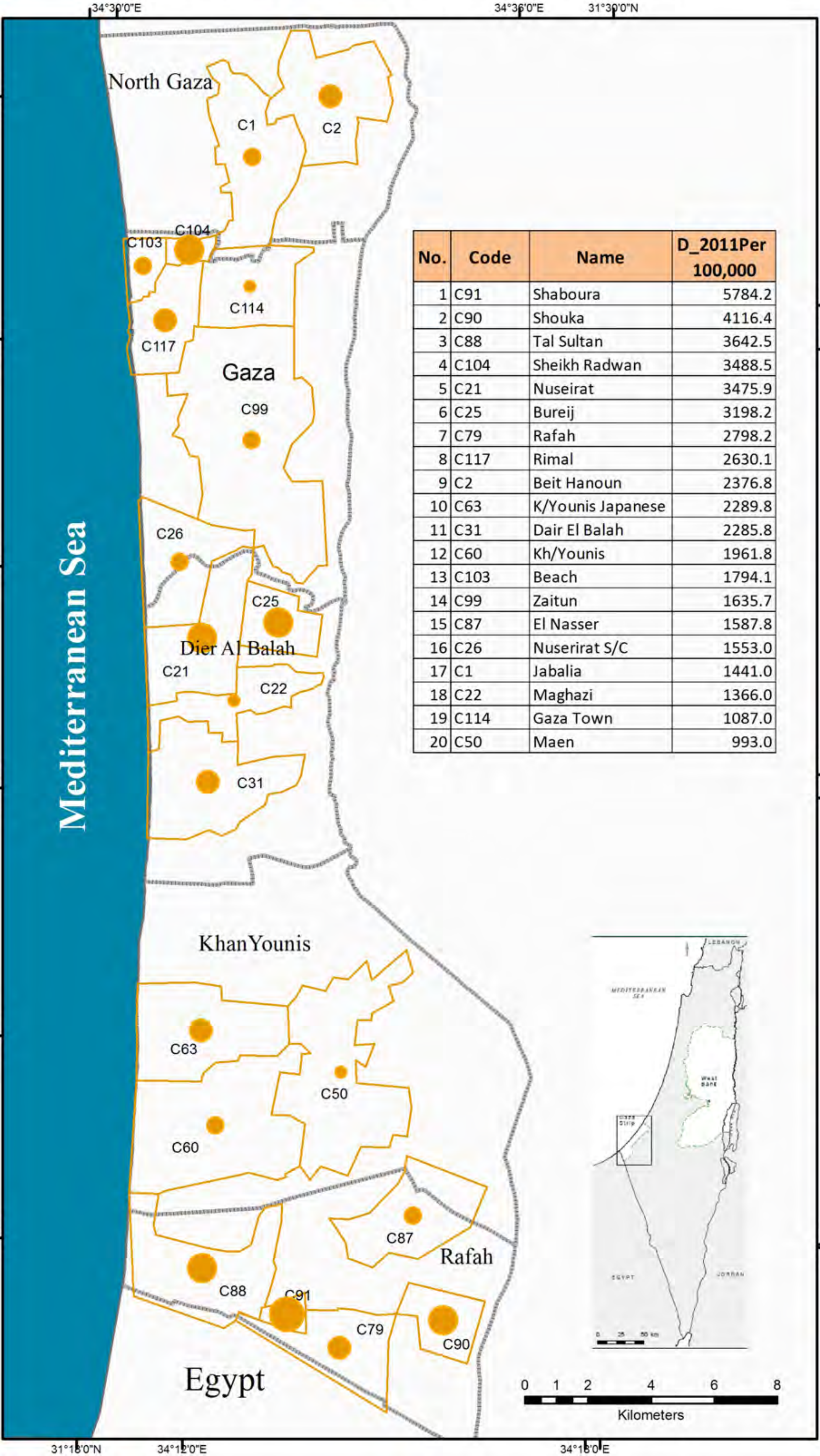


| No. | Code | Name | D_2011Per 100,000 |
|---|---|---|---|
| 1 | C91 | Shaboura | 5784.2 |
| 2 | C90 | Shouka | 4116.4 |
| 3 | C88 | Tal Sultan | 3642.5 |
| 4 | C104 | Sheikh Radwan | 3488.5 |
| 5 | C21 | Nuseirat | 3475.9 |
| 6 | C25 | Bureij | 3198.2 |
| 7 | C79 | Rafah | 2798.2 |
| 8 | C117 | Rimal | 2630.1 |
| 9 | C2 | Beit Hanoun | 2376.8 |
| 10 | C63 | K/Younis Japanese | 2289.8 |
| 11 | C31 | Dair El Balah | 2285.8 |
| 12 | C60 | Kh/Younis | 1961.8 |
| 13 | C103 | Beach | 1794.1 |
| 14 | C99 | Zaitun | 1635.7 |
| 15 | C87 | El Nasser | 1587.8 |
| 16 | C26 | Nuserirat S/C | 1553.0 |
| 17 | C1 | Jabalia | 1441.0 |
| 18 | C22 | Maghazi | 1366.0 |
| 19 | C114 | Gaza Town | 1087.0 |
| 20 | C50 | Maen | 993.0 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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## Legend

**Diarrheal Incidence per 100,000**

- 993.0 - 1366.0
- 1366.1 - 1961.8
- 1961.9 - 2798.2
- 2798.3 - 4116.4
- 4116.5 - 5784.2
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
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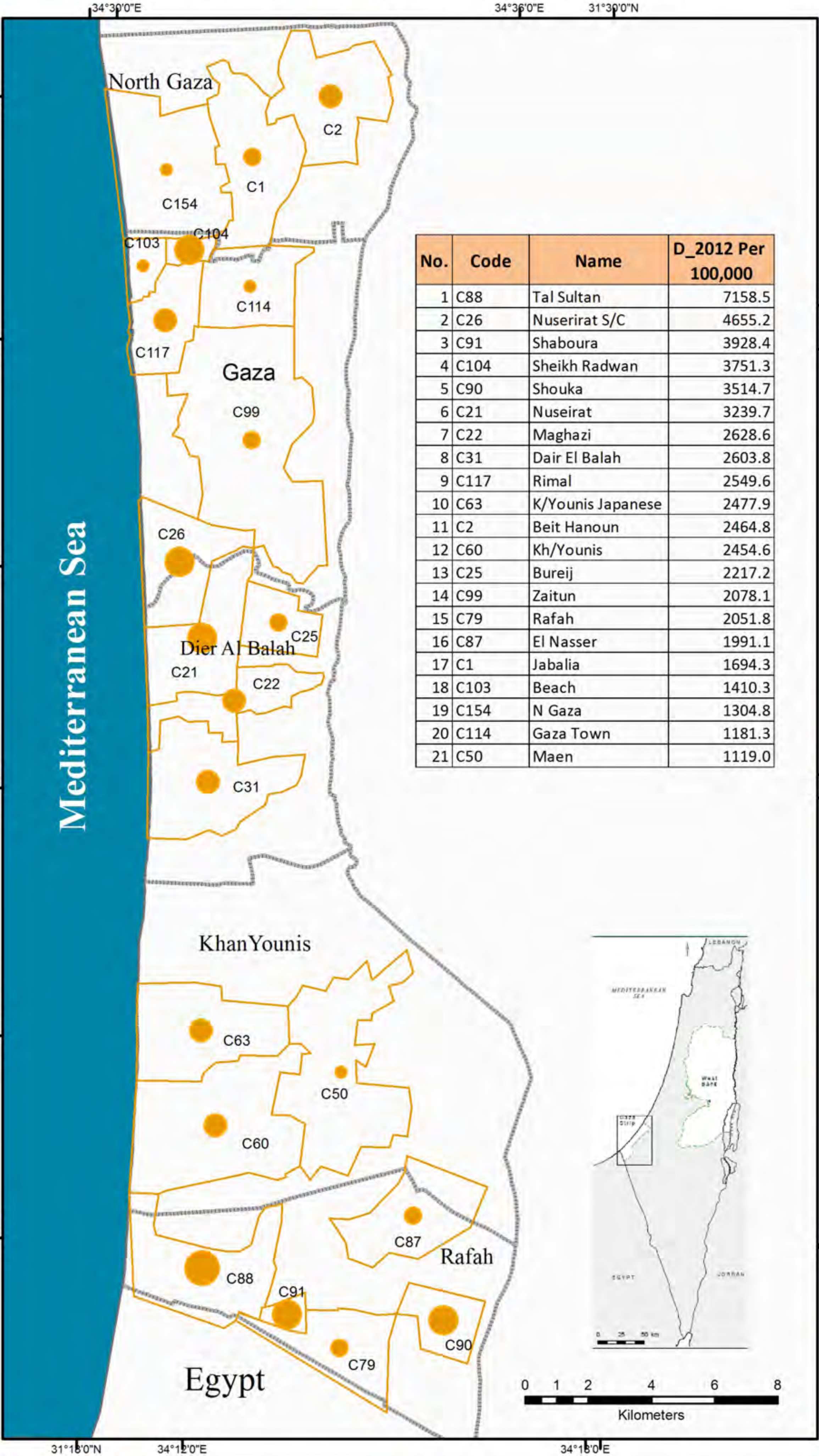


| No. | Code | Name | D_2012 Per 100,000 |
|---|---|---|---|
| 1 | C88 | Tal Sultan | 7158.5 |
| 2 | C26 | Nuserirat S/C | 4655.2 |
| 3 | C91 | Shaboura | 3928.4 |
| 4 | C104 | Sheikh Radwan | 3751.3 |
| 5 | C90 | Shouka | 3514.7 |
| 6 | C21 | Nuseirat | 3239.7 |
| 7 | C22 | Maghazi | 2628.6 |
| 8 | C31 | Dair El Balah | 2603.8 |
| 9 | C117 | Rimal | 2549.6 |
| 10 | C63 | K/Younis Japanese | 2477.9 |
| 11 | C2 | Beit Hanoun | 2464.8 |
| 12 | C60 | Kh/Younis | 2454.6 |
| 13 | C25 | Bureij | 2217.2 |
| 14 | C99 | Zaitun | 2078.1 |
| 15 | C79 | Rafah | 2051.8 |
| 16 | C87 | El Nasser | 1991.1 |
| 17 | C1 | Jabalia | 1694.3 |
| 18 | C103 | Beach | 1410.3 |
| 19 | C154 | N Gaza | 1304.8 |
| 20 | C114 | Gaza Town | 1181.3 |
| 21 | C50 | Maen | 1119.0 |

## Legend

**Diarrheal Incidence per 100,000**

- 1119.0 - 1410.3
- 1410.4 - 2217.2
- 2217.3 - 2628.6
- 2628.7 - 4655.2
- 4655.3 - 7158.5
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
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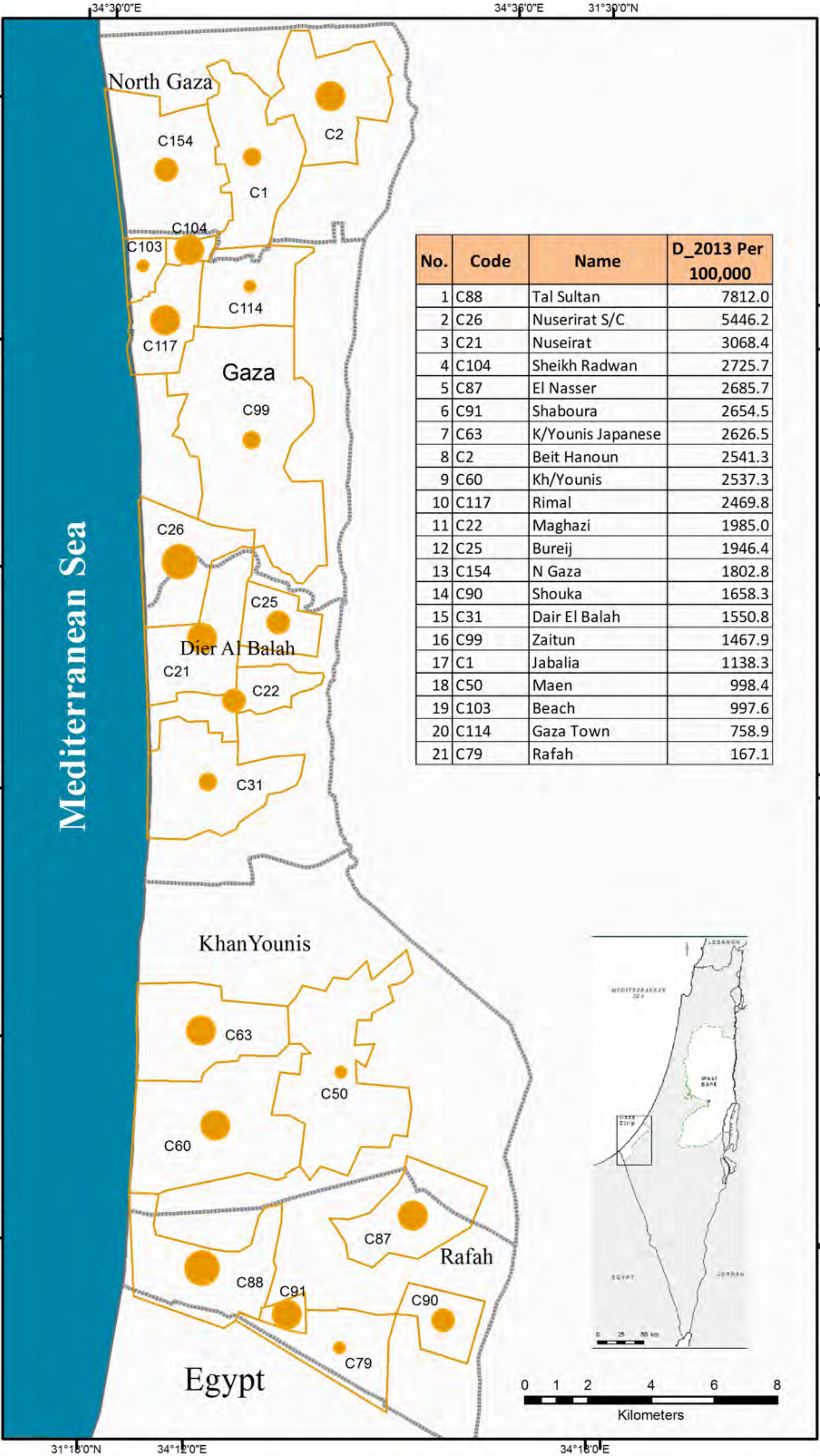


| No. | Code | Name | D_2013 Per 100,000 |
|---|---|---|---|
| 1 | C88 | Tal Sultan | 7812.0 |
| 2 | C26 | Nuserirat S/C | 5446.2 |
| 3 | C21 | Nuseirat | 3068.4 |
| 4 | C104 | Sheikh Radwan | 2725.7 |
| 5 | C87 | El Nasser | 2685.7 |
| 6 | C91 | Shaboura | 2654.5 |
| 7 | C63 | K/Younis Japanese | 2626.5 |
| 8 | C2 | Beit Hanoun | 2541.3 |
| 9 | C60 | Kh/Younis | 2537.3 |
| 10 | C117 | Rimal | 2469.8 |
| 11 | C22 | Maghazi | 1985.0 |
| 12 | C25 | Bureij | 1946.4 |
| 13 | C154 | N Gaza | 1802.8 |
| 14 | C90 | Shouka | 1658.3 |
| 15 | C31 | Dair El Balah | 1550.8 |
| 16 | C99 | Zaitun | 1467.9 |
| 17 | C1 | Jabalia | 1138.3 |
| 18 | C50 | Maen | 998.4 |
| 19 | C103 | Beach | 997.6 |
| 20 | C114 | Gaza Town | 758.9 |
| 21 | C79 | Rafah | 167.1 |

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## Legend

**Diarrheal Incidence per 100,000**

- 167.1 - 998.4
- 998.5 - 1550.8
- 1550.9 - 1985.0
- 1985.1 - 3068.4
- 3068.5 - 7812.0
- Catchment Area
- Governorate
- Sea

Source:
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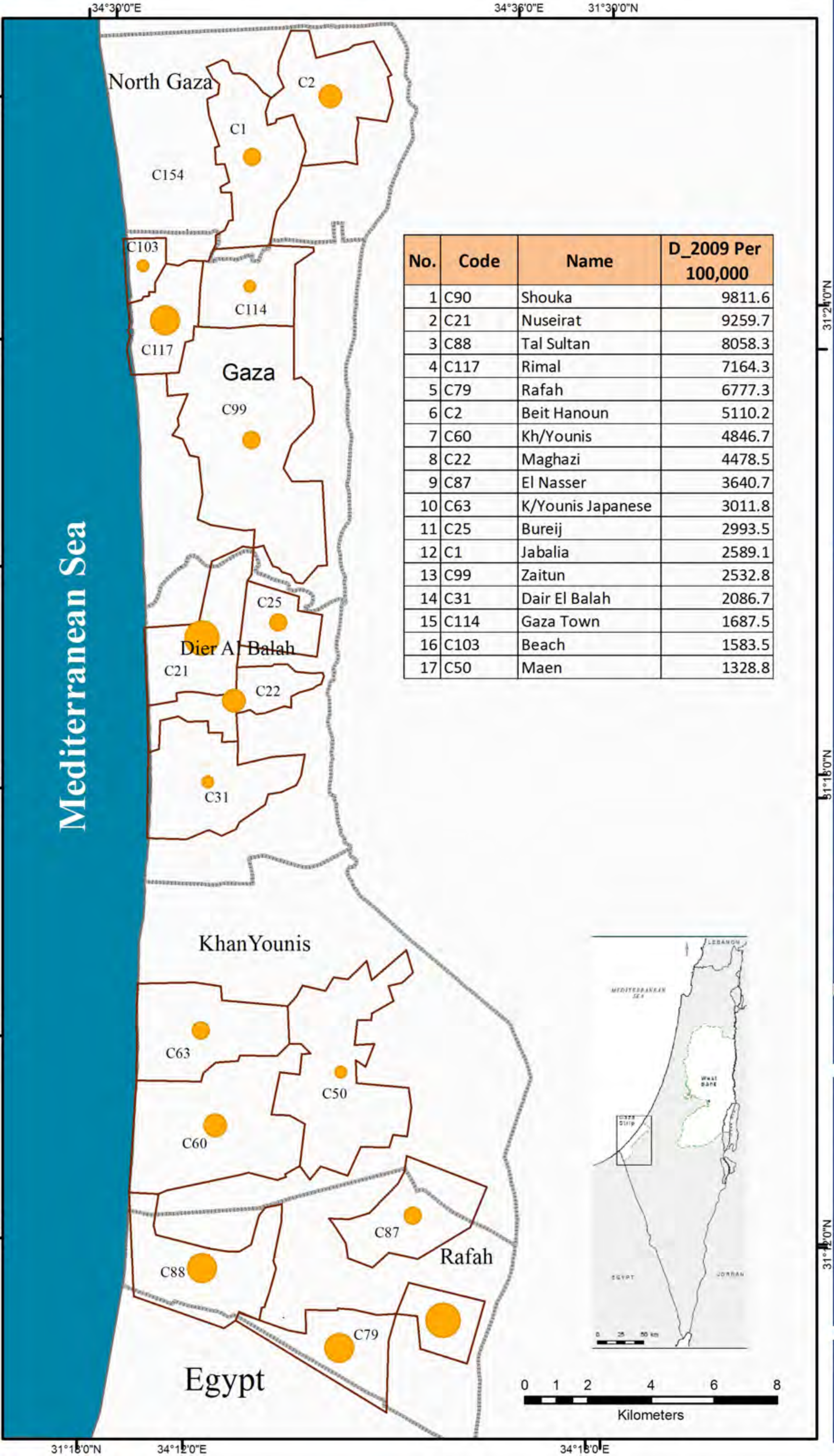
# Diarrheal incidence rate in Gaza Strip - UNRWA 2009

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2009 Per 100,000 |
|---|---|---|---|
| 1 | C90 | Shouka | 9811.6 |
| 2 | C21 | Nuseirat | 9259.7 |
| 3 | C88 | Tal Sultan | 8058.3 |
| 4 | C117 | Rimal | 7164.3 |
| 5 | C79 | Rafah | 6777.3 |
| 6 | C2 | Beit Hanoun | 5110.2 |
| 7 | C60 | Kh/Younis | 4846.7 |
| 8 | C22 | Maghazi | 4478.5 |
| 9 | C87 | El Nasser | 3640.7 |
| 10 | C63 | K/Younis Japanese | 3011.8 |
| 11 | C25 | Bureij | 2993.5 |
| 12 | C1 | Jabalia | 2589.1 |
| 13 | C99 | Zaitun | 2532.8 |
| 14 | C31 | Dair El Balah | 2086.7 |
| 15 | C114 | Gaza Town | 1687.5 |
| 16 | C103 | Beach | 1583.5 |
| 17 | C50 | Maen | 1328.8 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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N E S W

## Legend

**Diarrheal Incidence per 100,000**

- 1,328.8 - 2,086.7
- 2,086.8 - 3,640.7
- 3,640.8 - 5,110.2
- 5,110.3 - 8,058.3
- 8,058.4 - 9,811.6

Catchment Area

Governorate

Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

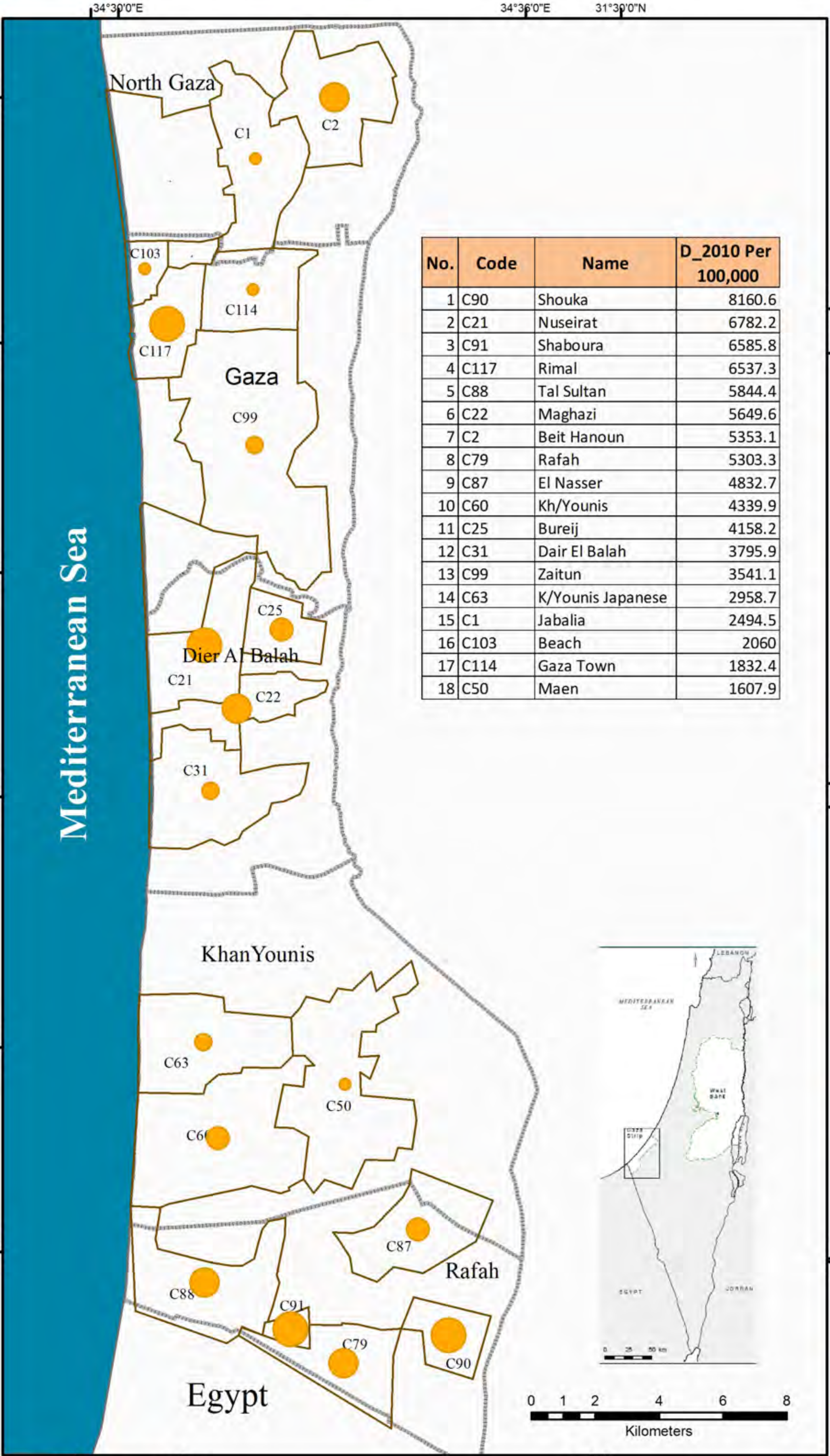
**Date: 4/22/2015**

**Funded by:**

Austrian Development Agency

# Diarrheal incidence rate in Gaza Strip - UNRWA 2010

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2010 Per 100,000 |
|---|---|---|---|
| 1 | C90 | Shouka | 8160.6 |
| 2 | C21 | Nuseirat | 6782.2 |
| 3 | C91 | Shaboura | 6585.8 |
| 4 | C117 | Rimal | 6537.3 |
| 5 | C88 | Tal Sultan | 5844.4 |
| 6 | C22 | Maghazi | 5649.6 |
| 7 | C2 | Beit Hanoun | 5353.1 |
| 8 | C79 | Rafah | 5303.3 |
| 9 | C87 | El Nasser | 4832.7 |
| 10 | C60 | Kh/Younis | 4339.9 |
| 11 | C25 | Bureij | 4158.2 |
| 12 | C31 | Dair El Balah | 3795.9 |
| 13 | C99 | Zaitun | 3541.1 |
| 14 | C63 | K/Younis Japanese | 2958.7 |
| 15 | C1 | Jabalia | 2494.5 |
| 16 | C103 | Beach | 2060 |
| 17 | C114 | Gaza Town | 1832.4 |
| 18 | C50 | Maen | 1607.9 |

سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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N E S W

## Legend

**Diarrheal Incidence per 100,000**

- 1,607.9 - 2,494.5
- 2,494.6 - 3,795.9
- 3,796.0 - 4,832.7
- 4,832.8 - 5,844.4
- 5,844.5 - 8,160.6
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
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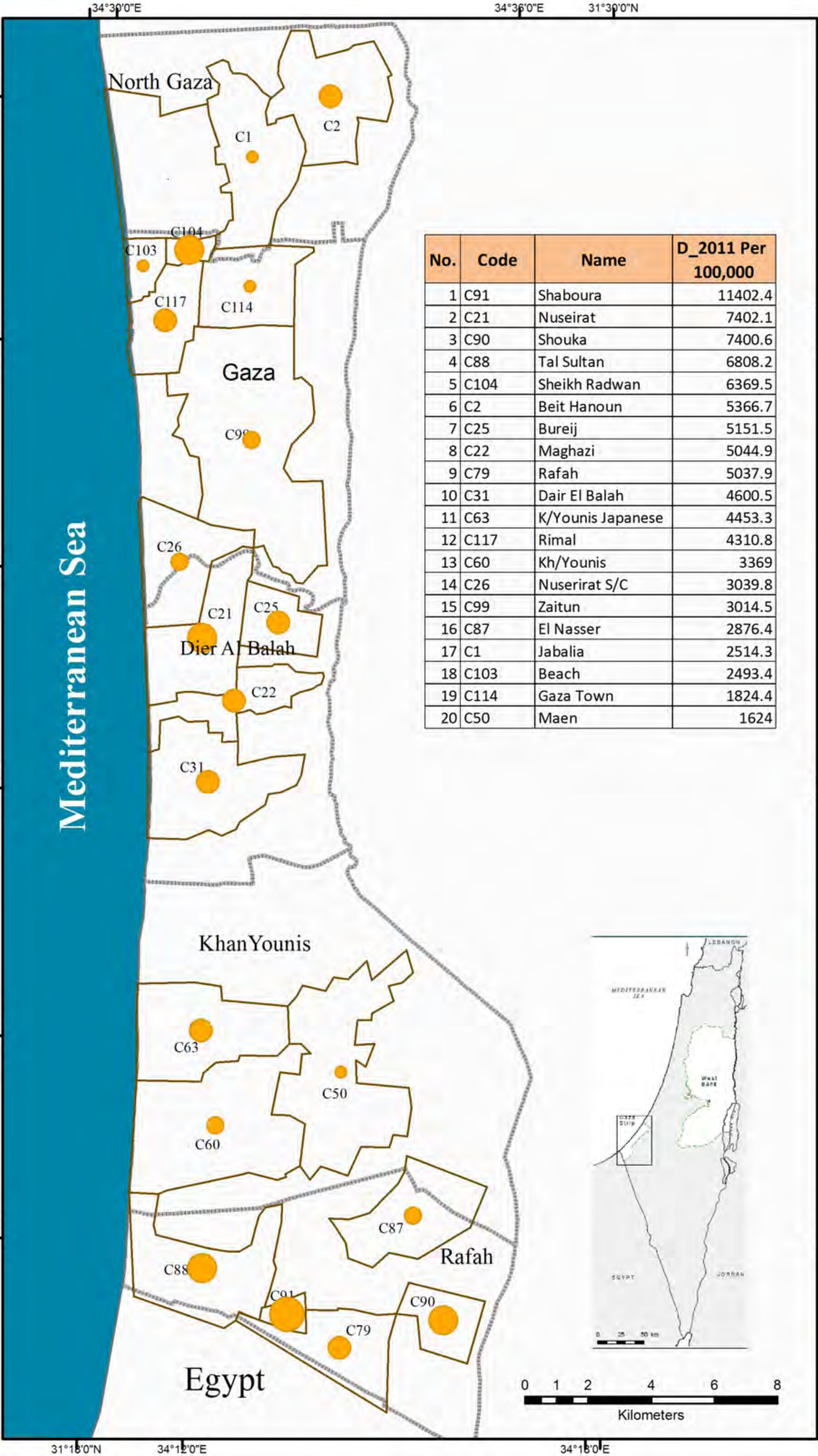
# Diarrheal incidence rate in Gaza Strip - UNRWA 2011

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2011 Per 100,000 |
|---|---|---|---|
| 1 | C91 | Shaboura | 11402.4 |
| 2 | C21 | Nuseirat | 7402.1 |
| 3 | C90 | Shouka | 7400.6 |
| 4 | C88 | Tal Sultan | 6808.2 |
| 5 | C104 | Sheikh Radwan | 6369.5 |
| 6 | C2 | Beit Hanoun | 5366.7 |
| 7 | C25 | Bureij | 5151.5 |
| 8 | C22 | Maghazi | 5044.9 |
| 9 | C79 | Rafah | 5037.9 |
| 10 | C31 | Dair El Balah | 4600.5 |
| 11 | C63 | K/Younis Japanese | 4453.3 |
| 12 | C117 | Rimal | 4310.8 |
| 13 | C60 | Kh/Younis | 3369 |
| 14 | C26 | Nuserirat S/C | 3039.8 |
| 15 | C99 | Zaitun | 3014.5 |
| 16 | C87 | El Nasser | 2876.4 |
| 17 | C1 | Jabalia | 2514.3 |
| 18 | C103 | Beach | 2493.4 |
| 19 | C114 | Gaza Town | 1824.4 |
| 20 | C50 | Maen | 1624 |

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## Legend

**Diarrheal**

**Incidence per 100,000**

- 1,624.0 - 2,514.3
- 2,514.4 - 3,369.0
- 3,369.1 - 5,366.7
- 5,366.8 - 7,402.1
- 7,402.2 - 11,402.4

Catchment Area

Governorate

Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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Units: Meter

**Date: 4/22/2015**

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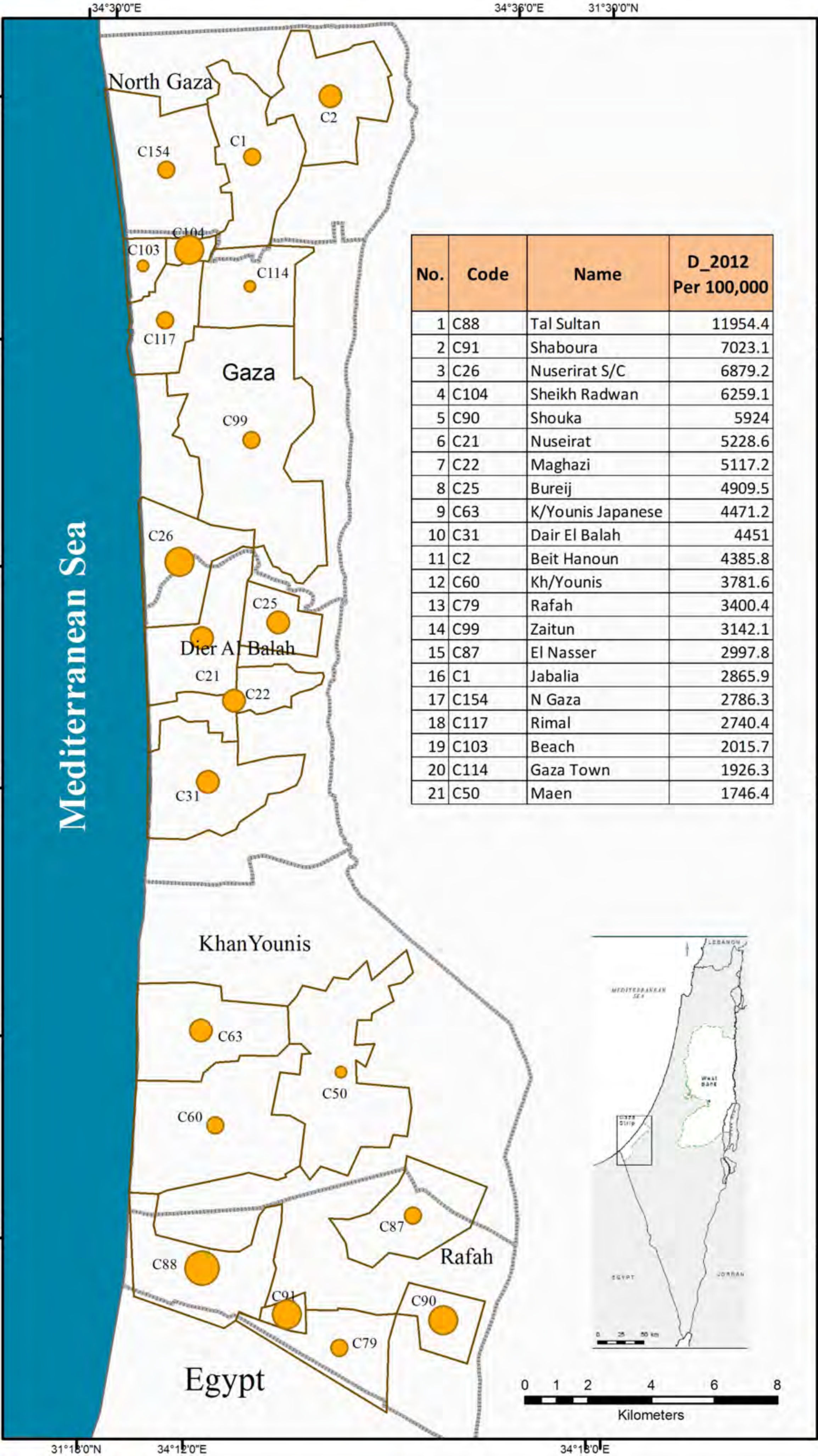
# Diarrheal incidence rate in Gaza Strip - UNRWA 2012

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2012 Per 100,000 |
|---|---|---|---|
| 1 | C88 | Tal Sultan | 11954.4 |
| 2 | C91 | Shaboura | 7023.1 |
| 3 | C26 | Nuserirat S/C | 6879.2 |
| 4 | C104 | Sheikh Radwan | 6259.1 |
| 5 | C90 | Shouka | 5924 |
| 6 | C21 | Nuseirat | 5228.6 |
| 7 | C22 | Maghazi | 5117.2 |
| 8 | C25 | Bureij | 4909.5 |
| 9 | C63 | K/Younis Japanese | 4471.2 |
| 10 | C31 | Dair El Balah | 4451 |
| 11 | C2 | Beit Hanoun | 4385.8 |
| 12 | C60 | Kh/Younis | 3781.6 |
| 13 | C79 | Rafah | 3400.4 |
| 14 | C99 | Zaitun | 3142.1 |
| 15 | C87 | El Nasser | 2997.8 |
| 16 | C1 | Jabalia | 2865.9 |
| 17 | C154 | N Gaza | 2786.3 |
| 18 | C117 | Rimal | 2740.4 |
| 19 | C103 | Beach | 2015.7 |
| 20 | C114 | Gaza Town | 1926.3 |
| 21 | C50 | Maen | 1746.4 |

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## Legend

**Diarrheal Incidence per 100,000**

- 1,746.4 - 2,015.7
- 2,015.8 - 3,781.6
- 3,781.7 - 5,228.6
- 5,228.7 - 7,023.1
- 7,023.2 - 11,954.4
- Catchment Area
- Governorate
- Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

Coordinate System:
Palestine 1923 Palestine Grid
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Units: Meter

**Date: 4/22/2015**

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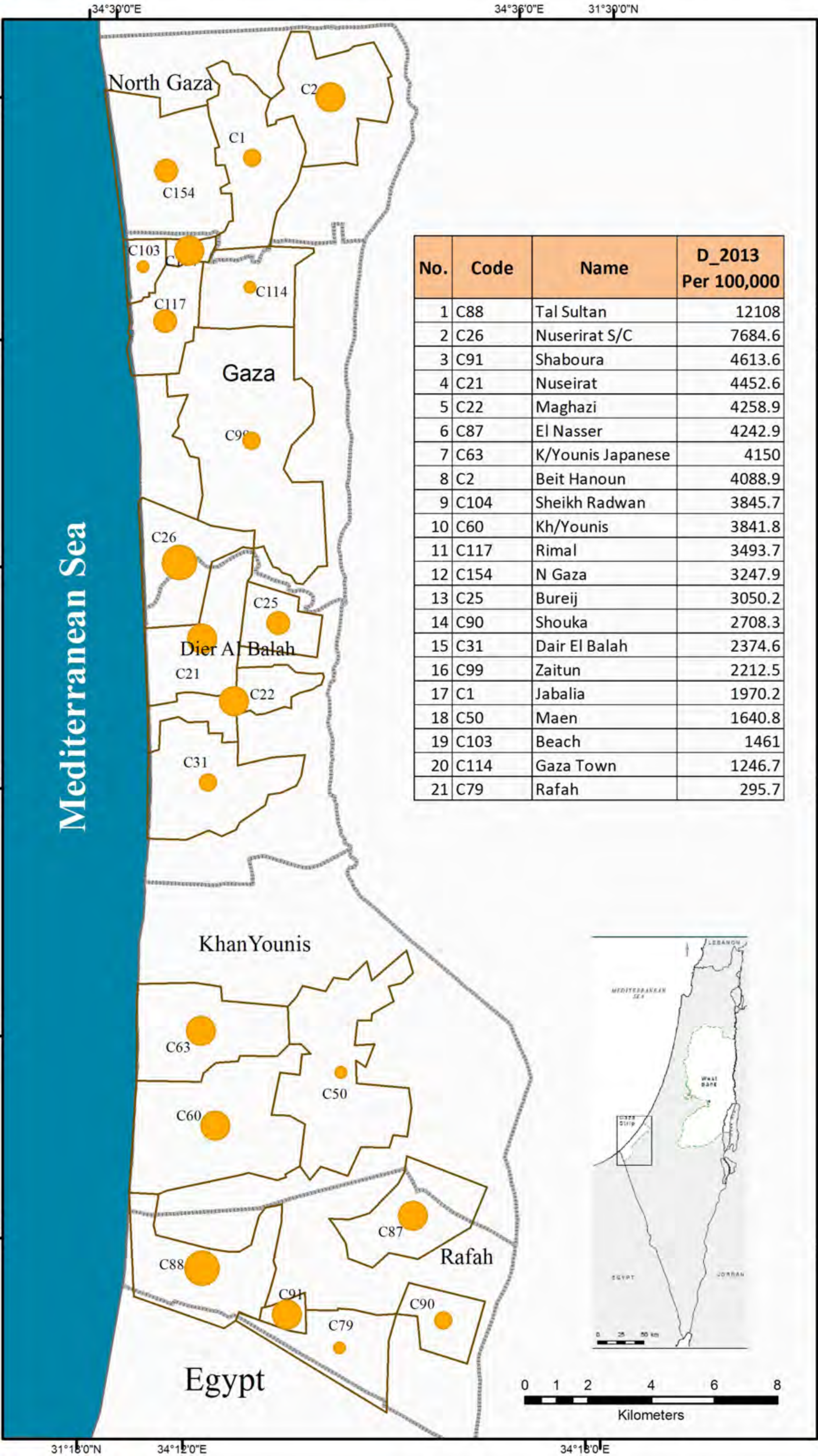
# Diarrheal incidence rate in Gaza Strip - UNRWA 2013

Baseline Study on Water Quality and Public Health - April, 2015




| No. | Code | Name | D_2013 Per 100,000 |
|---|---|---|---|
| 1 | C88 | Tal Sultan | 12108 |
| 2 | C26 | Nuserirat S/C | 7684.6 |
| 3 | C91 | Shaboura | 4613.6 |
| 4 | C21 | Nuseirat | 4452.6 |
| 5 | C22 | Maghazi | 4258.9 |
| 6 | C87 | El Nasser | 4242.9 |
| 7 | C63 | K/Younis Japanese | 4150 |
| 8 | C2 | Beit Hanoun | 4088.9 |
| 9 | C104 | Sheikh Radwan | 3845.7 |
| 10 | C60 | Kh/Younis | 3841.8 |
| 11 | C117 | Rimal | 3493.7 |
| 12 | C154 | N Gaza | 3247.9 |
| 13 | C25 | Bureij | 3050.2 |
| 14 | C90 | Shouka | 2708.3 |
| 15 | C31 | Dair El Balah | 2374.6 |
| 16 | C99 | Zaitun | 2212.5 |
| 17 | C1 | Jabalia | 1970.2 |
| 18 | C50 | Maen | 1640.8 |
| 19 | C103 | Beach | 1461 |
| 20 | C114 | Gaza Town | 1246.7 |
| 21 | C79 | Rafah | 295.7 |

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## Legend

**Diarrheal Incidence per 100,000**

- 295.7 - 1,640.8
- 1,640.9 - 2,708.3
- 2,708.4 - 3,493.7
- 3,493.8 - 4,613.6
- 4,613.7 - 12,108.0

Catchment Area
Governorate
Sea

Source:
Gaza Filed Office| UNRWA
Date of Data : 2009-2013

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**Date: 4/22/2015**

**Funded by:**

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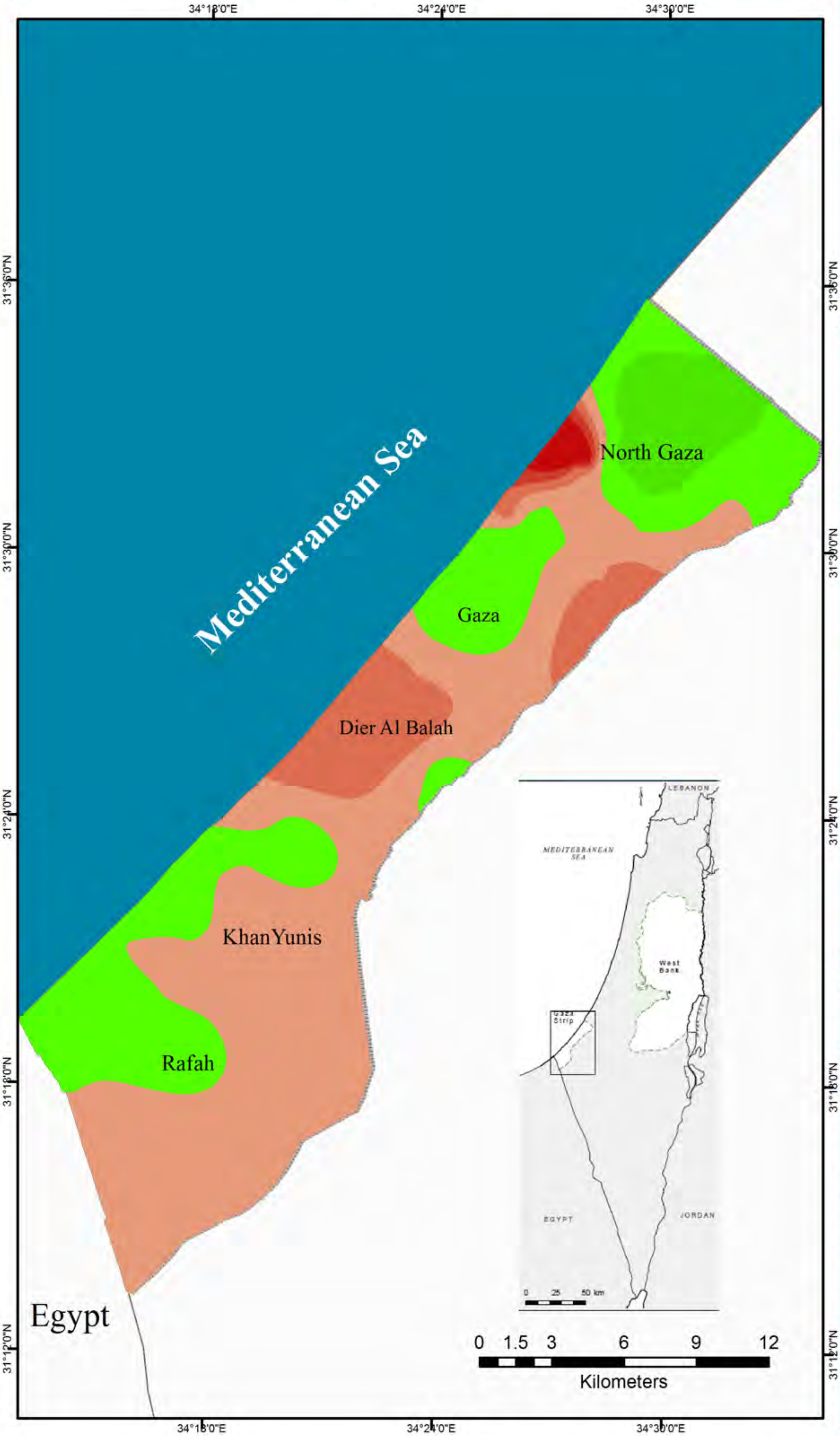
# Gaza Strip : Average Chloride Concentration for Year 2009 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015

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PALESTINIAN WATER AUTHORITY

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**Legend**

**CL mg/L 2009**

- ≤ 250
- 251 – 600
- 601 – 1,000
- 1,001 – 1,400
- 1,401 – 2,000
- > 2,000
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
Projection: Cassini
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**Date: 4/22/2015**


**Funded by:**

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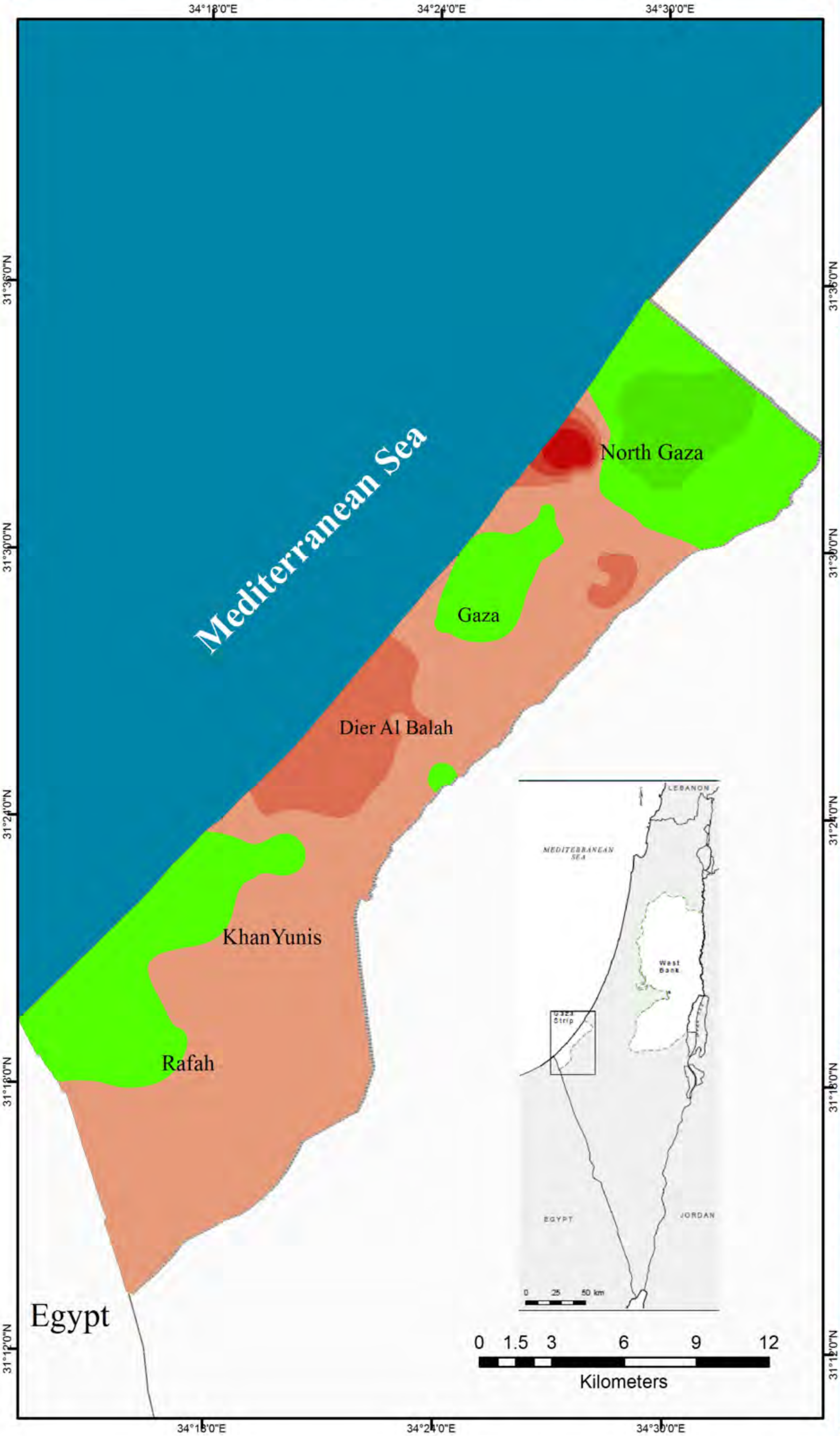
# Gaza Strip : Average Chloride Concentration for Year 2010 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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N W E S

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- ≤ 250
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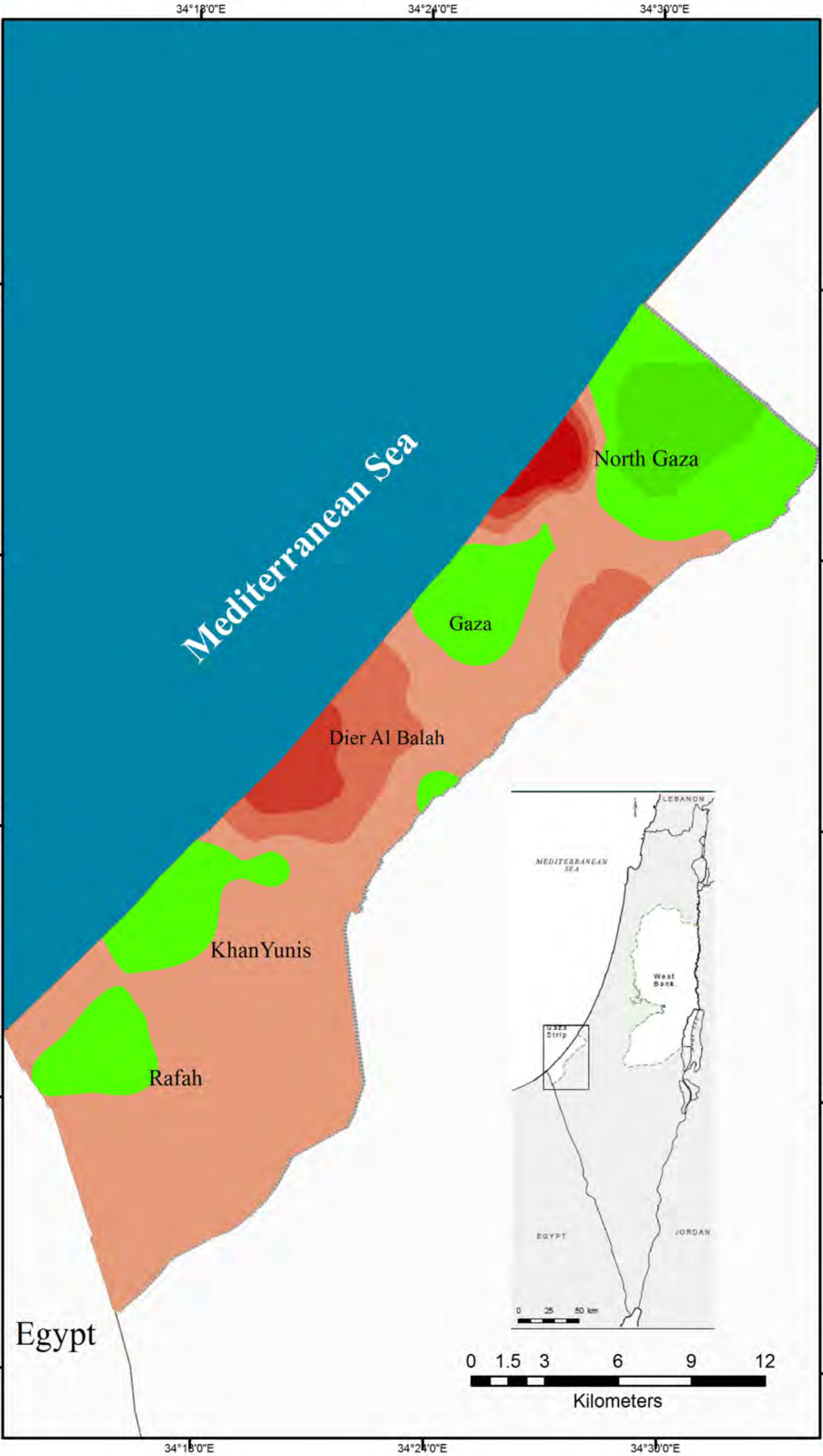


PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

N W E S

**Legend**

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**Date: 4/22/2015**

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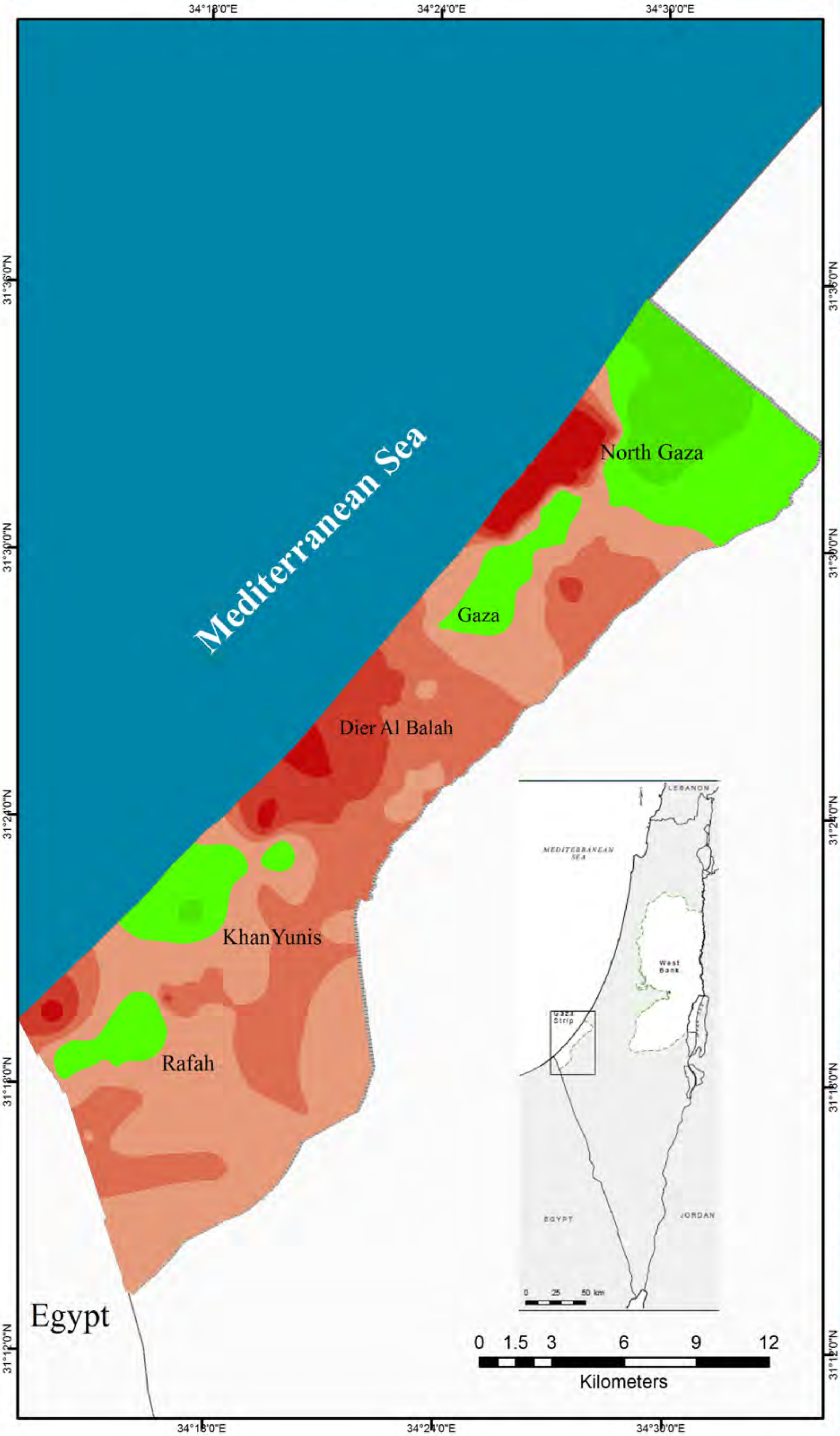
# Gaza Strip : Average Chloride Concentration for Year 2012 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




N
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**Legend**

**CL mg/L 2012**

- ≤ 250
- 251 – 600
- 601 – 1,000
- 1,001 – 1,400
- 1,401 – 2,000
- > 2,000
- Governorate
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Source:
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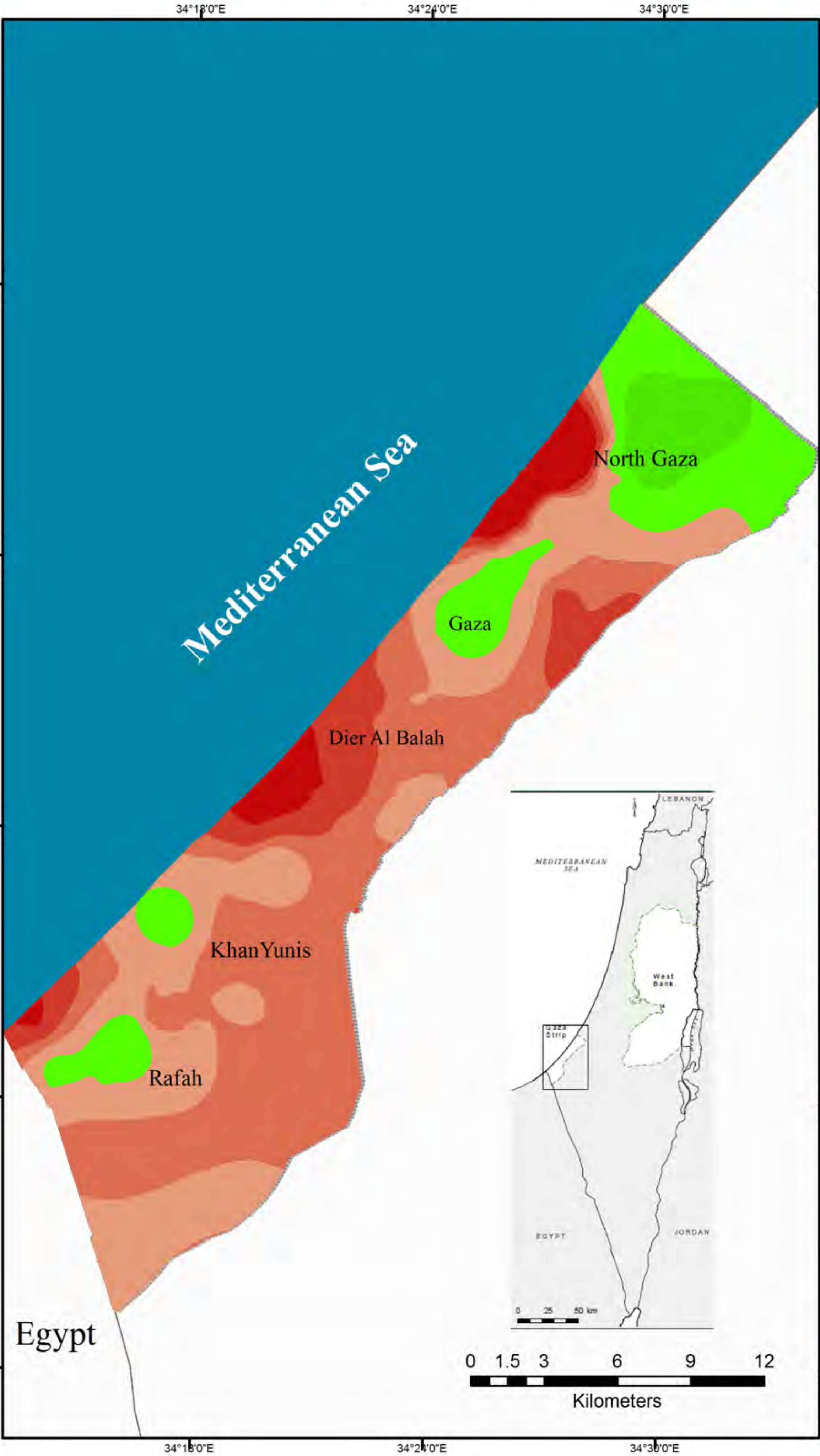
# Gaza Strip : Average Chloride Concentration for Year 2013 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

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S

**Legend**

**CL mg/L 2013**

- $\leq 250$
- 251 – 600
- 601 – 1,000
- 1,001 – 1,400
- 1,401 – 2,000
- $>$ 2,000
- Governorate
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- Coastal Municipal Water Utility (CMWU)

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central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

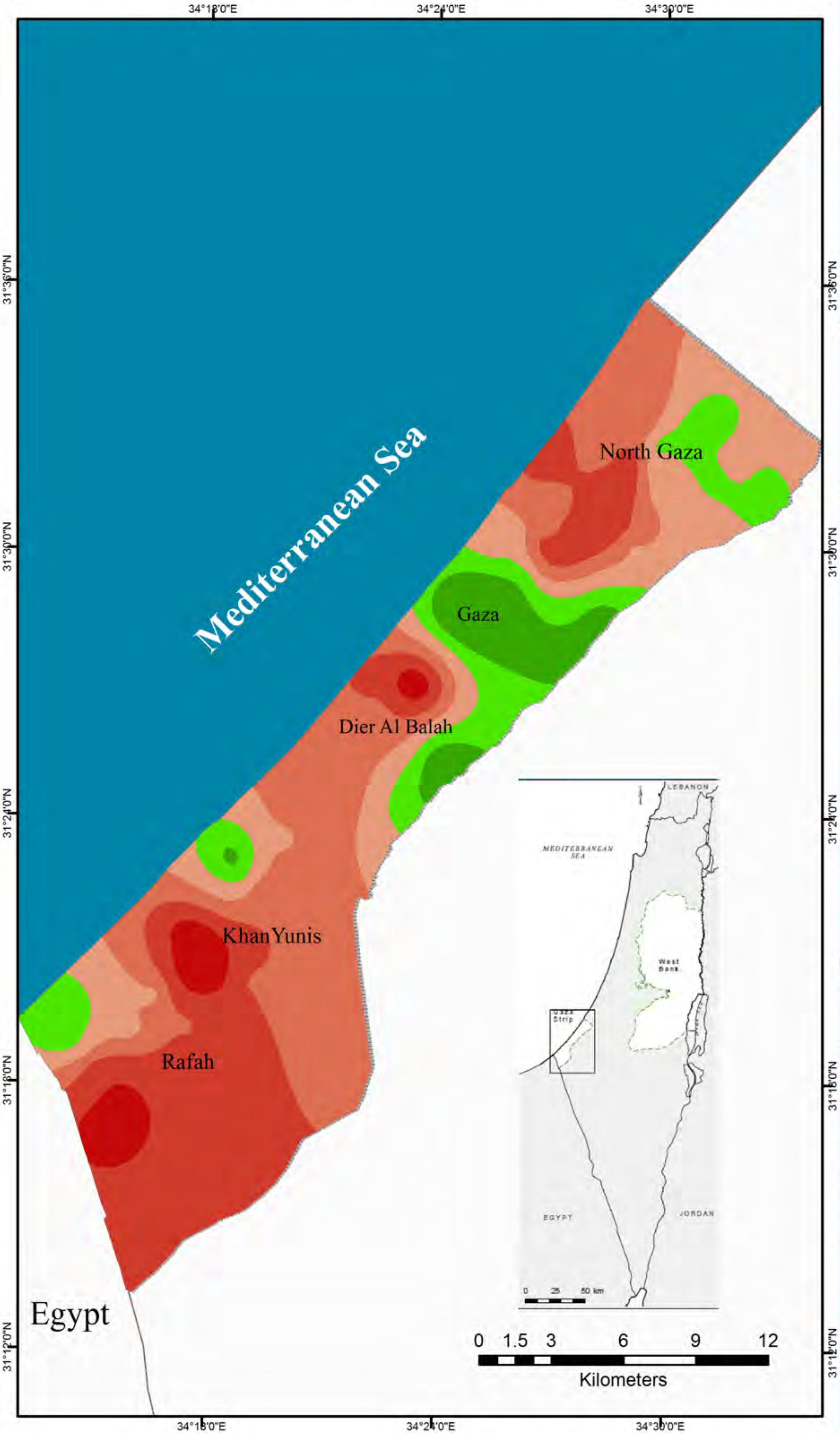
**Date: 4/22/2015**

**Funded by:**

Austrian
Development Agency

# Gaza Strip : Average Nitrate Concentration for Year 2009 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

N
W E
S

## Legend

**No3 mg/L 2009**

- ≤ 50
- 51 – 70
- 71 – 100
- 101 – 140
- 141 – 200
- > 201
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
Projection: Cassini
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false easting: 170,251.5550
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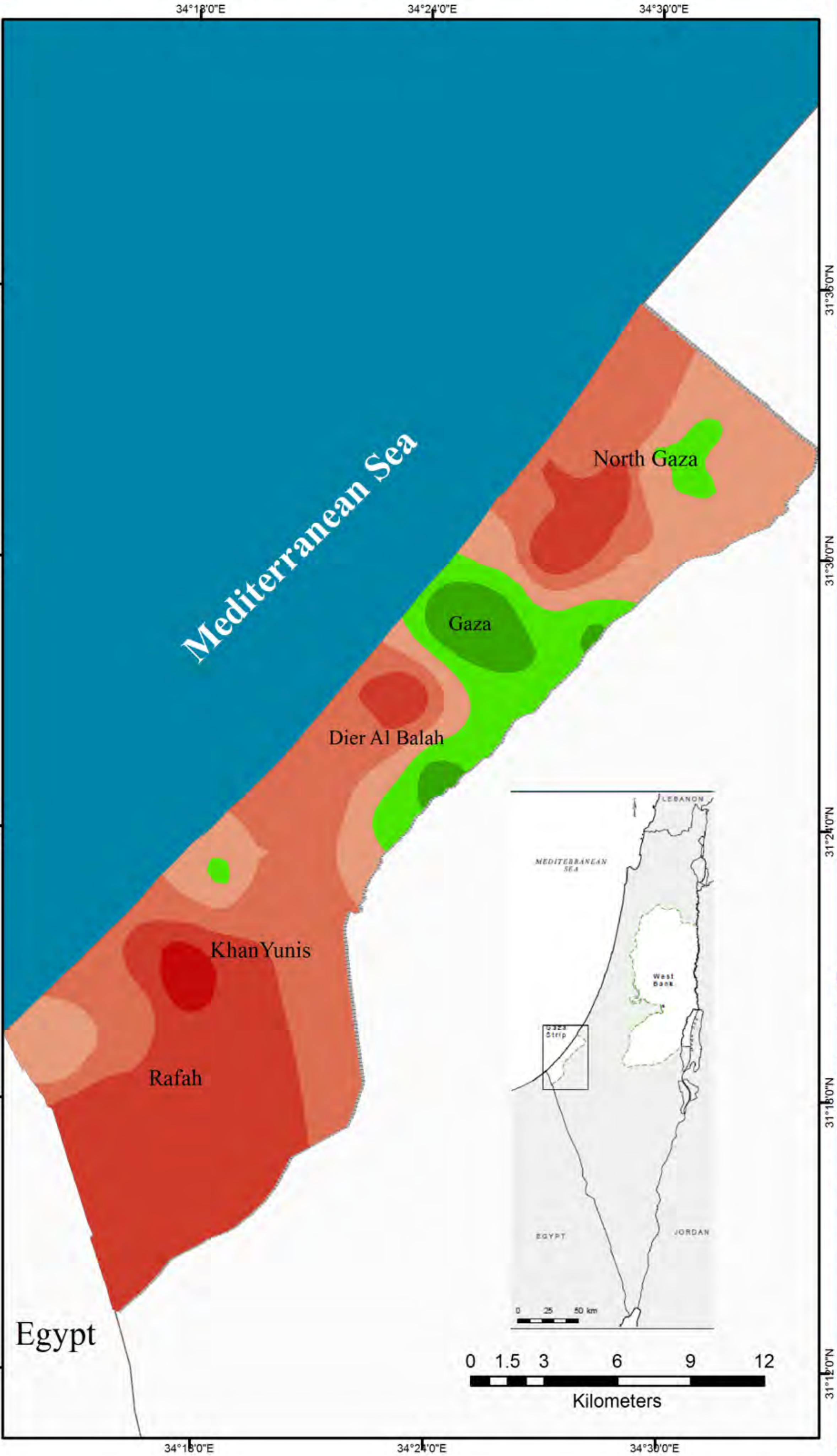
# Gaza Strip : Average Nitrate Concentration for Year 2010 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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N W E S

## Legend

**No3 mg/L 2010**

- ≤ 50
- 51 – 70
- 71 – 100
- 101 – 140
- 141 – 200
- > 201
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
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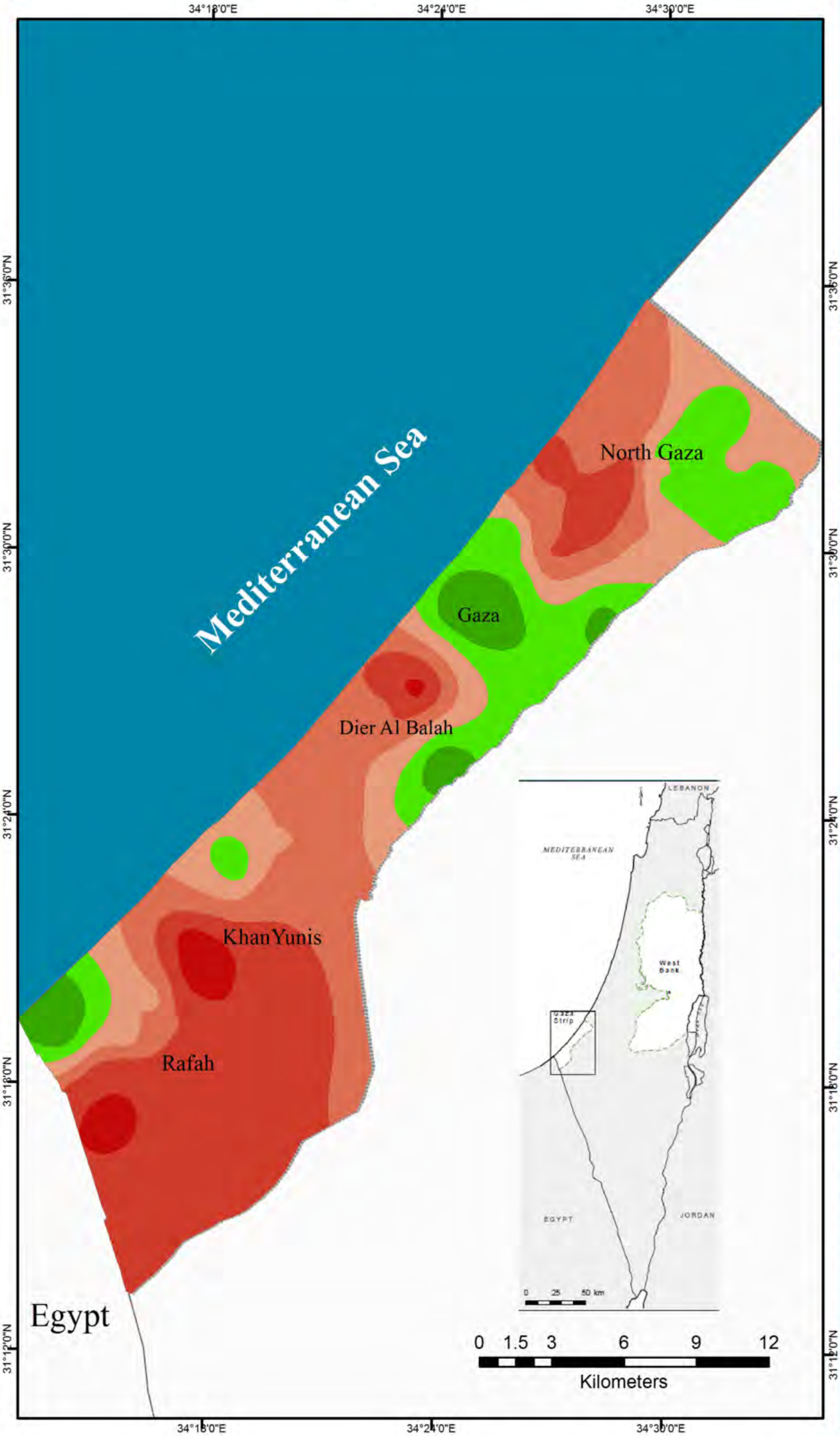
# Gaza Strip : Average Nitrate Concentration for Year 2011
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




**Legend**

**No3 mg/L 2011**

- ≤ 50
- 51 – 70
- 71 – 100
- 101 – 140
- 141 – 200
- > 201
- Governorate
- Sea

Source:
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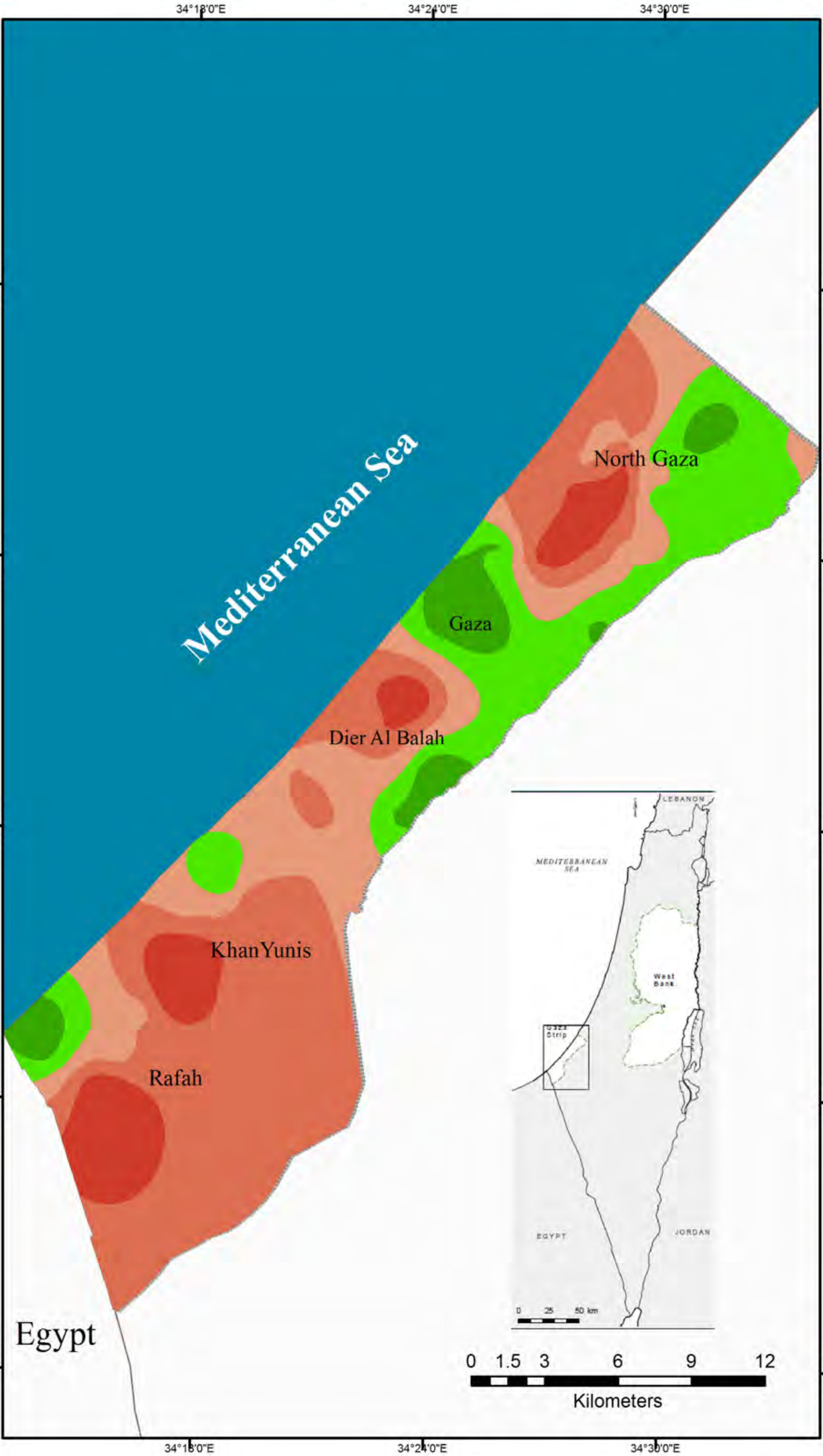
# Gaza Strip : Average Nitrate Concentration for Year 2012
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

N
W E
S

**Legend**

**No3 mg/L 2012**

- ≤ 50
- 51 – 70
- 71 – 100
- 101 – 140
- 141 – 200
- > 201
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
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false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
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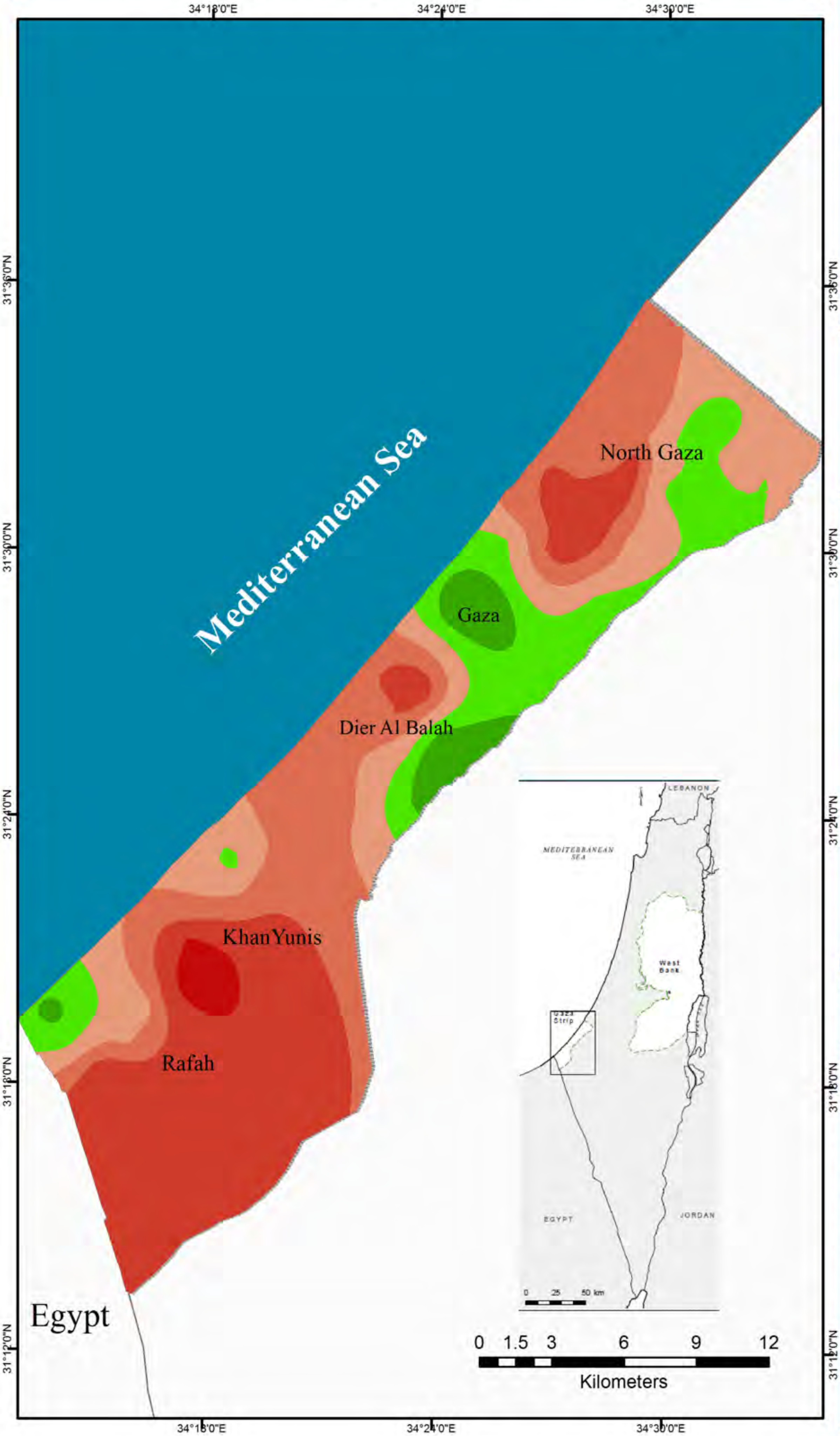
Development Agency

# Gaza Strip : Average Nitrate Concentration for Year 2013
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

N
W E
S

**Legend**

**No3 mg/L 2013**

- ≤ 50
- 51 – 70
- 71 – 100
- 101 – 140
- 141 – 200
- > 201
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
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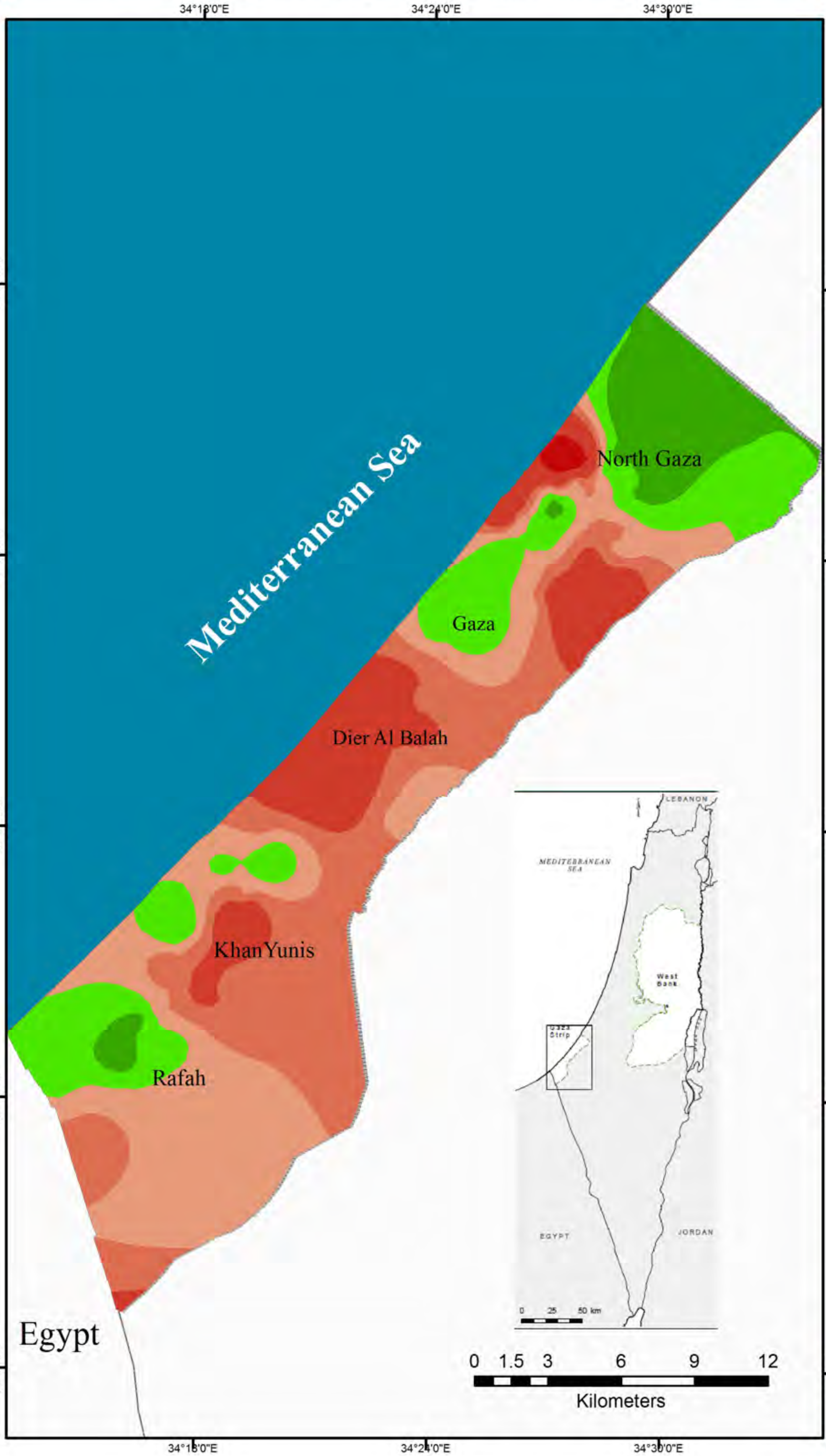
# Gaza Strip : Average TDS Concentration for Year 2009 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

EcoConServ ENVIRONMENTAL SOLUTIONS

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S

## Legend

**TDS mg/L 2009**

- ≤ 1,000
- 1,001 – 1,500
- 1,501 – 2,000
- 2,001 – 2,500
- 2,501 – 5,000
- > 5,000
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

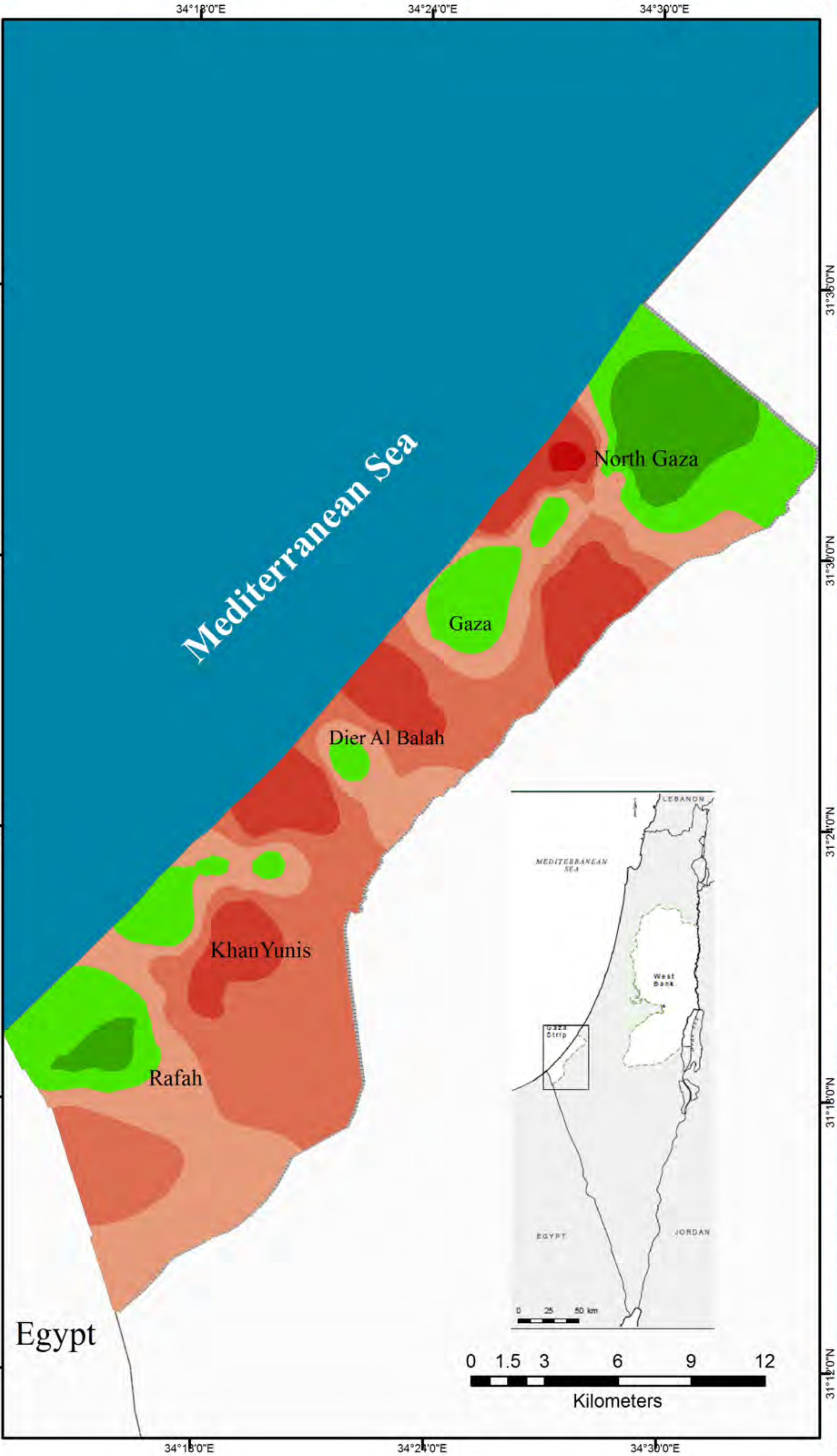
Coordinate System: Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**

**Funded by:**
Austrian Development Agency

# Gaza Strip : Average TDS Concentration for Year 2010
# Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

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**Legend**

**TDS mg/L 2010**

- ≤ 1,000
- 1,001 – 1,500
- 1,501 – 2,000
- 2,001 – 2,500
- 2,501 – 5,000
- > 5,000
- Governorate
- Sea

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

Coordinate System: Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
false easting: 170,251.5550
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter

**Date: 4/22/2015**


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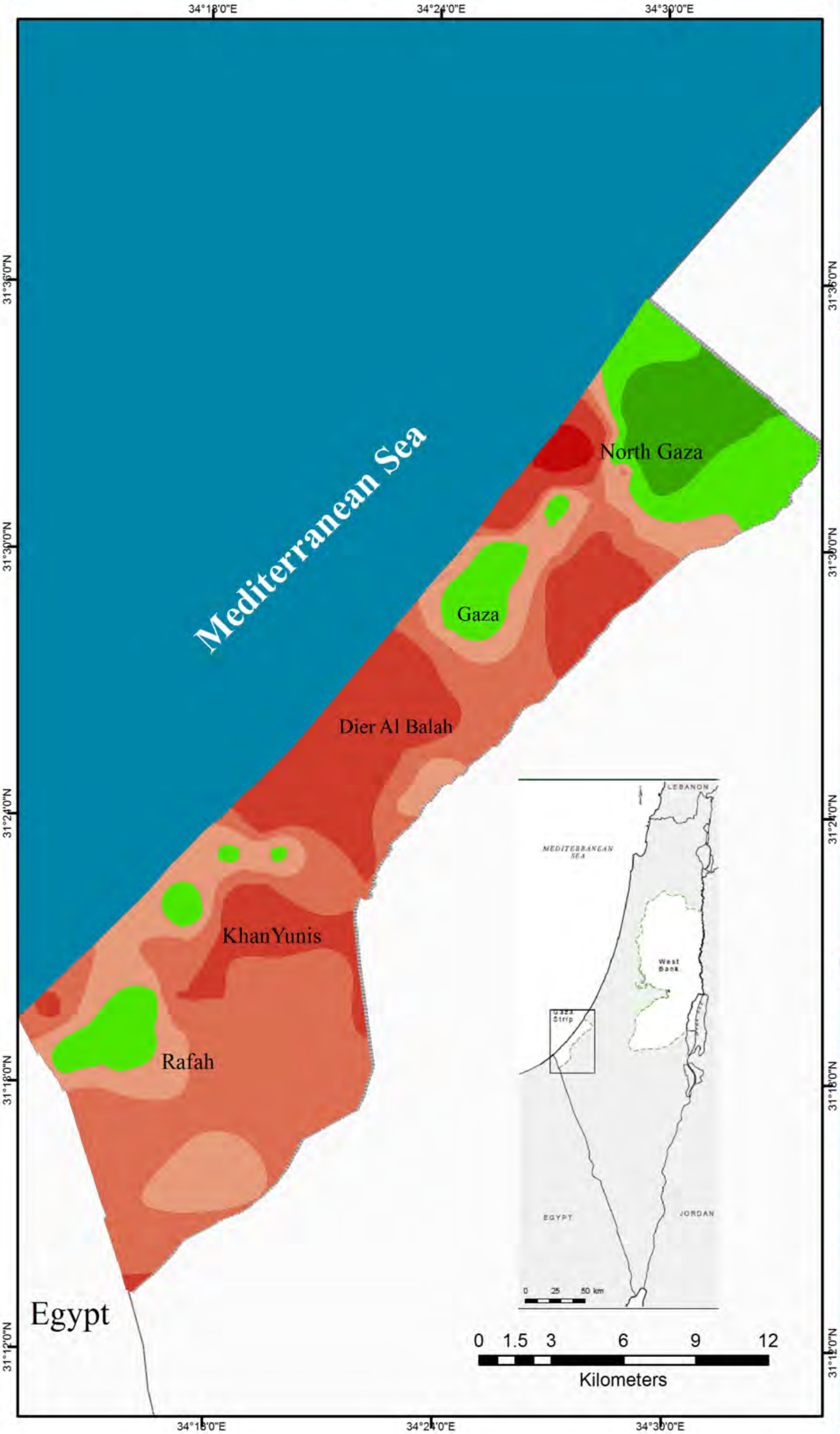
# Gaza Strip : Average TDS Concentration for Year 2011 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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## Legend

**TDS mg/L 2011**

- ≤ 1,000
- 1,001 – 1,500
- 1,501 – 2,000
- 2,001 – 2,500
- 2,501 – 5,000
- > 5,000
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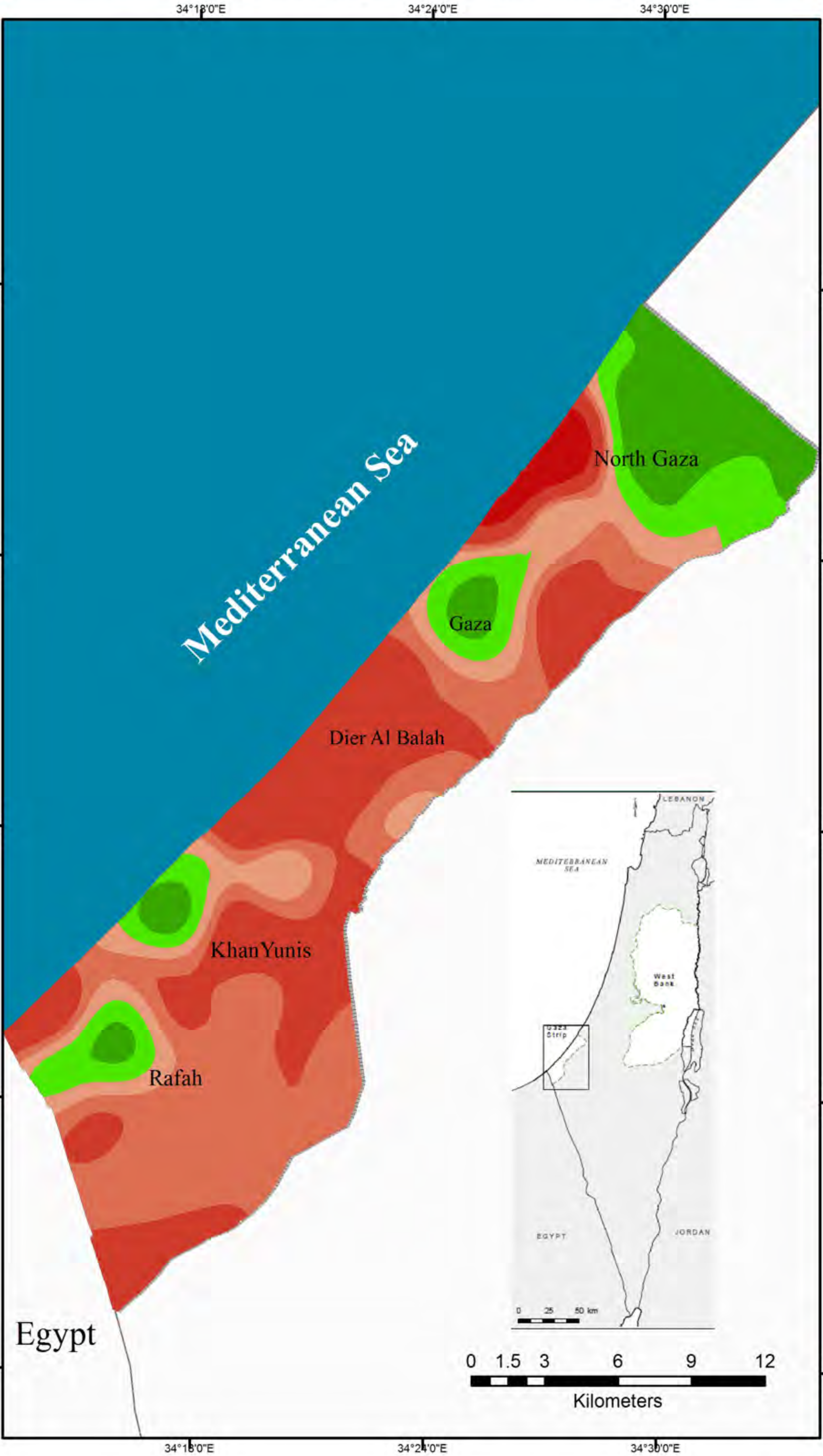
# Gaza Strip : Average TDS Concentration for Year 2012 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015

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**Legend**

**TDS mg/L 2012**

- ≤ 1,000
- 1,001 – 1,500
- 1,501 – 2,000
- 2,001 – 2,500
- 2,501 – 5,000
- > 5,000
- Governorate
- Sea

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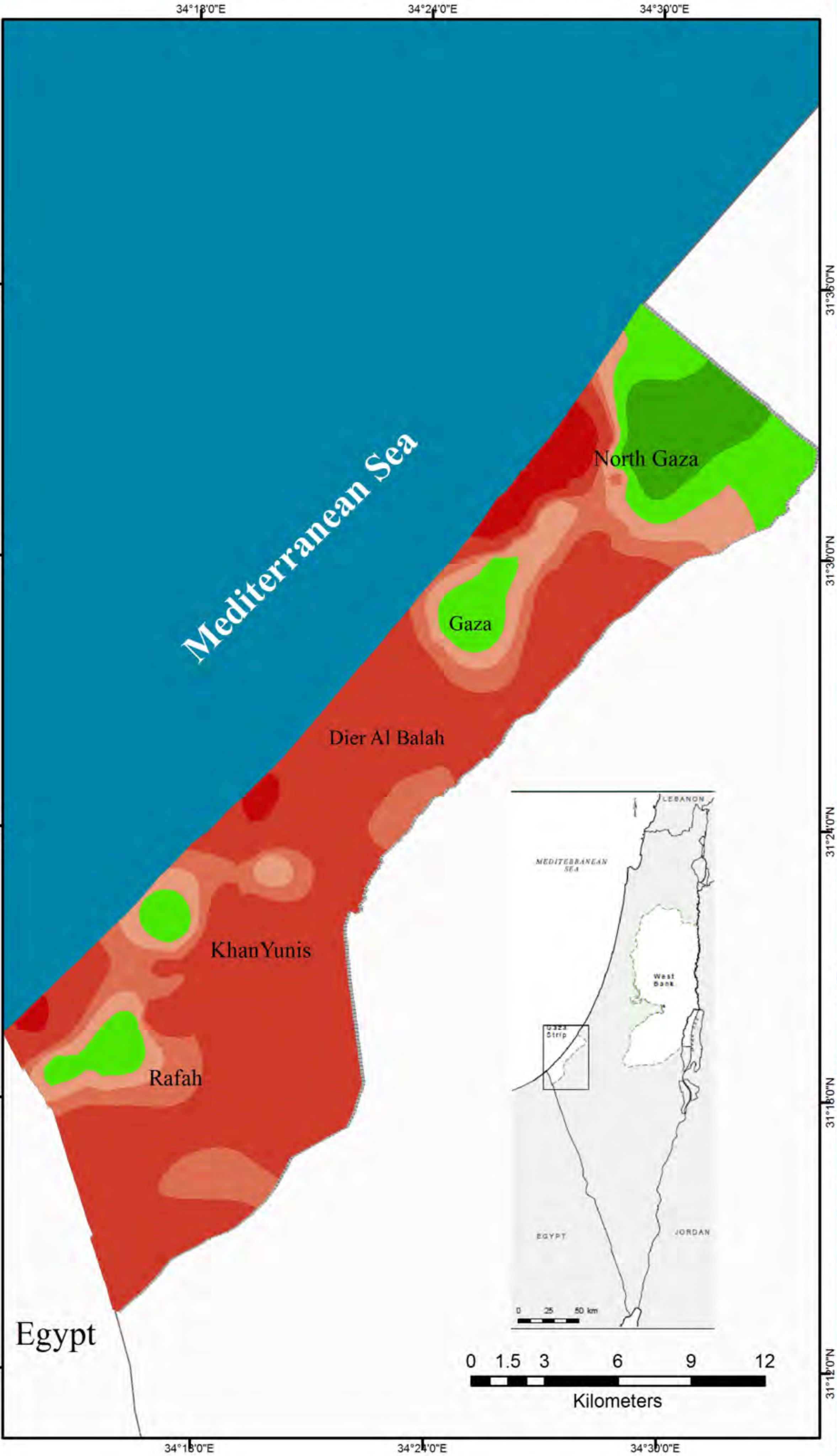
# Gaza Strip : Average TDS Concentration for Year 2013
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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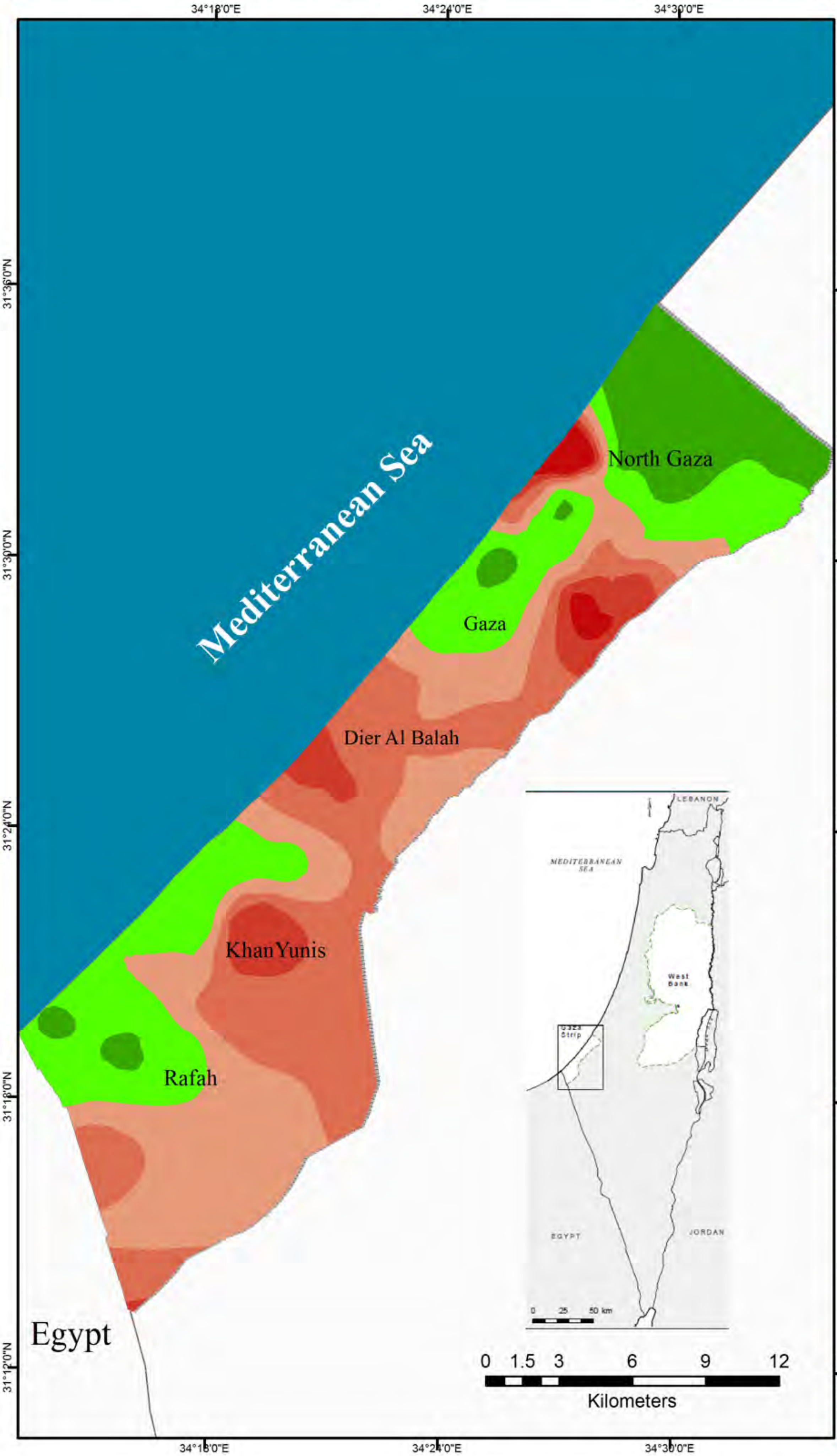
# Gaza Strip : Average Sodium Concentration for Year 2009
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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**Legend**

**Na mg/L 2009**

- ≤ 200
- 201 – 400
- 401 – 600
- 601 – 800
- 801 – 1,000
- > 1,001
- Governorate
- Sea

Source:
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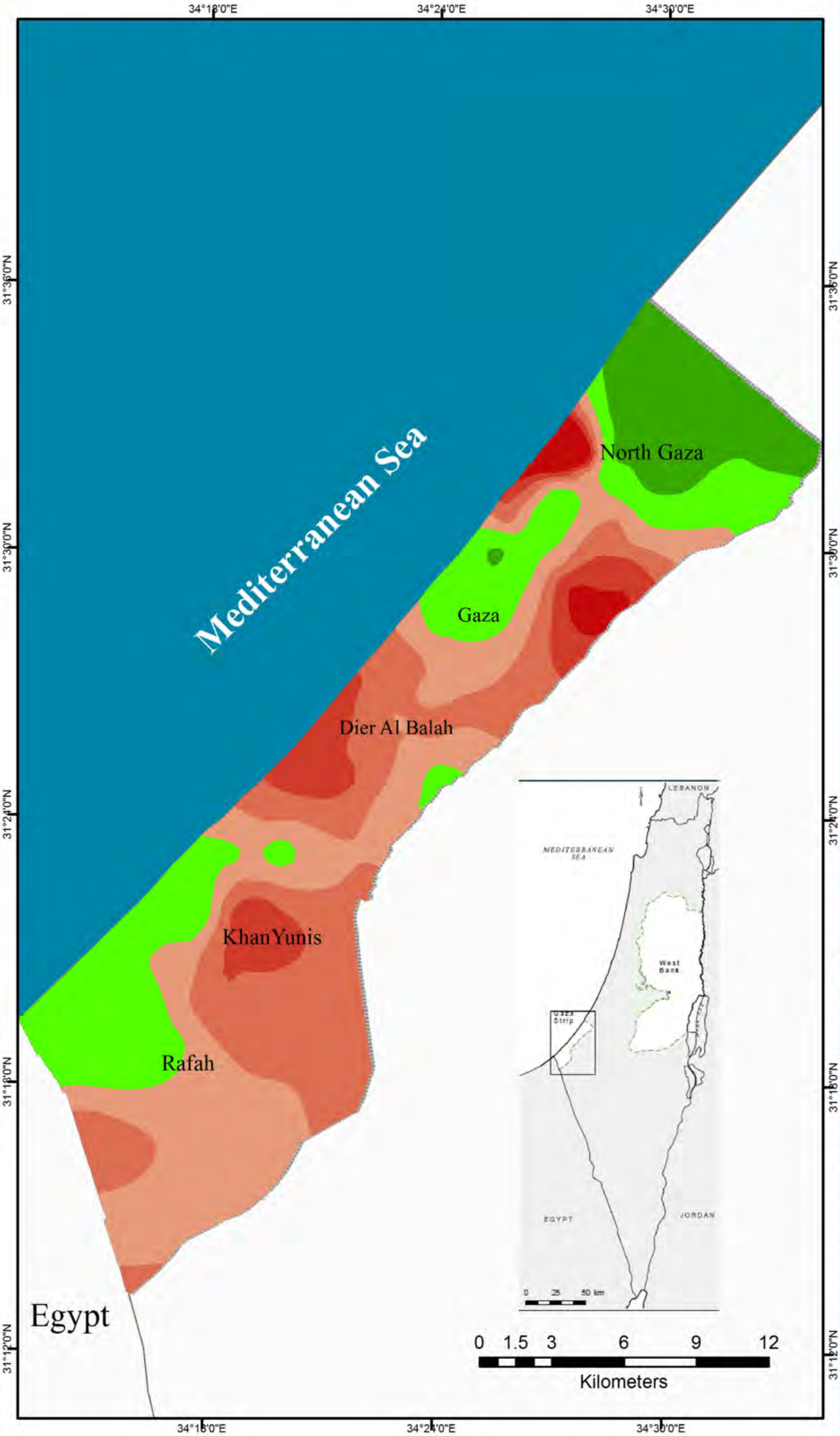
## Gaza Strip : Average Sodium Concentration for Year 2010 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015

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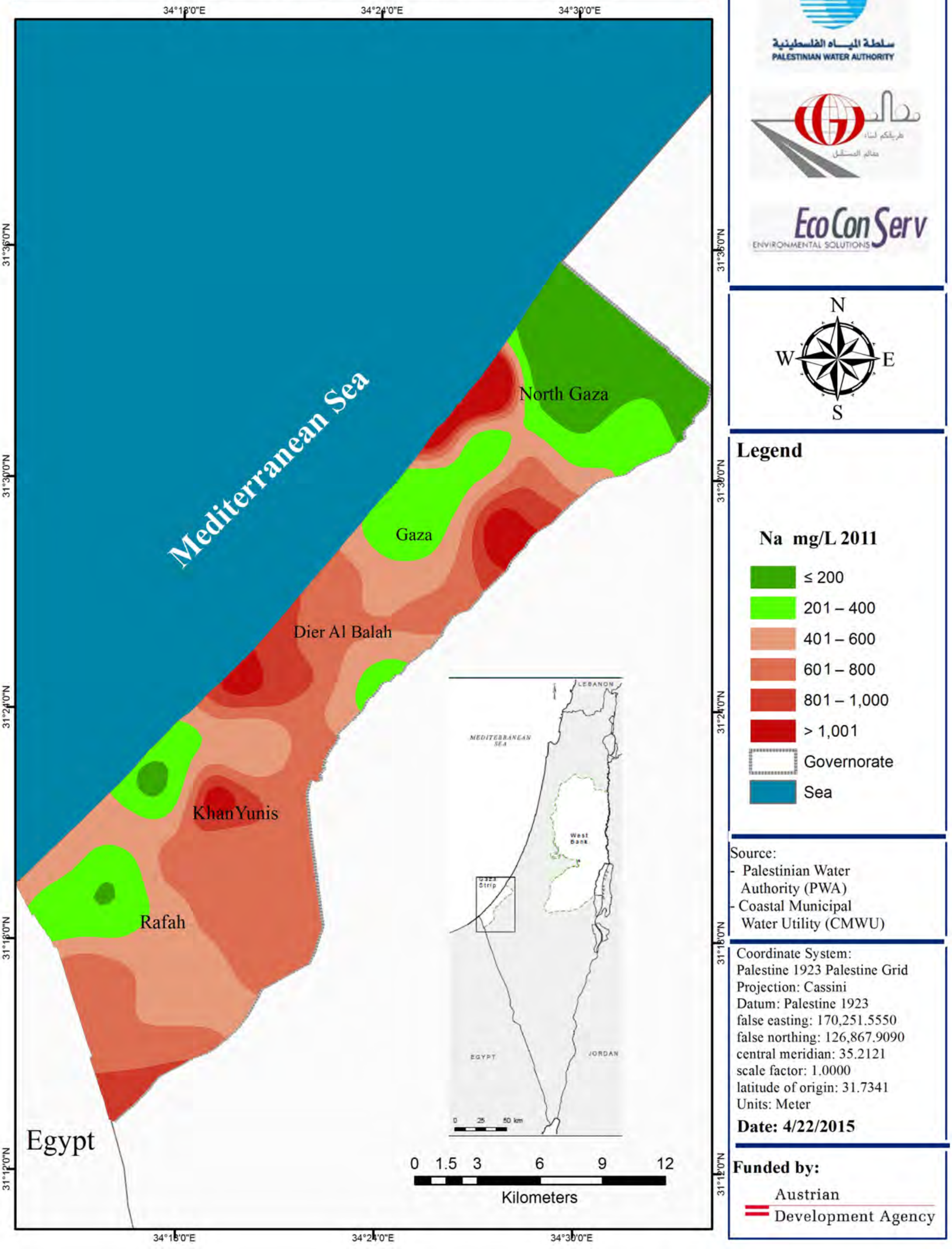

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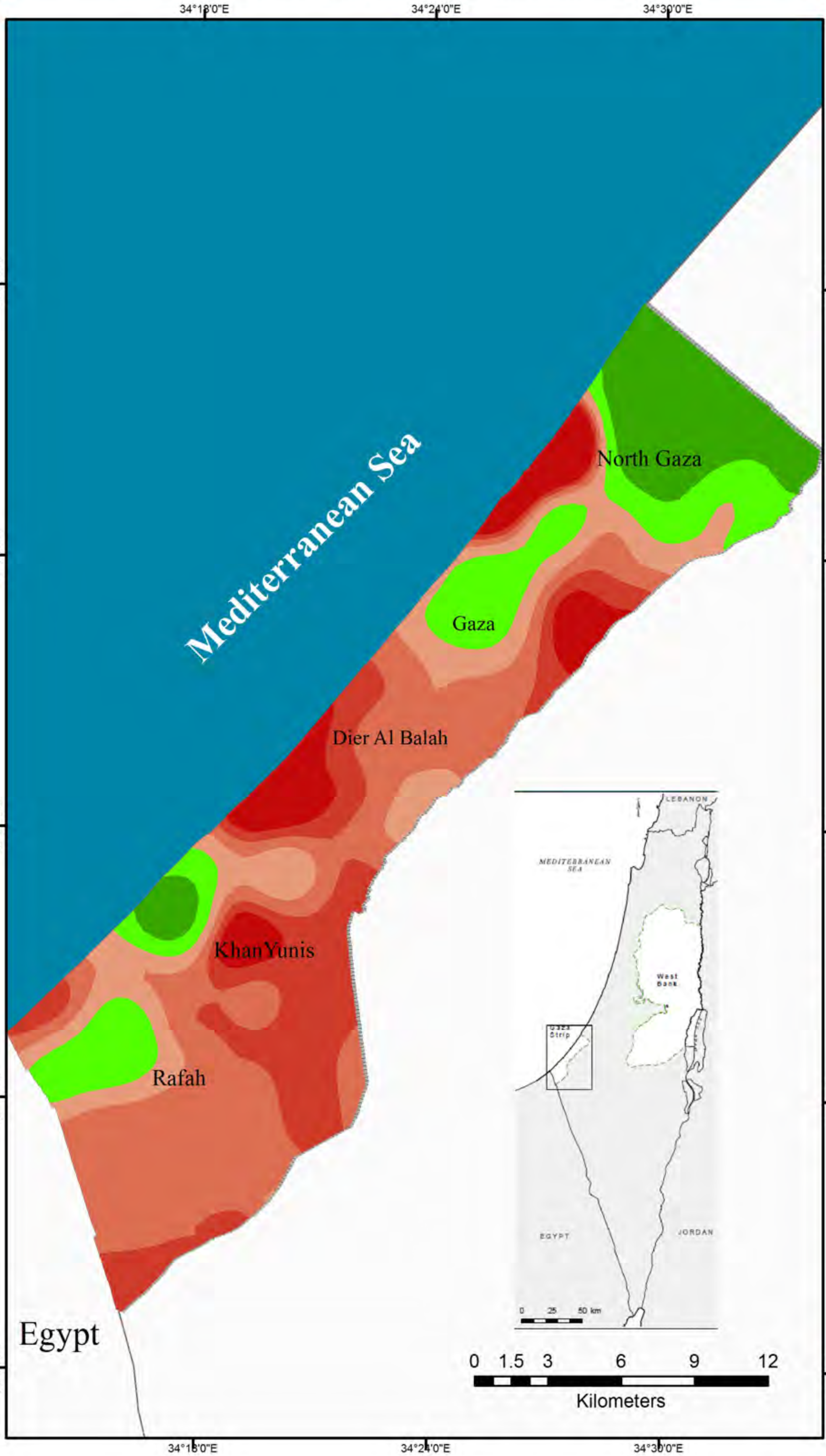
Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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ENVIRONMENTAL SOLUTIONS

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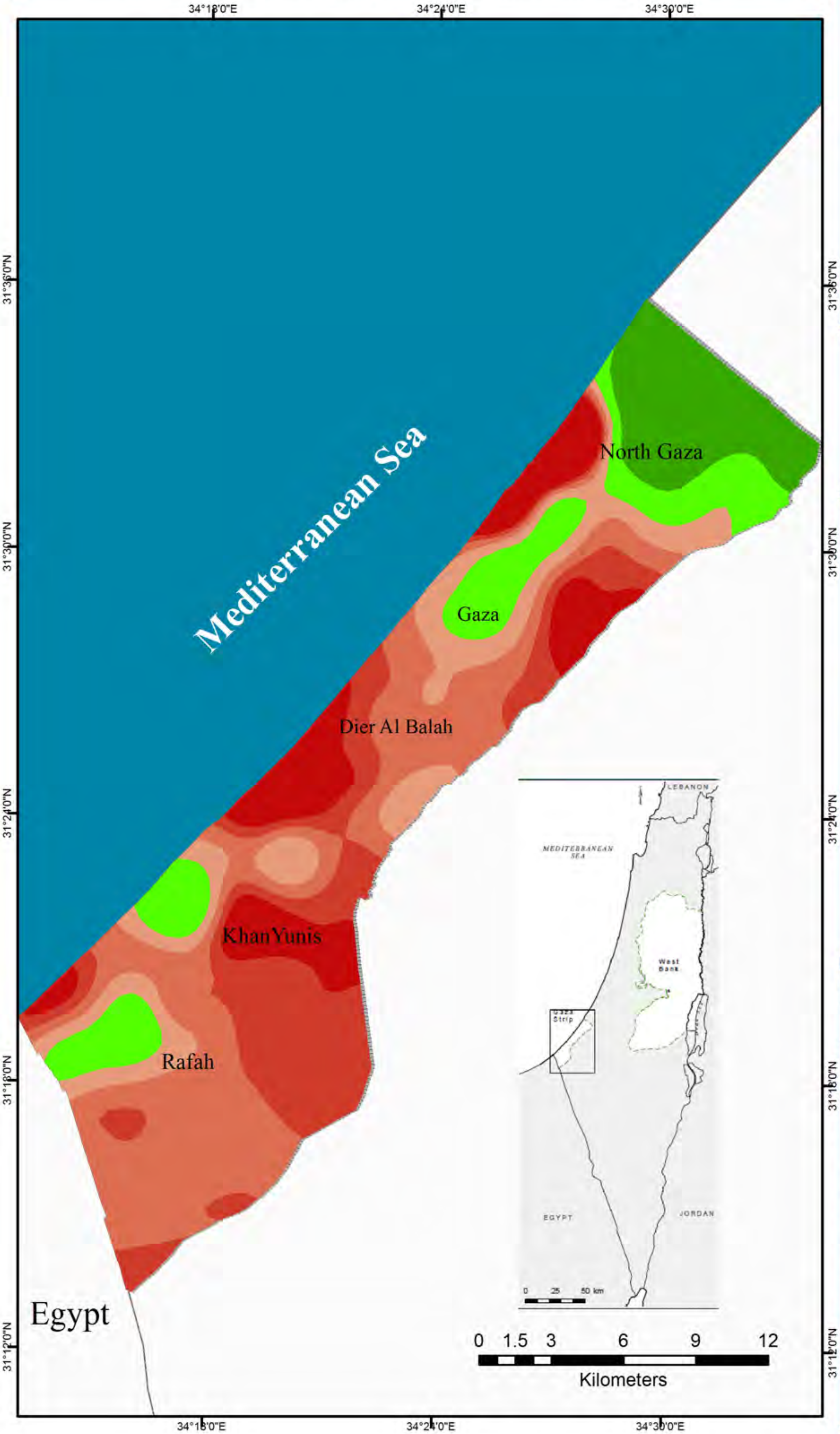
Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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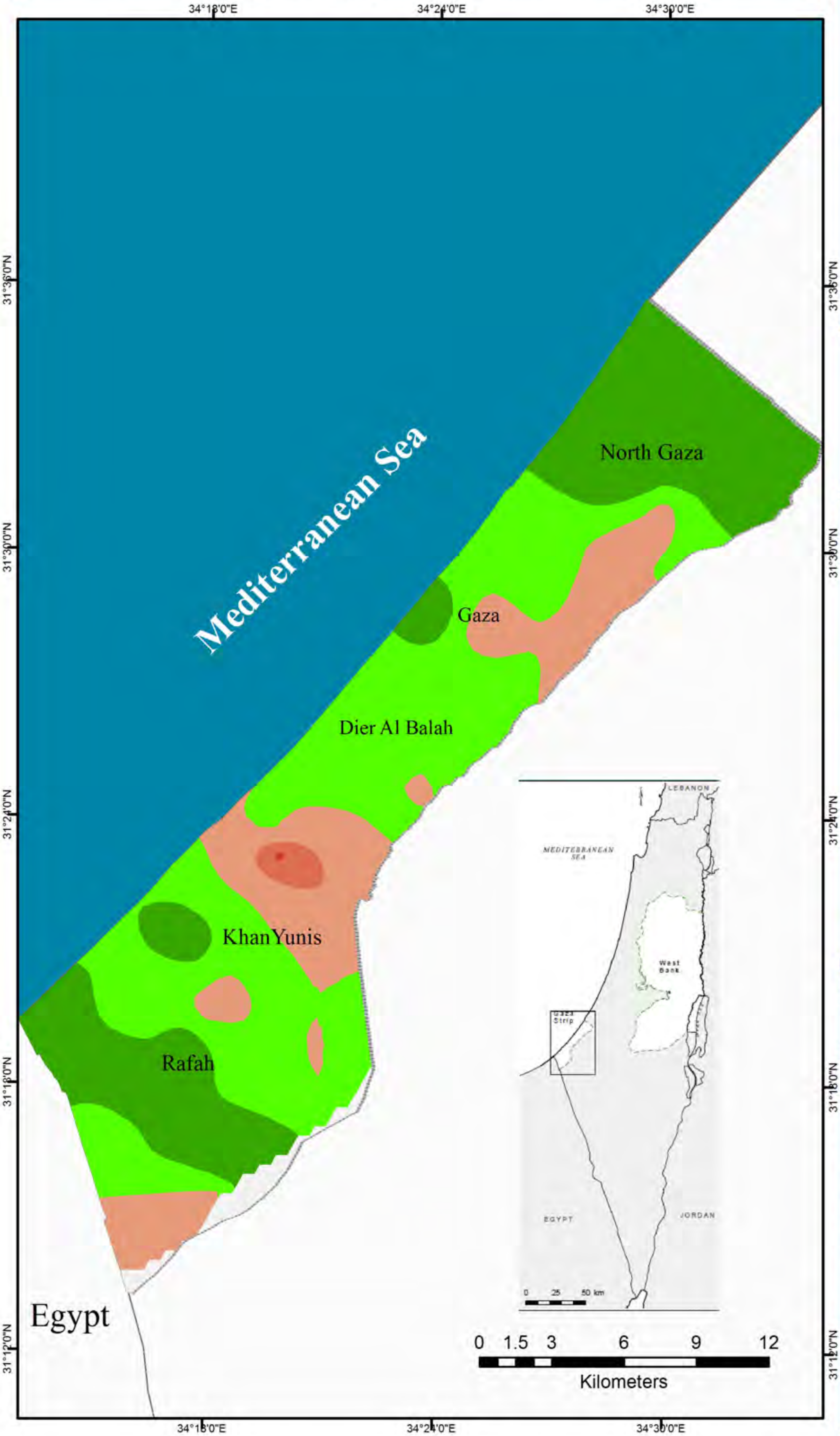
# Gaza Strip : Average Fluoride Concentration for Year 2010
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015

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**Legend**

**F mg/L 2010**

- ≤ 1
- 1.1 – 1.5
- 1.6 – 2
- 2.1 – 2.5
- 2.6 – 3
- > 3
- Governorate
- Sea

Source:
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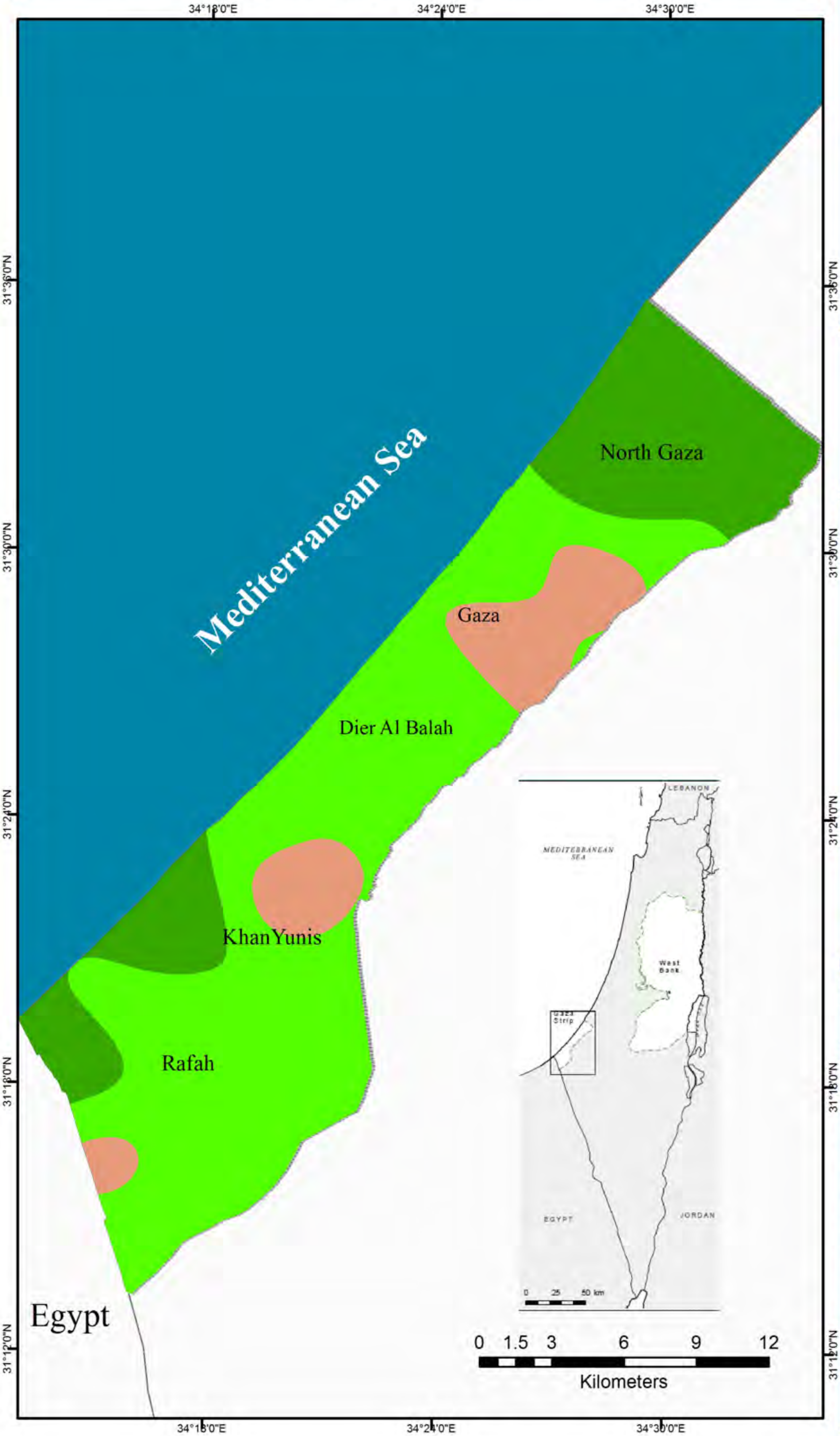
# Gaza Strip : Average Fluoride Concentration for Year 2011 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015

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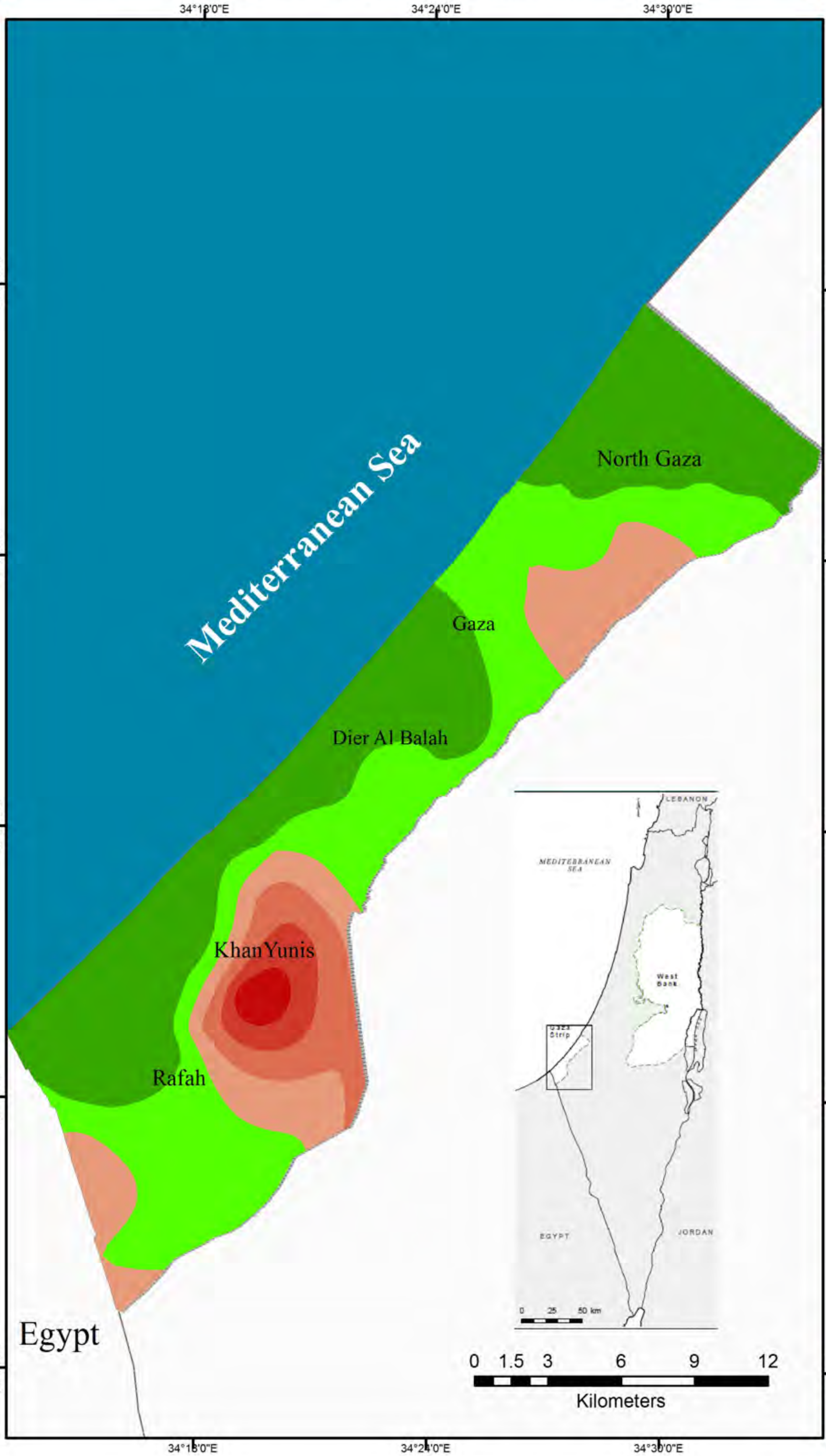
# Gaza Strip : Average Fluoride Concentration for Year 2012
## Municipal Wells
Baseline Study on Water Quality and Public Health - April, 2015

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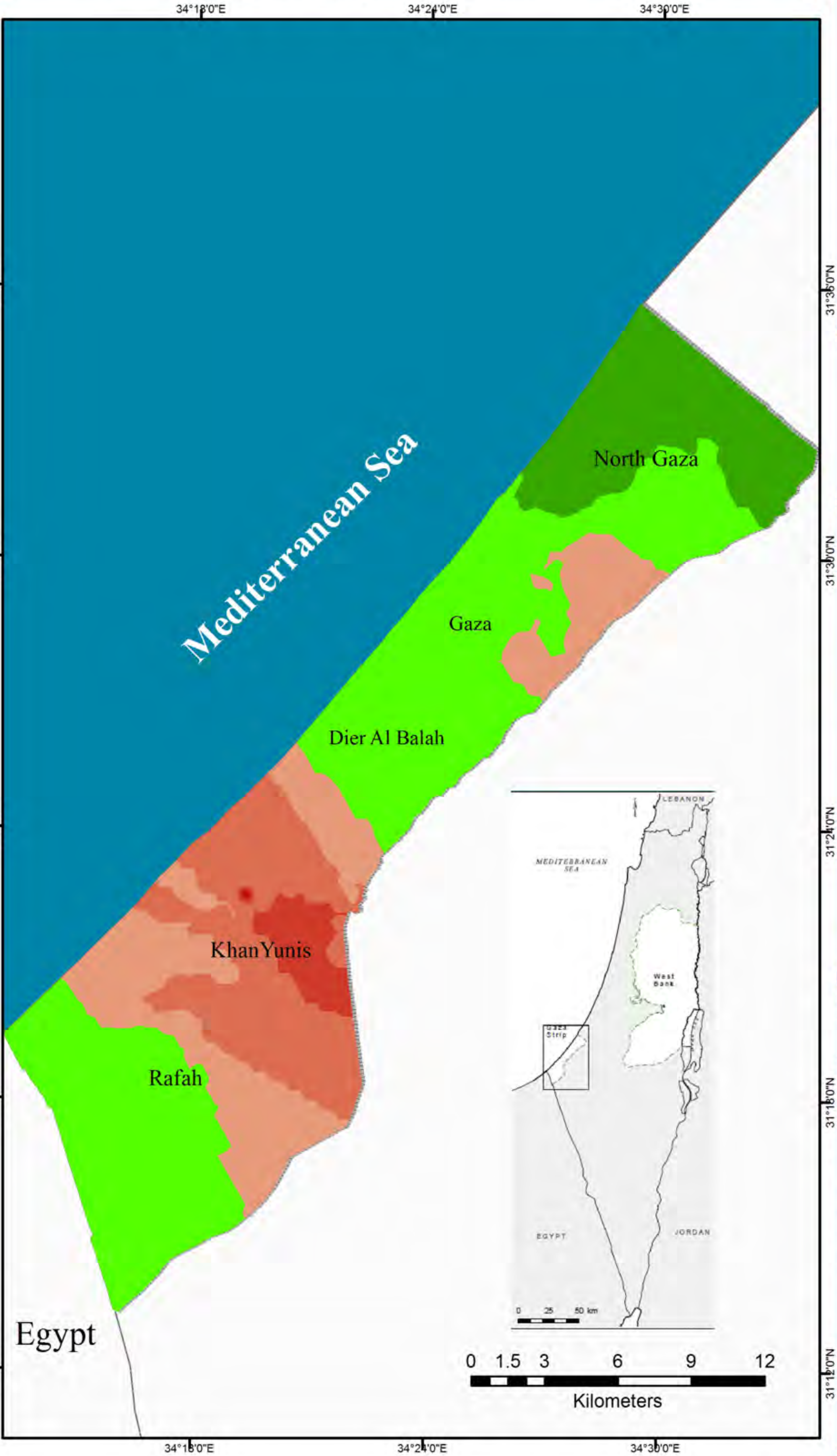
# Gaza Strip : Average Fluoride Concentration for Year 2013 Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

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**Date: 4/22/2015**

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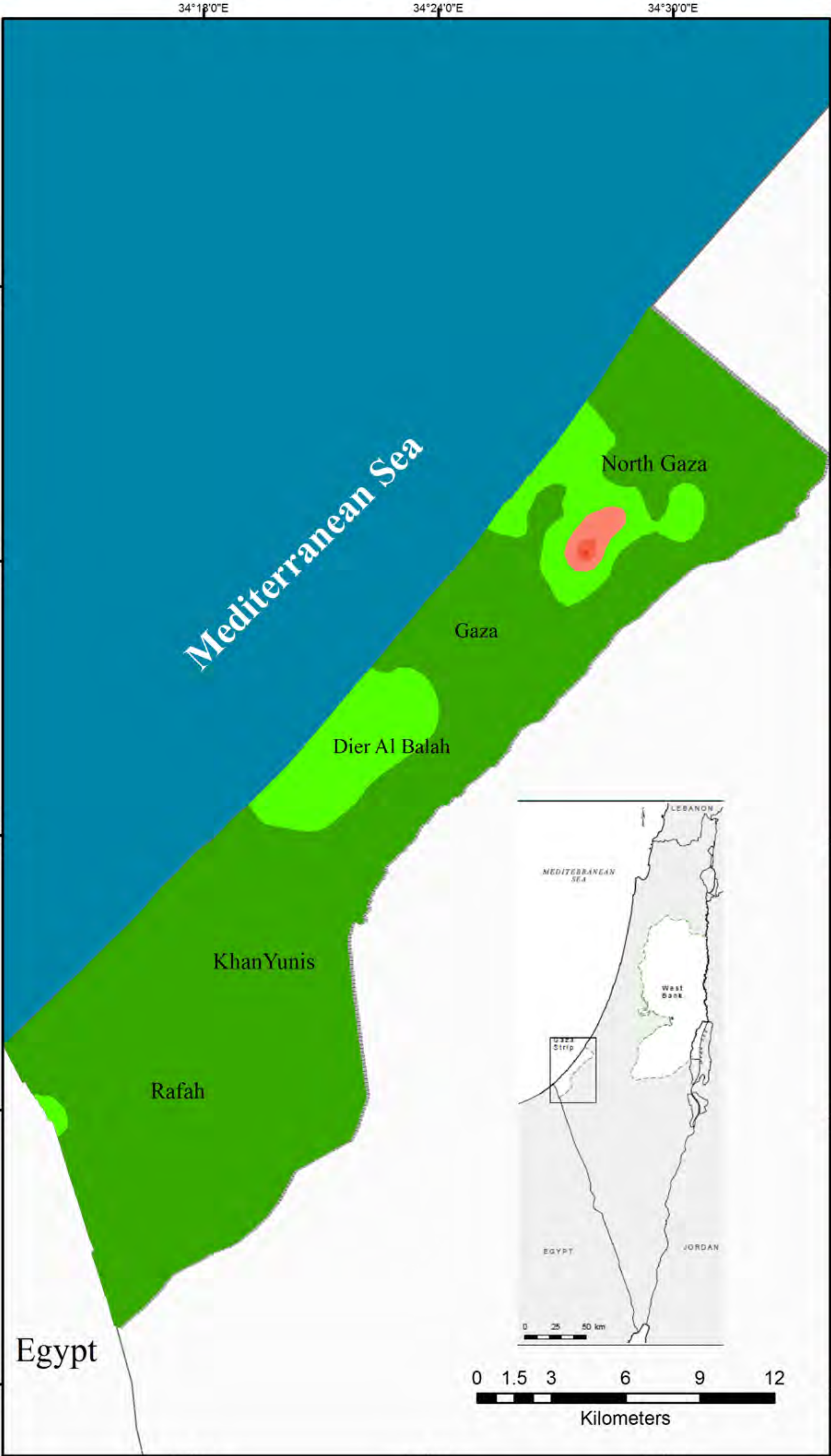
# Gaza Strip : Average Potassium Concentration for Year 2009
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




**Legend**

**K mg/L 2009**

- ≤ 6
- 6.1 – 12
- 12.1 – 18
- 18.1 – 24
- 24.1 – 30
- > 30
- Sea
- Governorate

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

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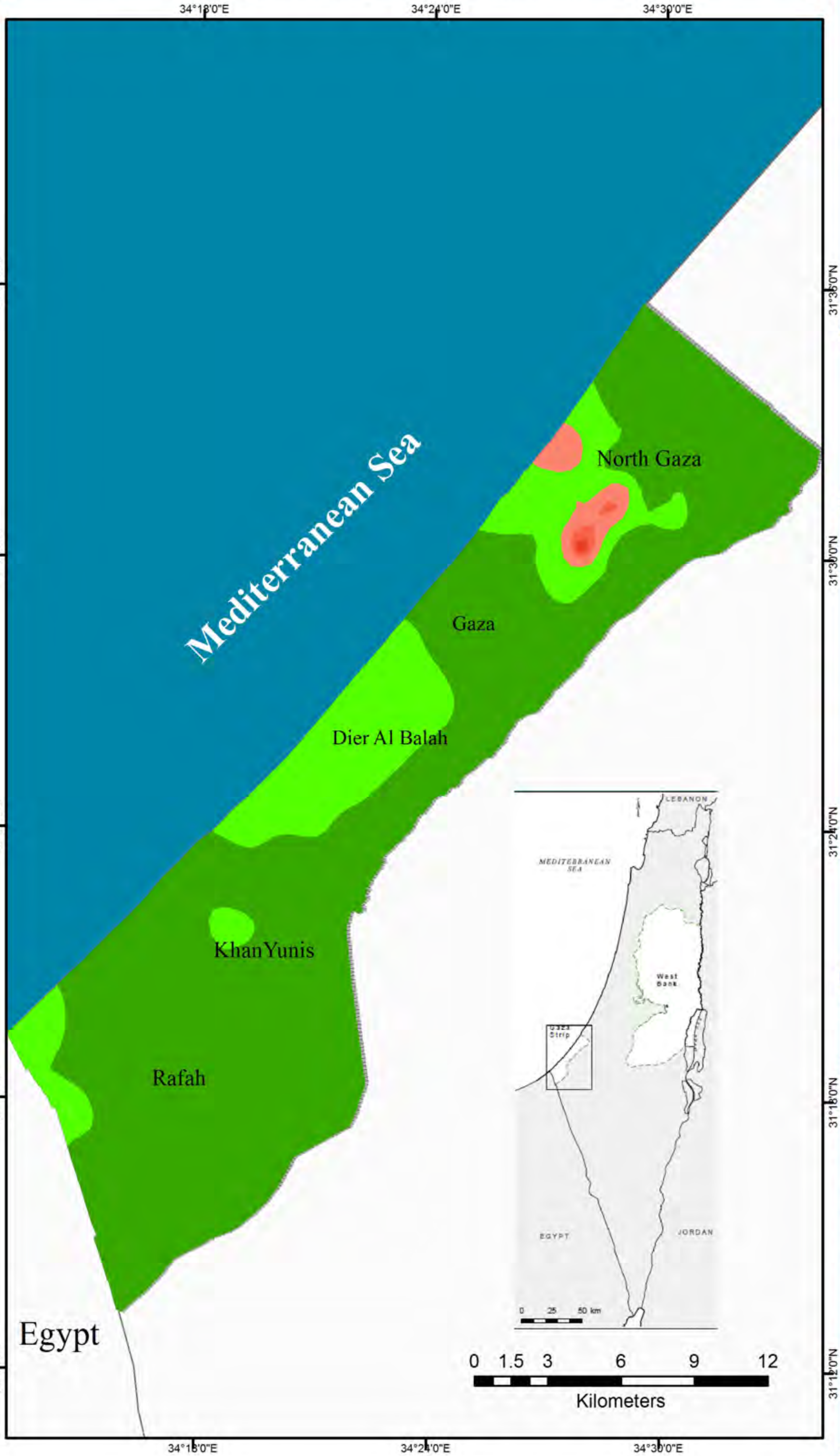
# Gaza Strip : Average Potassium Concentration for Year 2010
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015

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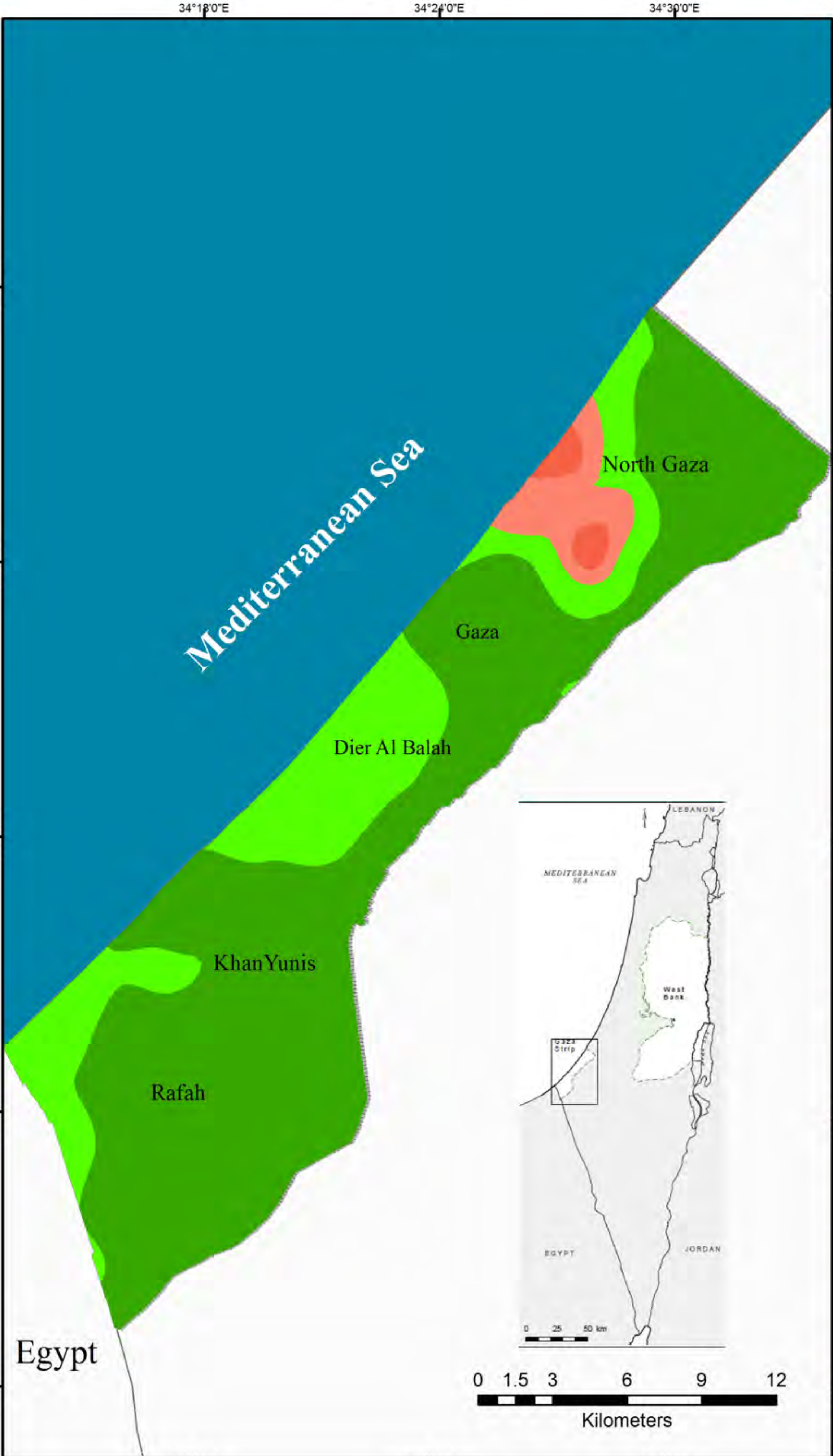
# Gaza Strip : Average Potassium Concentration for Year 2011
# Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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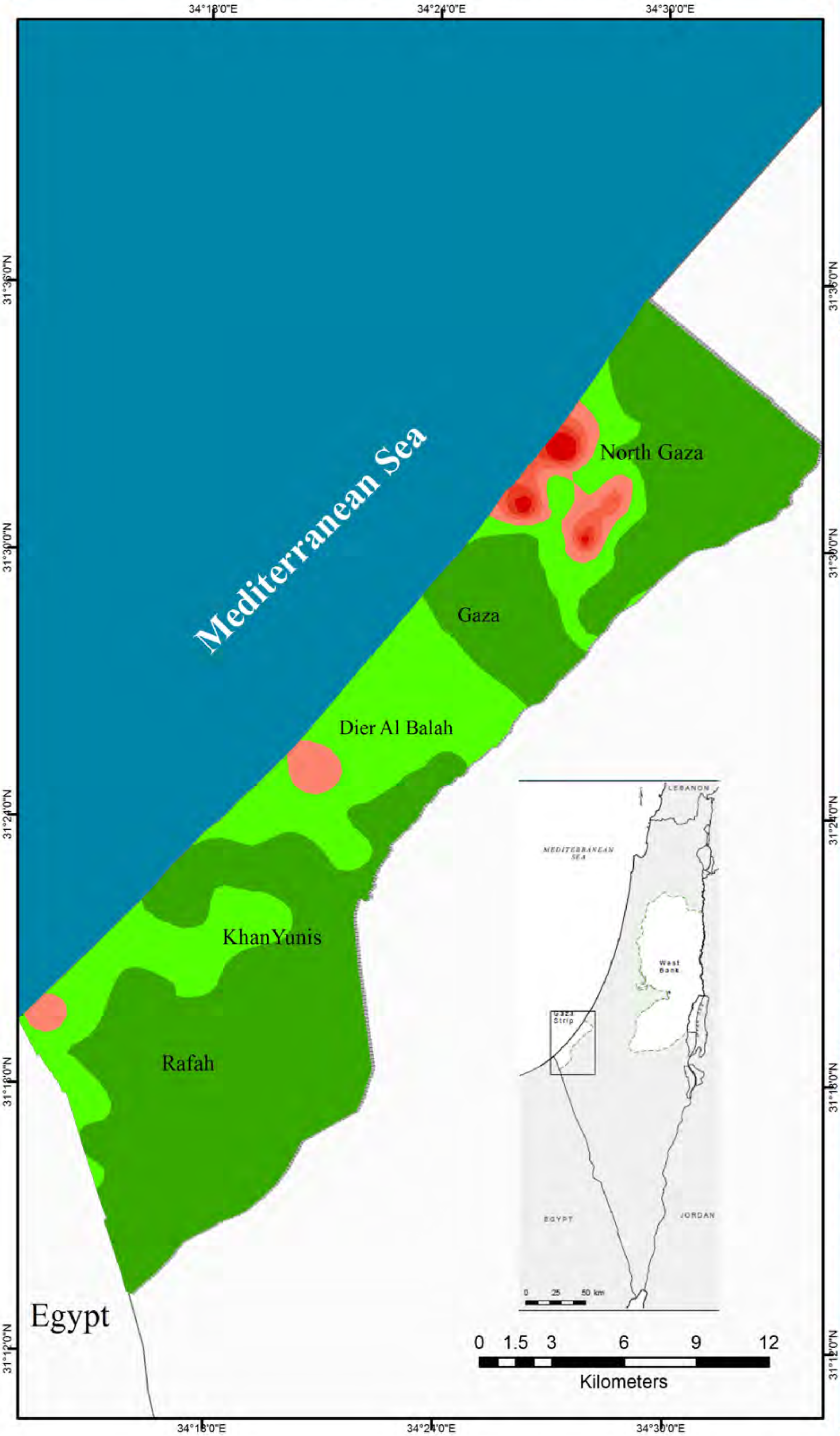
# Gaza Strip : Average Potassium Concentration for Year 2012
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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## Municipal Wells

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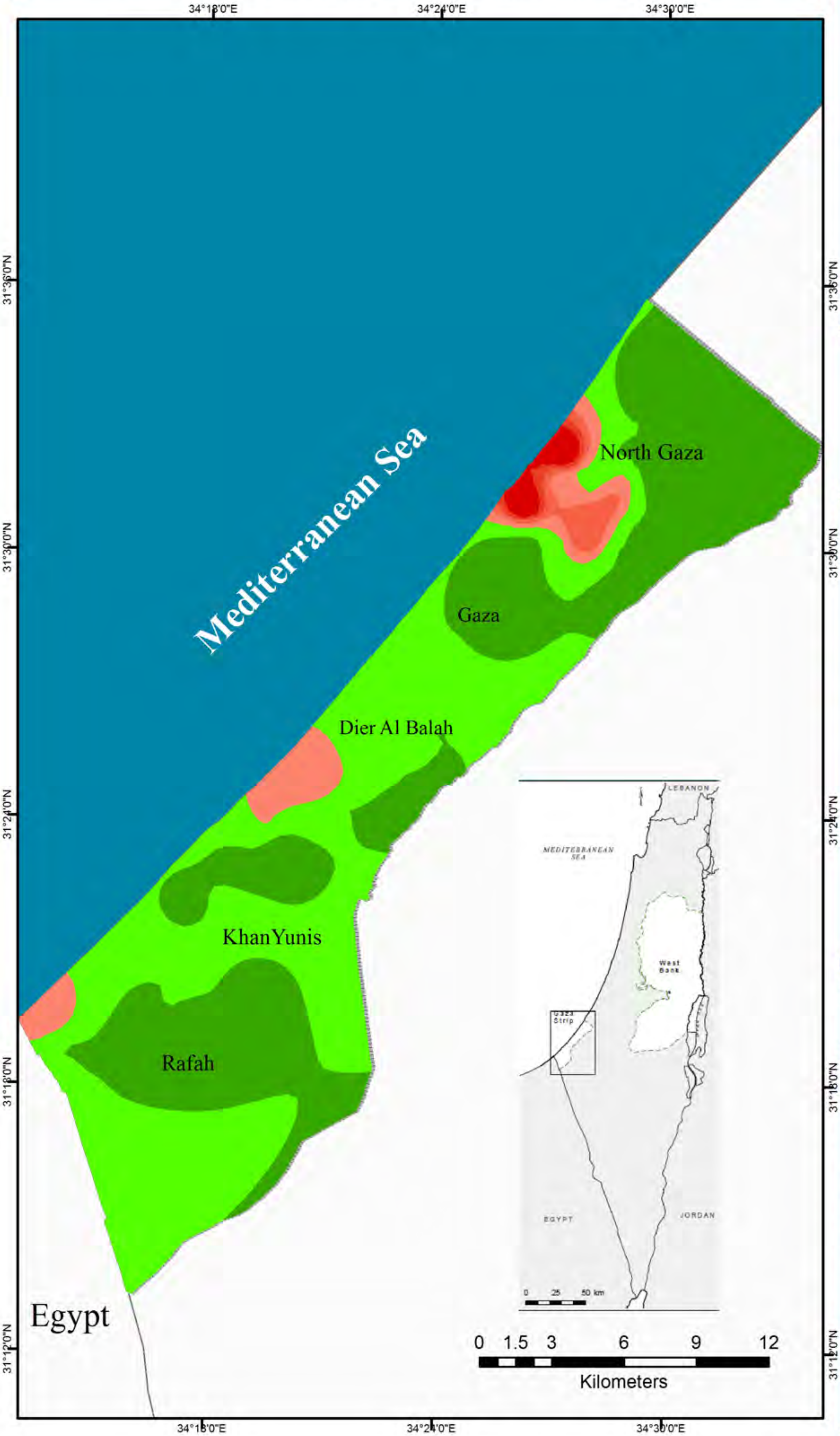


PALESTINIAN WATER AUTHORITY

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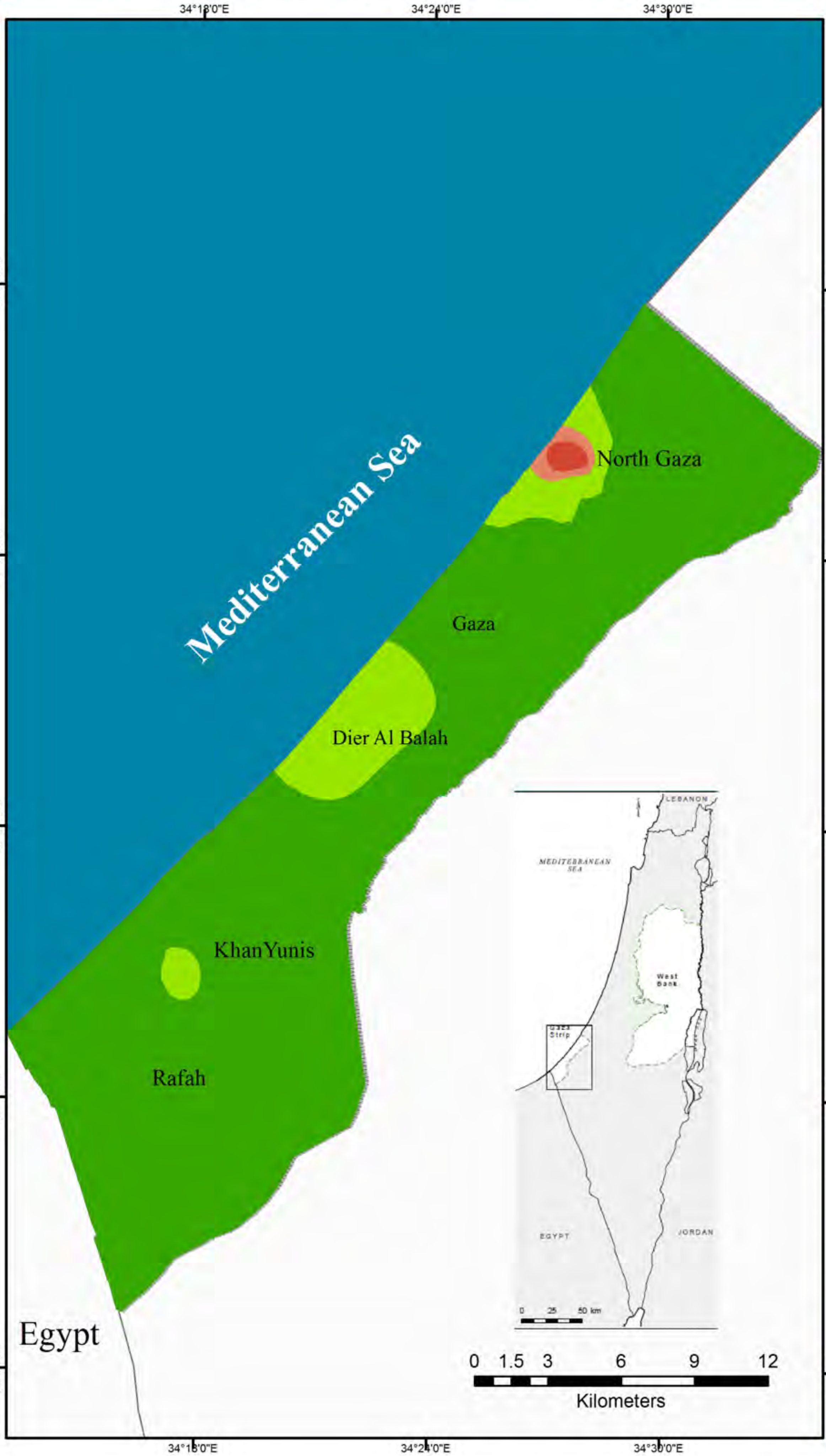
# Gaza Strip : Average Magnesium Concentration for Year 2009
## Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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**Legend**

**Mg mg/L 2009**

- ≤ 80
- 81 – 150
- 151 – 200
- 201 – 300
- > 300
- Governorate
- Sea

Source:
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# Gaza Strip : Average Magnesium Concentration for Year 2010 Municipal Wells

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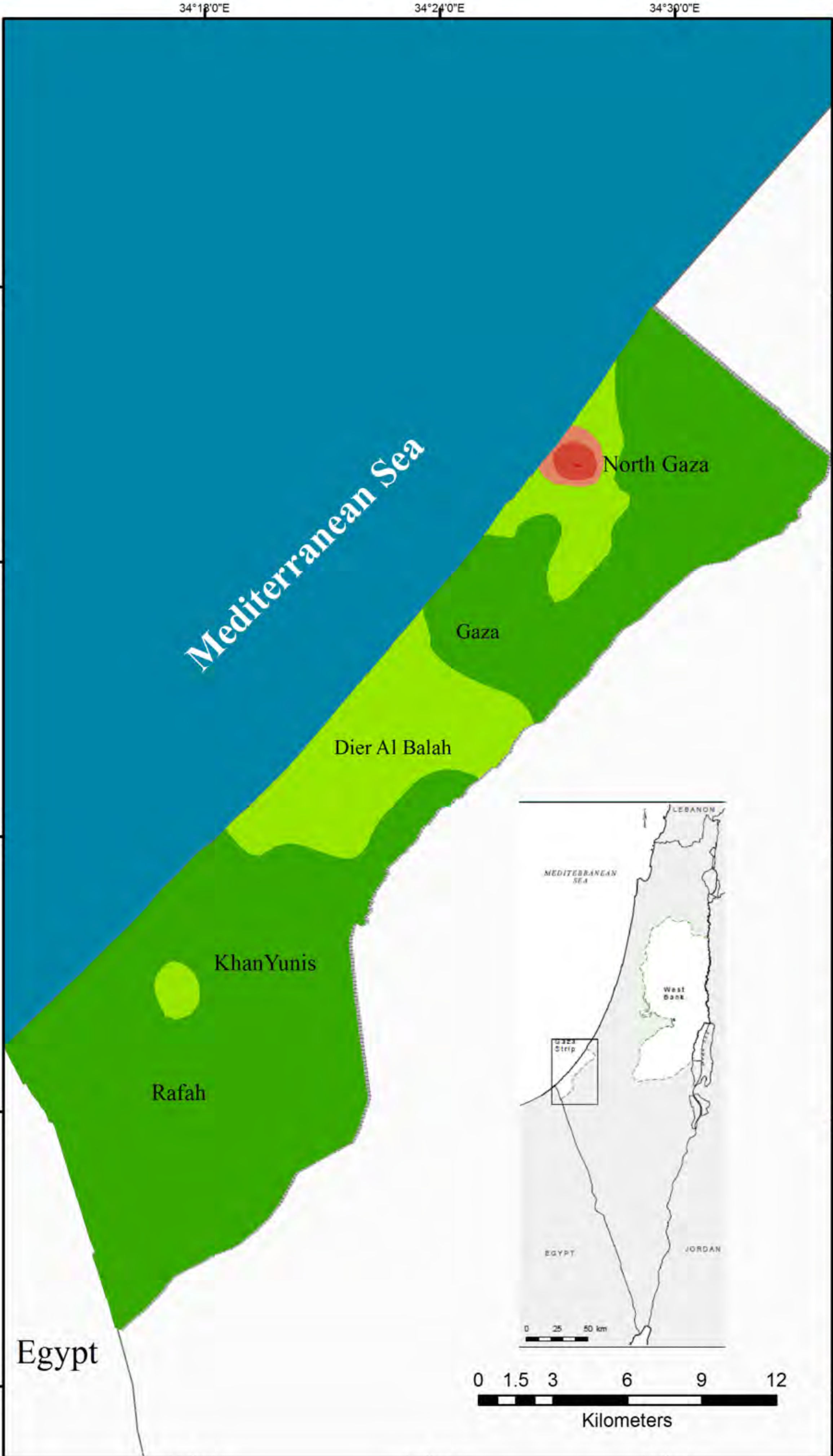



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## Municipal Wells

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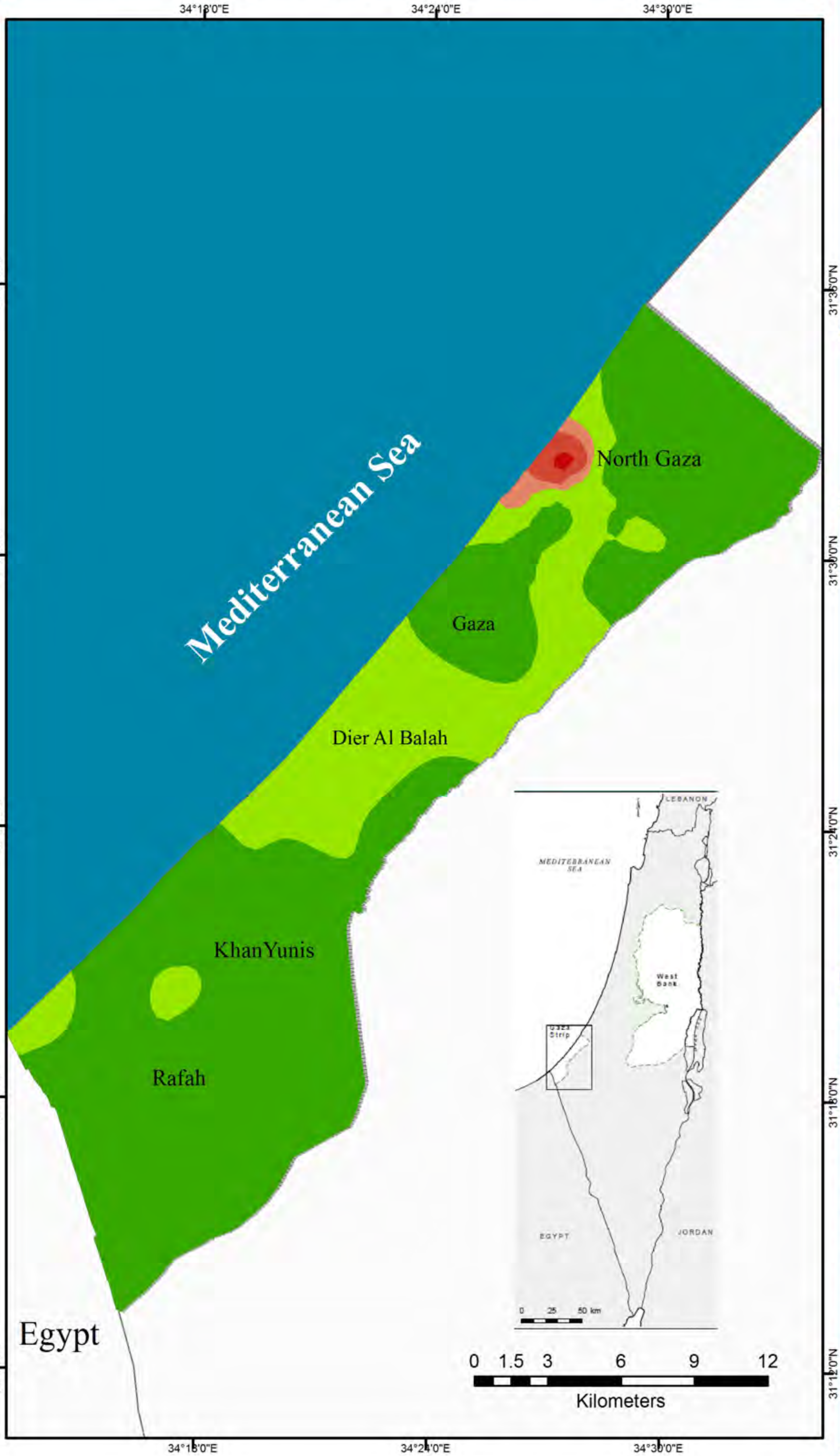


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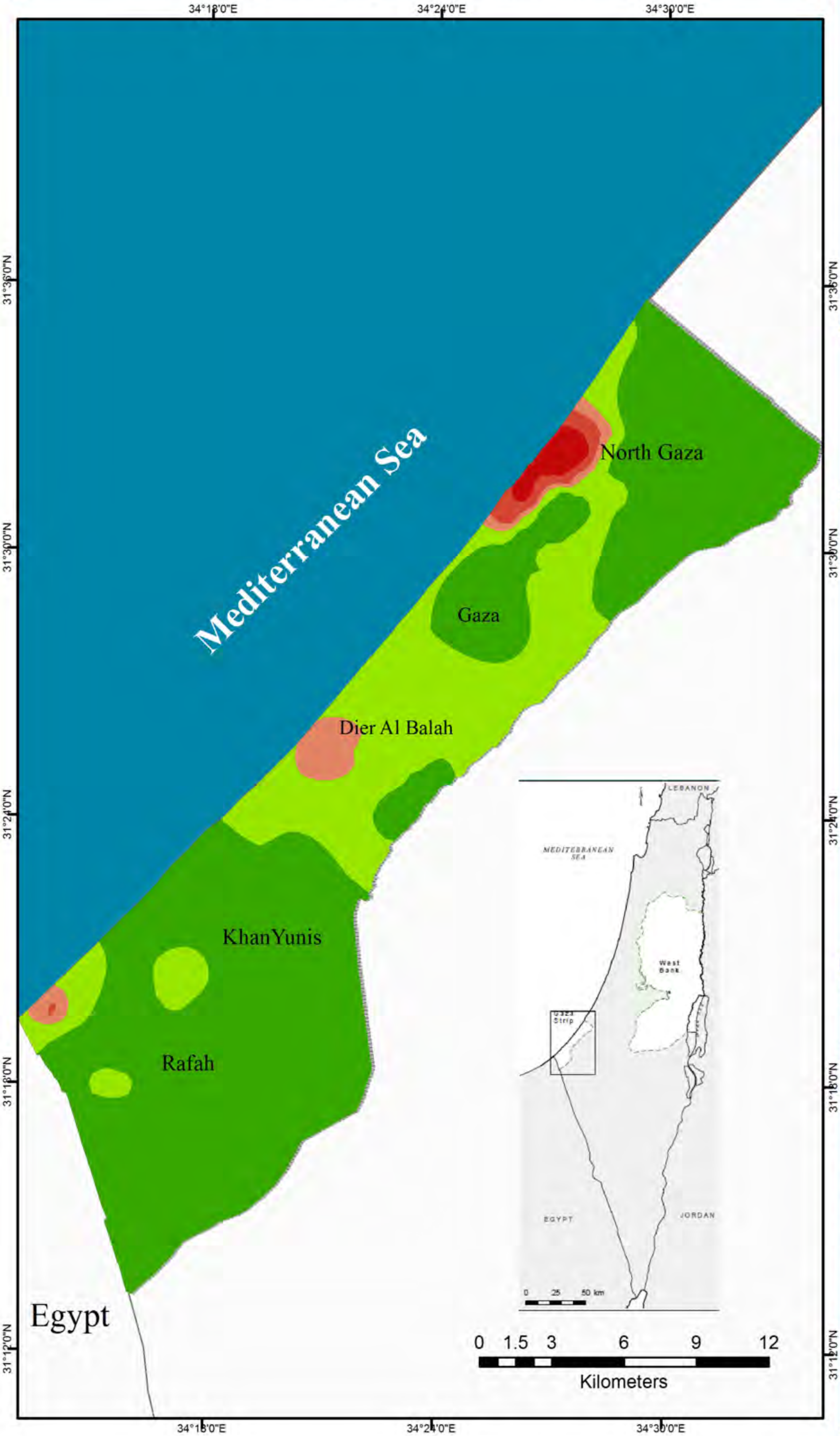


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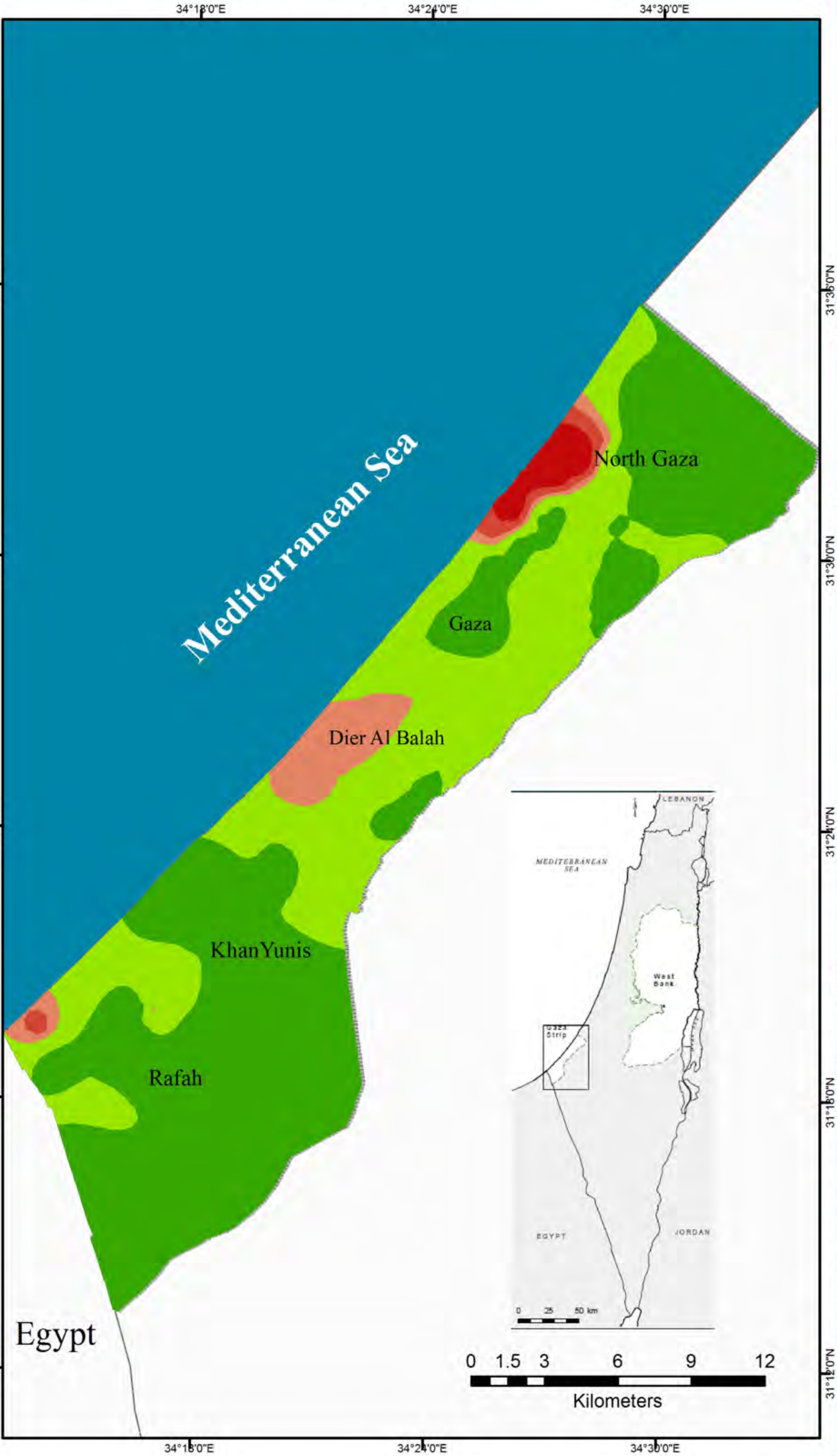


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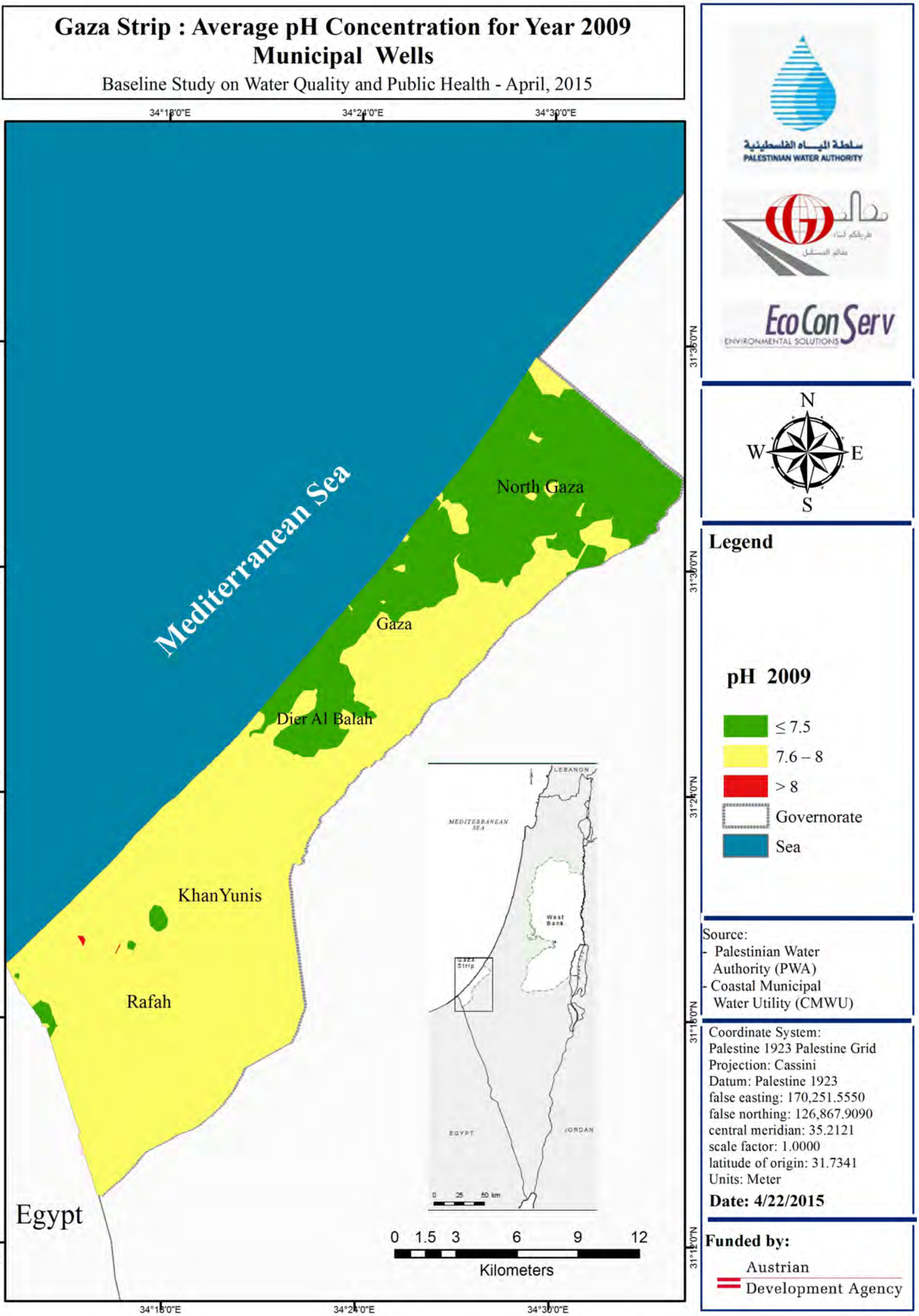
Gaza Strip : Average pH Concentration for Year 2009
Municipal Wells
Baseline Study on Water Quality and Public Health - April, 2015
34°18'0"E
34°24'0"E
34°30'0"E
31°36'0"N
31°30'0"N
31°24'0"N
31°18'0"N
31°12'0"N
Mediterranean Sea
North Gaza
Gaza
Dier Al Balah
KhanYunis
Rafah
Egypt
LEBANON
MEDITERRANEAN SEA
West Bank
Gaza Strip
EGYPT
JORDAN
0 25 50 km
0 1.5 3 6 9 12
Kilometers
سلطة المياه الفلسطينية
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pH 2009
≤ 7.5
7.6 – 8
> 8
Governorate
Sea
Source:
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Coordinate System:
Palestine 1923 Palestine Grid
Projection: Cassini
Datum: Palestine 1923
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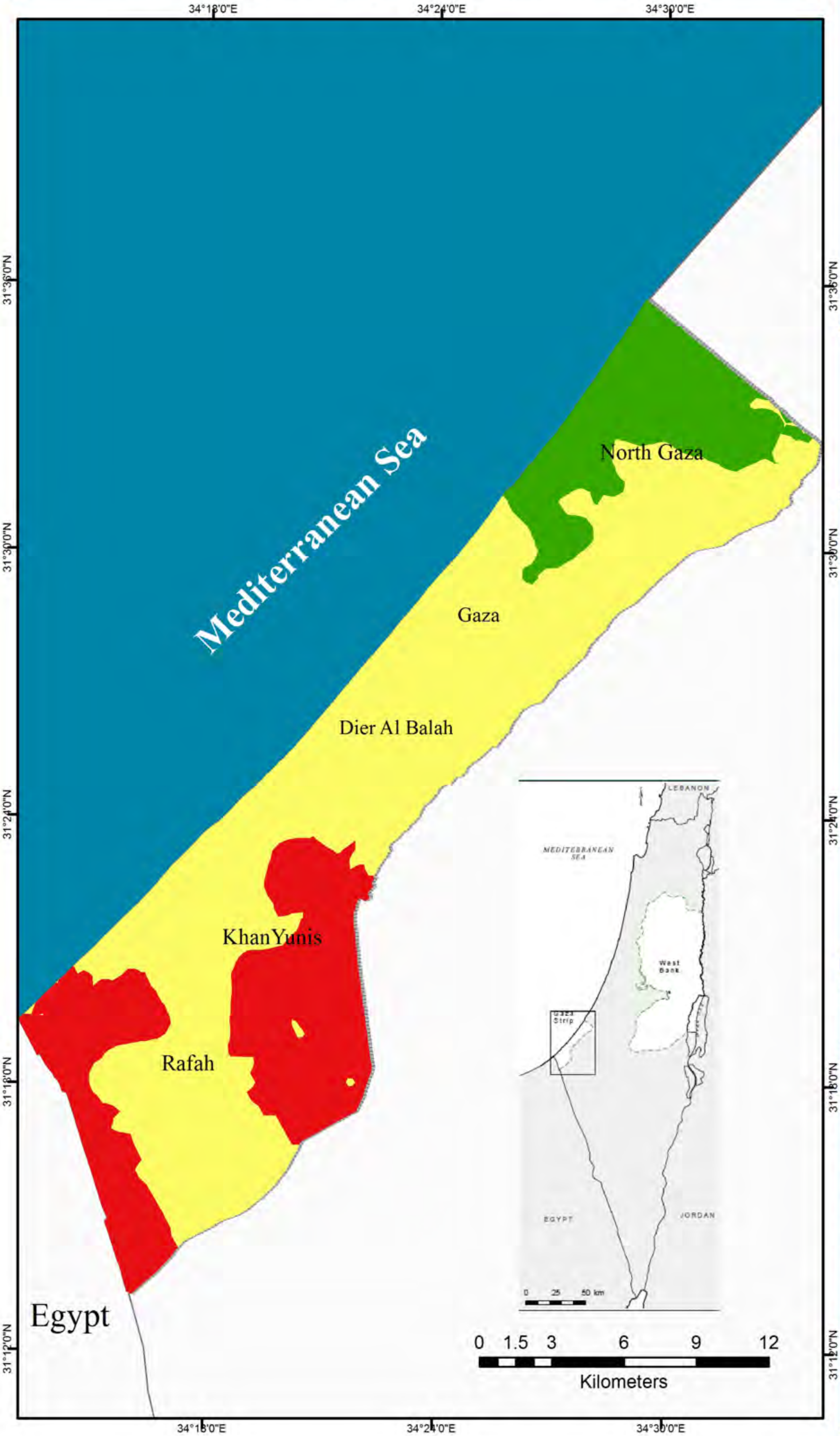
false northing: 126,867.9090
central meridian: 35.2121
scale factor: 1.0000
latitude of origin: 31.7341
Units: Meter
Date: 4/22/2015
Funded by:
Austrian
Development Agency

# Gaza Strip : Average pH Concentration for Year 2010
# Municipal Wells

Baseline Study on Water Quality and Public Health - April, 2015

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**Legend**

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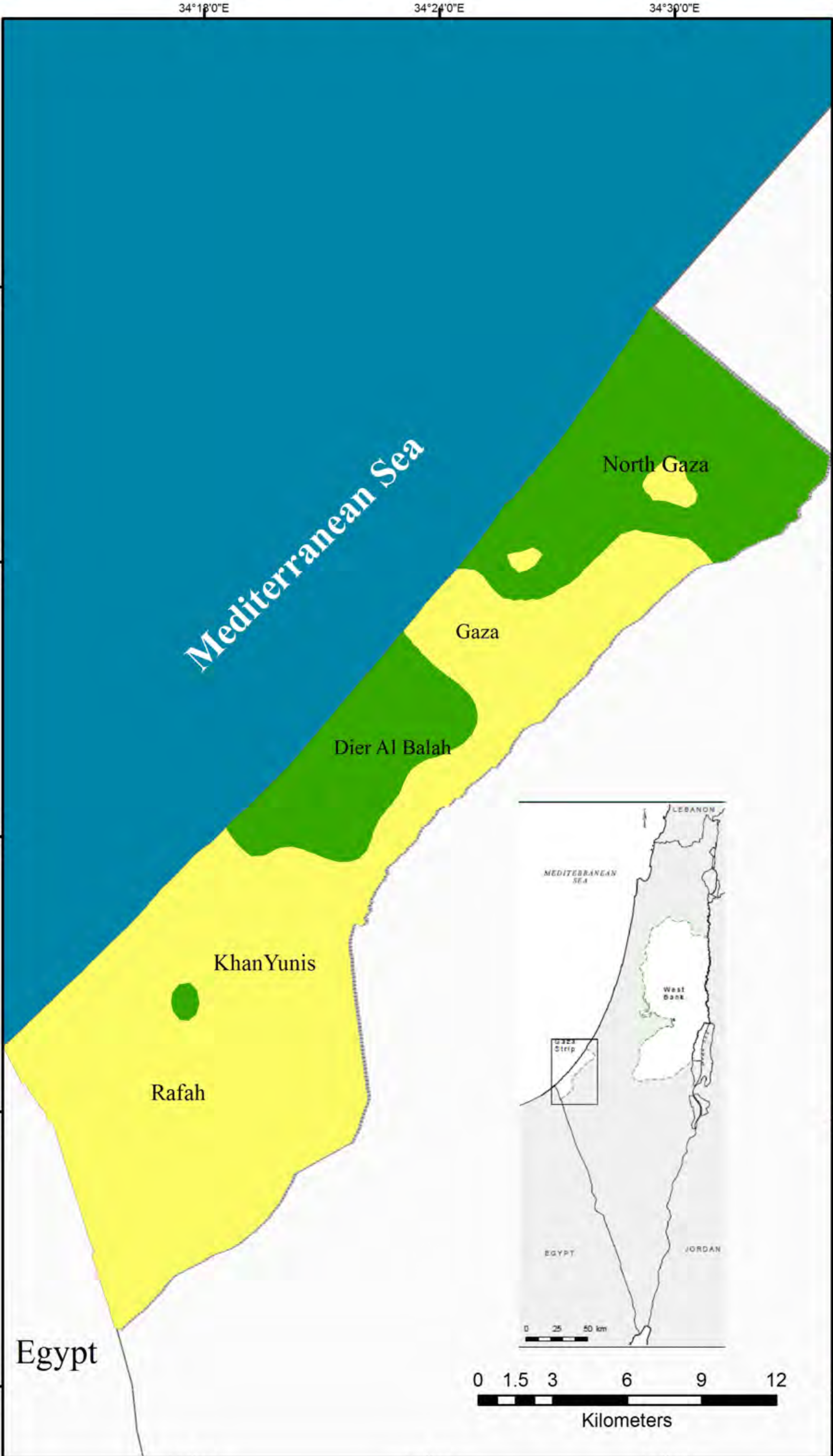


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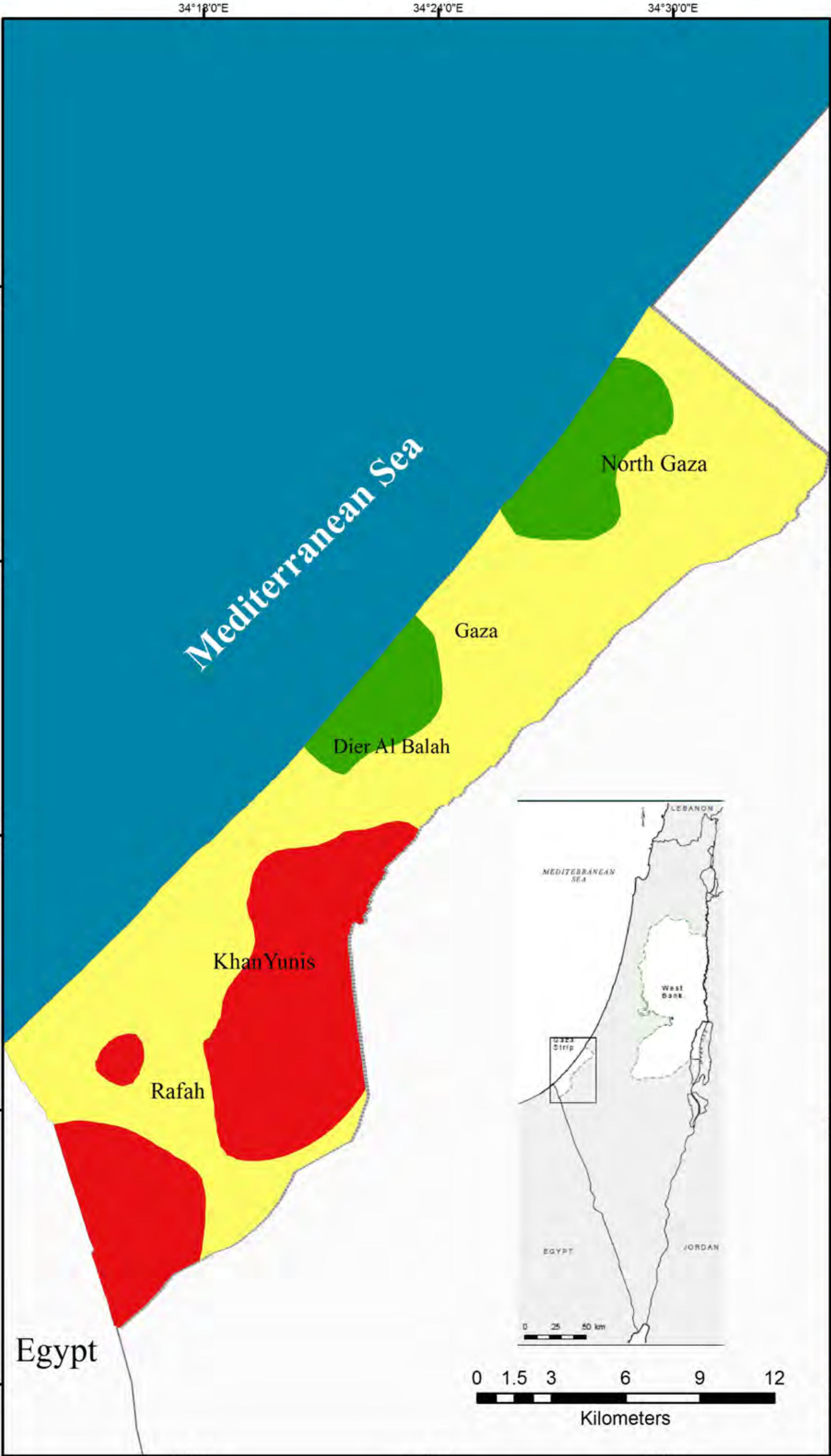


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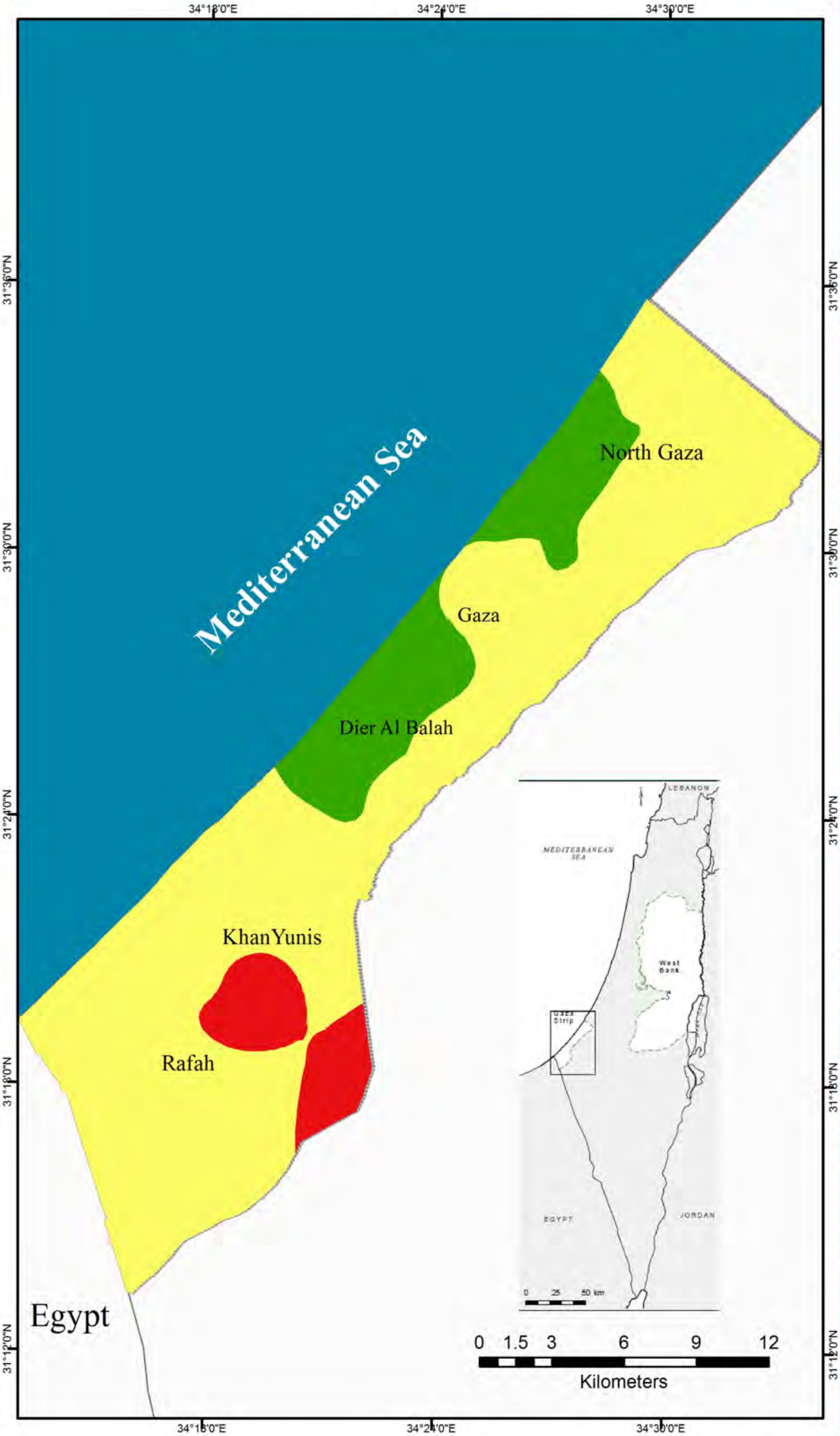


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**Date: 4/22/2015**

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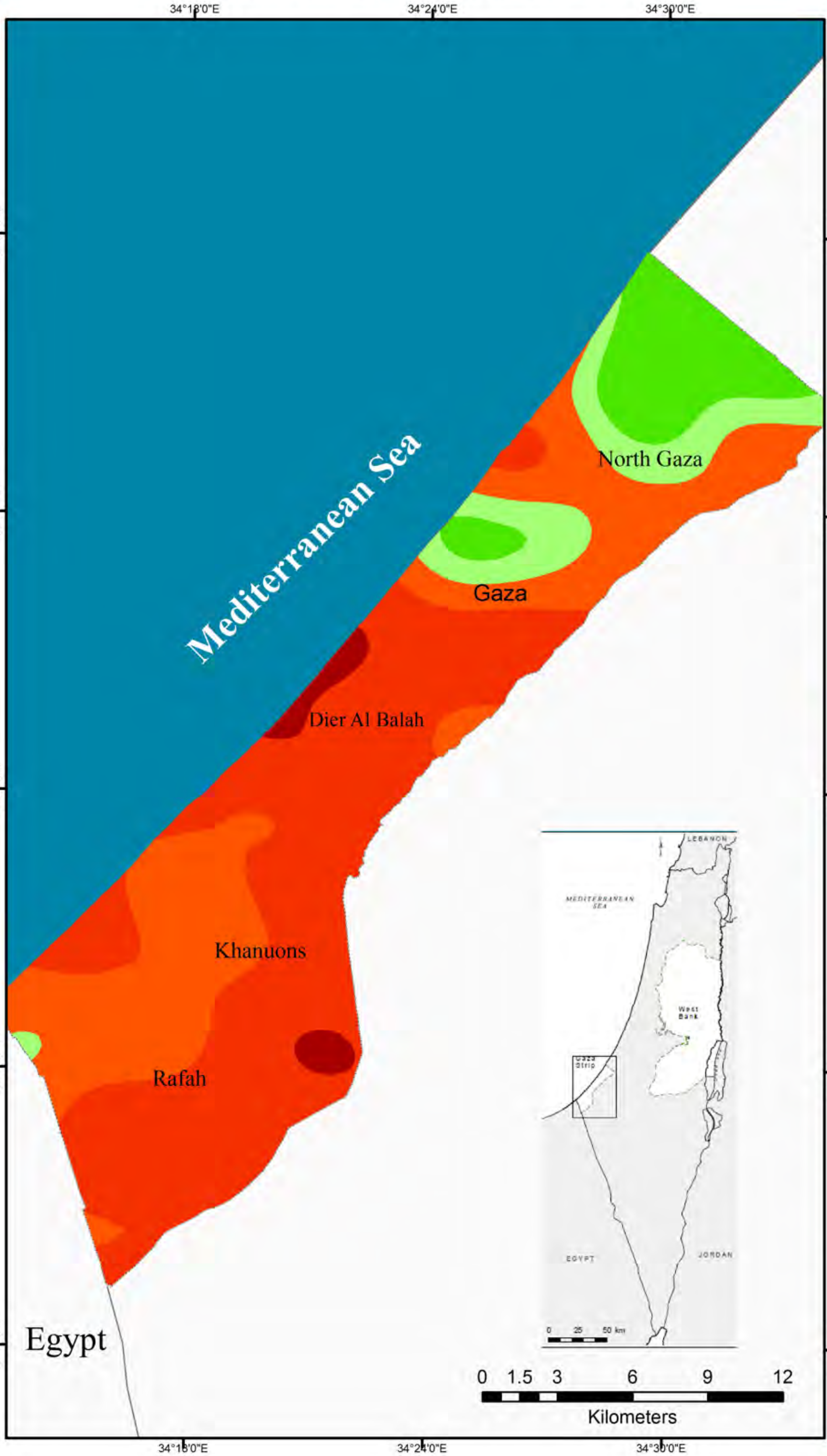
# Gaza Strip : Average Cholride Concentration for Year 2009 Agricultural Wells

Baseline Study on Water Quality and Public Health - April, 2015




## Legend

**Cl mg/L 2009**

- ≤ 300
- 301 - 500
- 501 - 600
- 601 - 1000
- 1001 - 1300
- > 1300

Source:
- Palestinian Water Authority (PWA)
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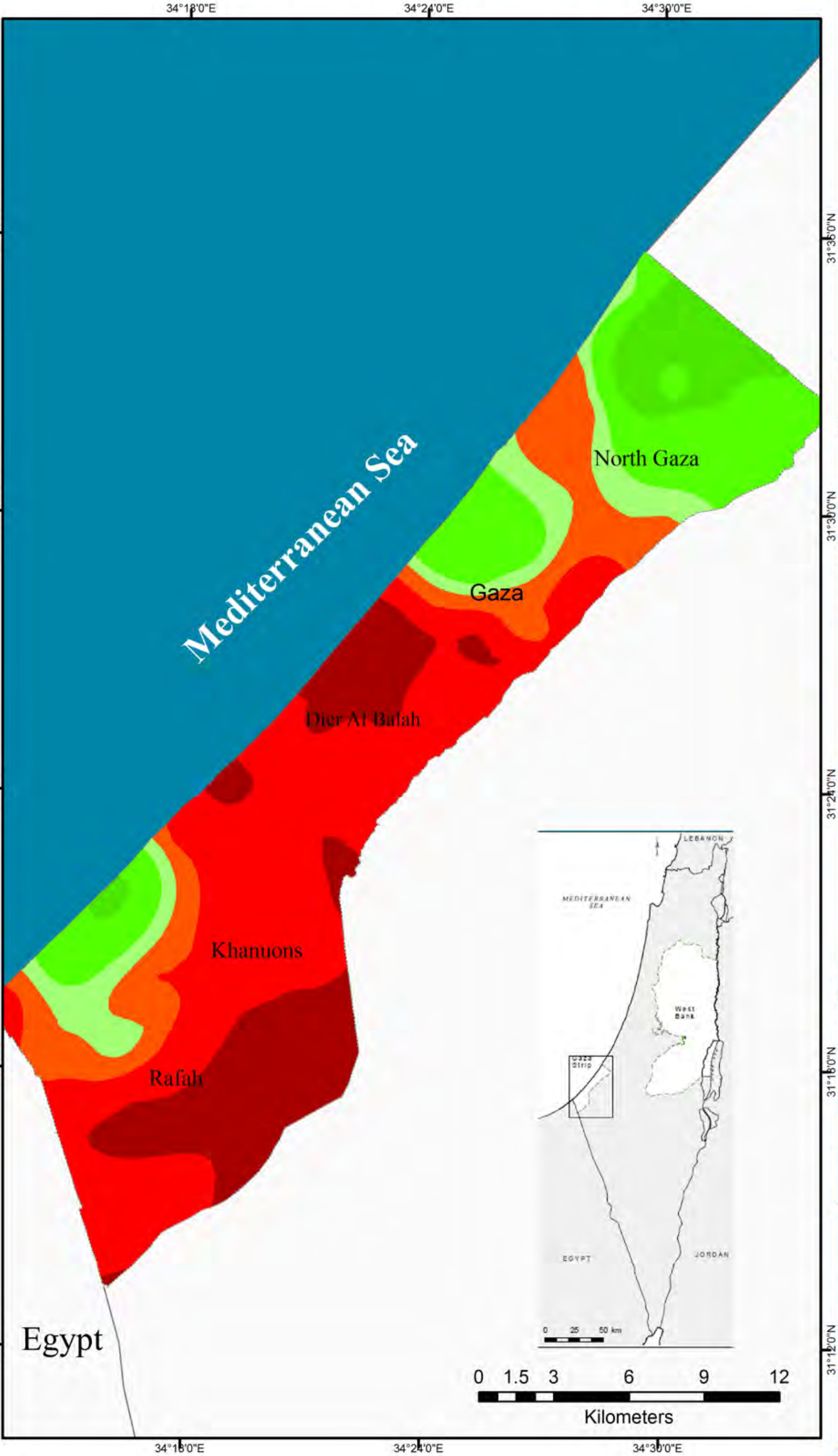


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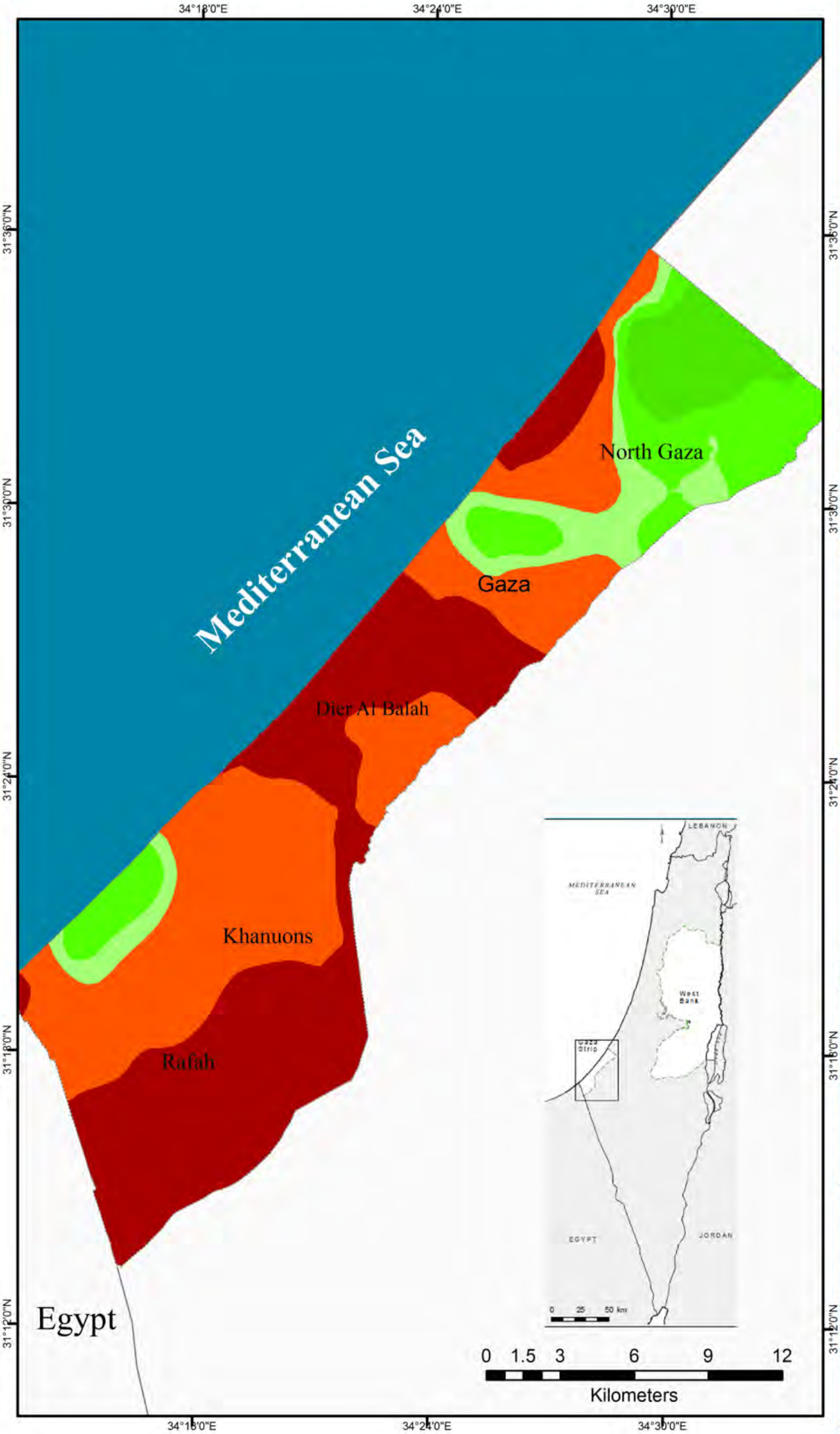


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- 601 - 1000
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- > 1300

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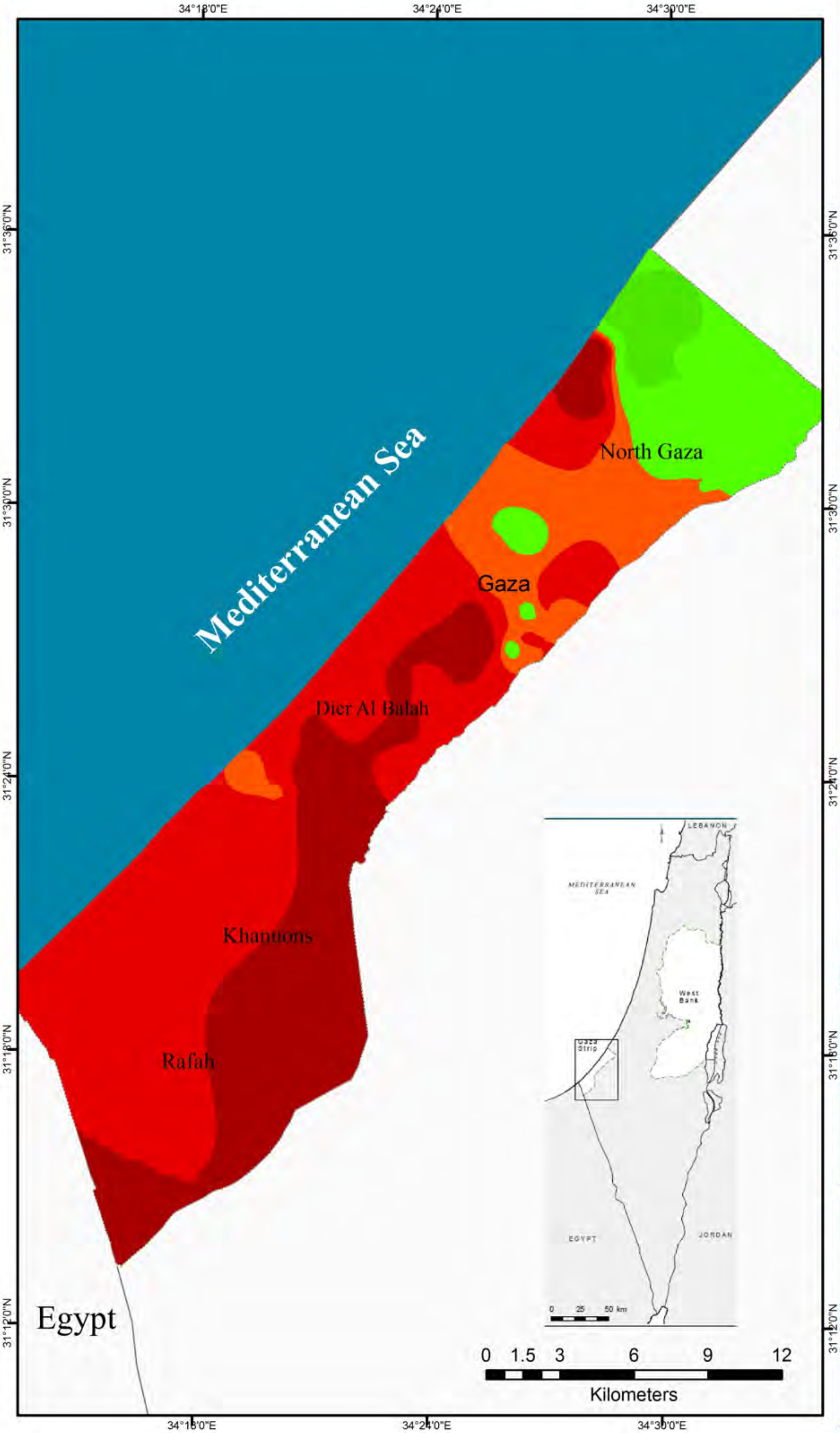


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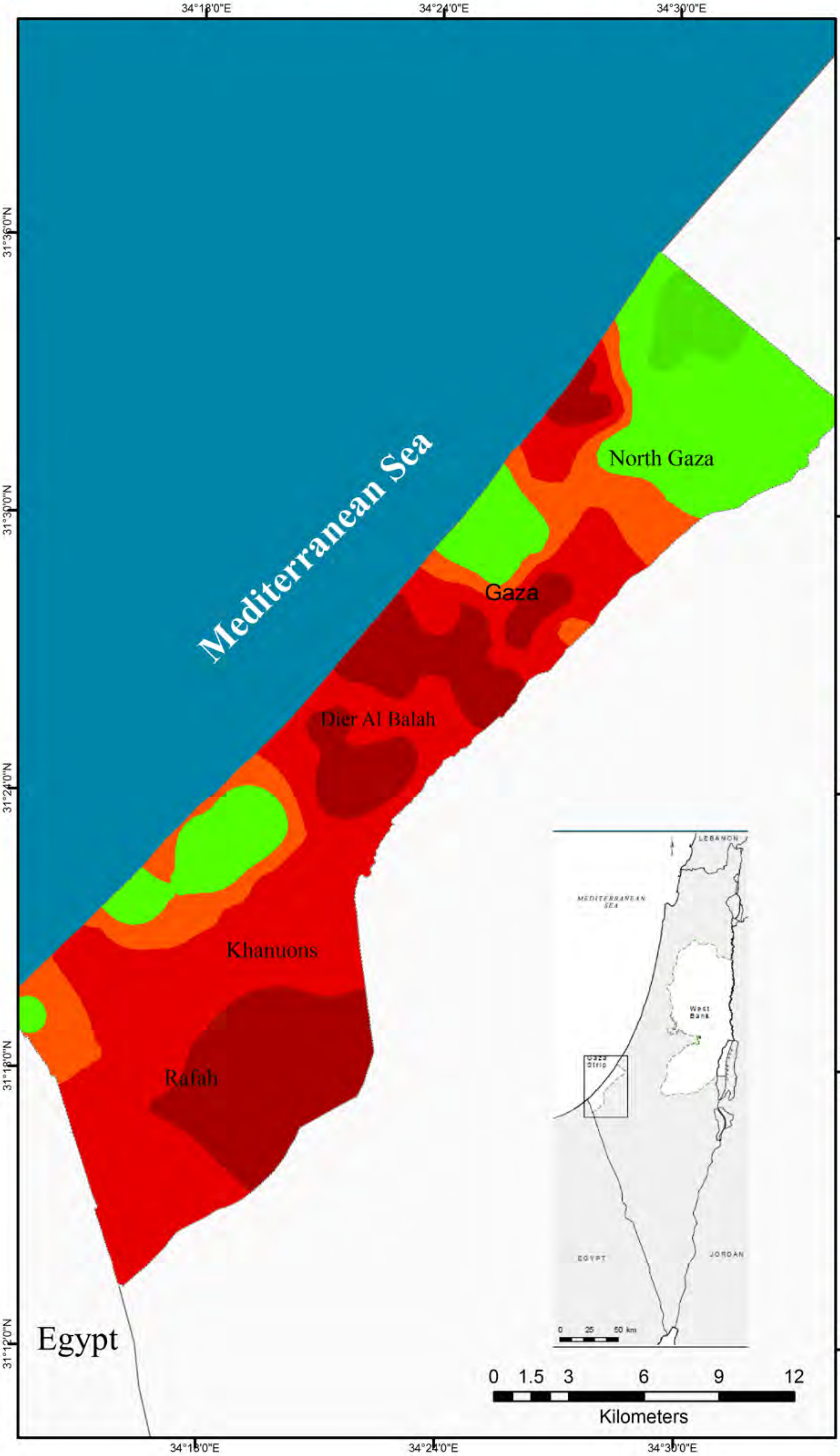


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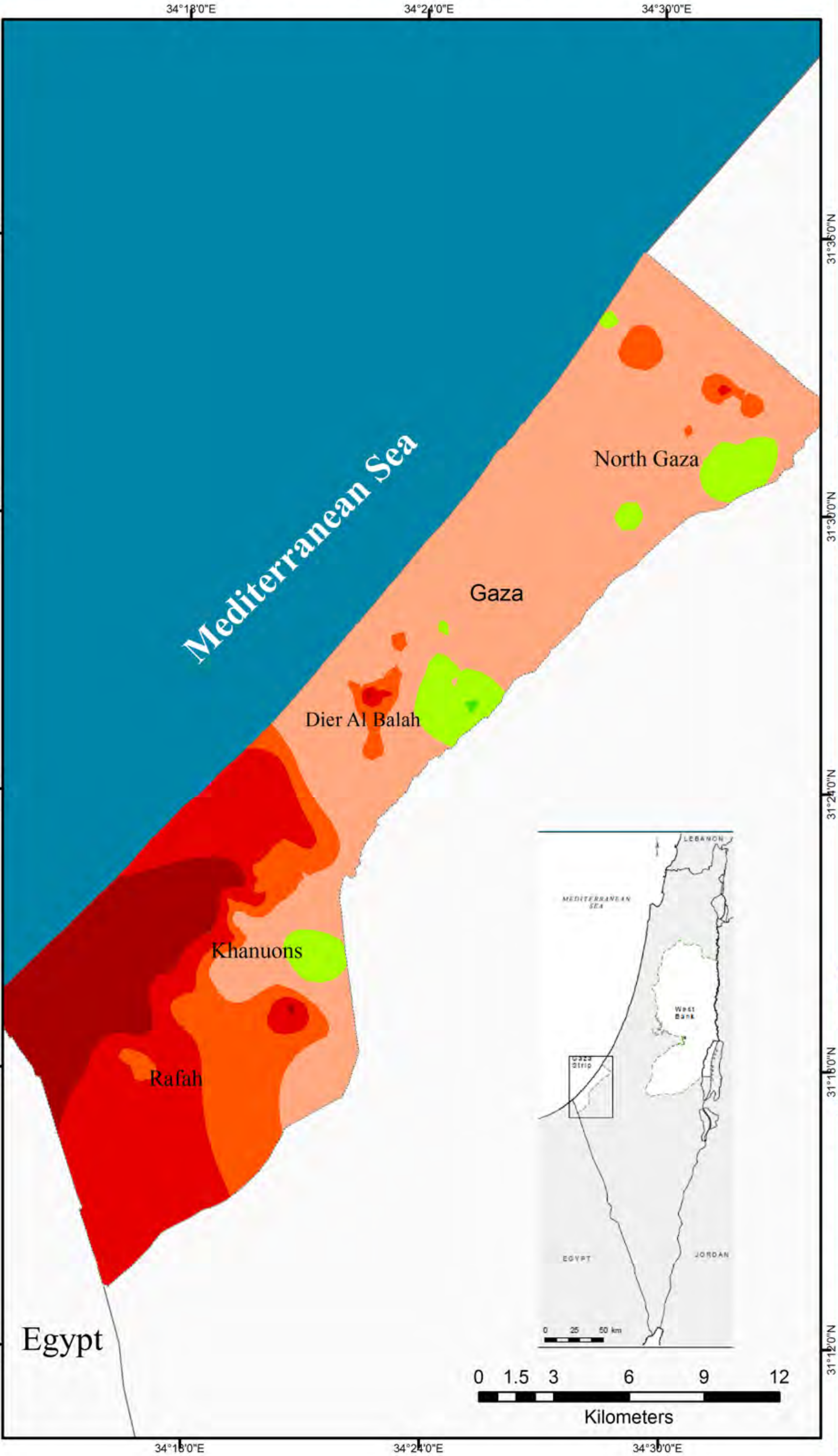
# Gaza Strip : Average Nitrate Concentration for Year 2008 Agricultural Wells

Baseline Study on Water Quality and Public Health - April, 2015




PALESTINIAN WATER AUTHORITY

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**Legend**

**No3 mg/L 2008**

- ≤ 35
- 36 - 70
- 71 - 150
- 151 - 200
- 201 - 250
- > 250

Source:
- Palestinian Water Authority (PWA)
- Coastal Municipal Water Utility (CMWU)

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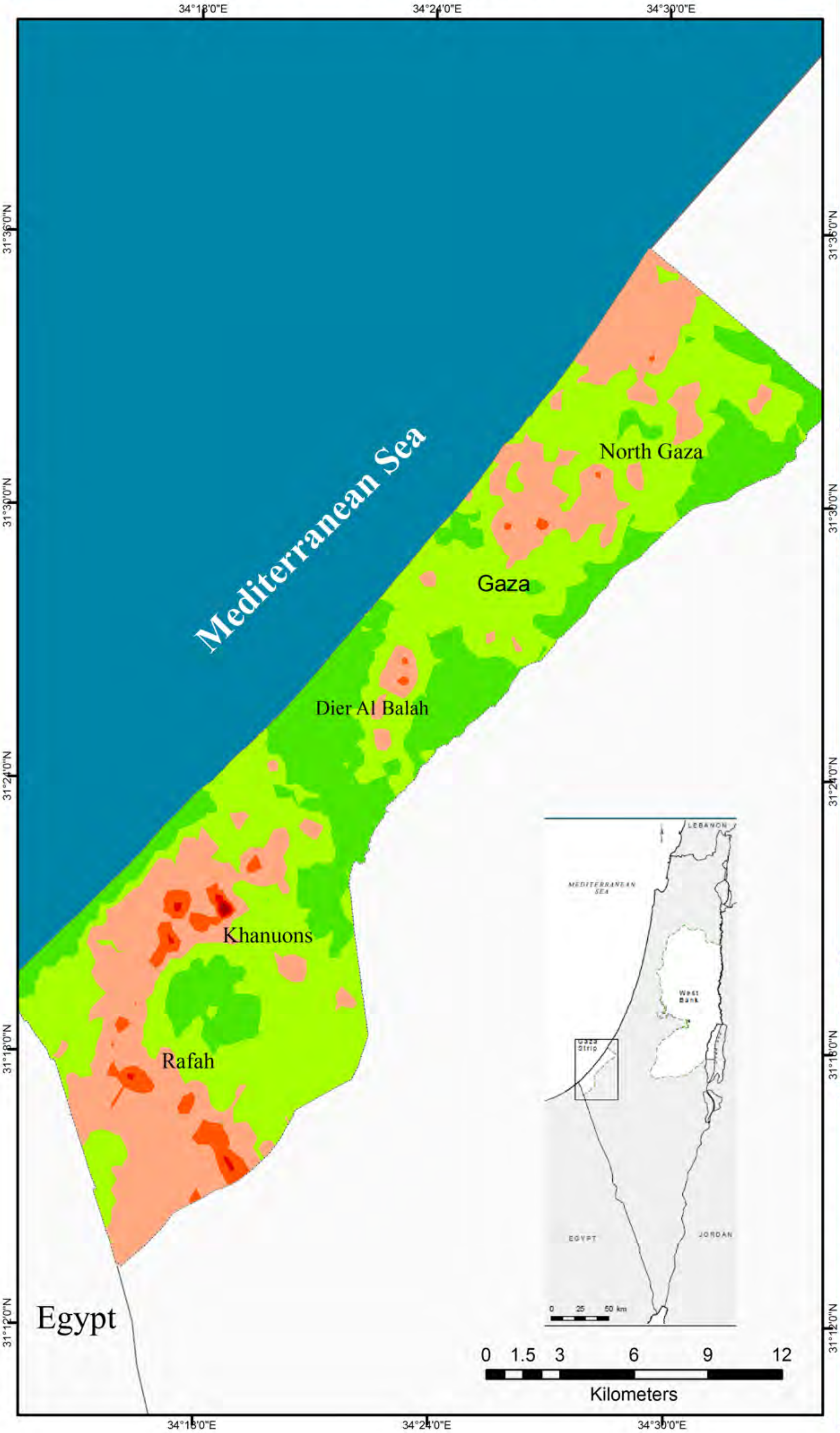
# Gaza Strip : Average Nitrate Concentration for Year 2010 Agricultural Wells

Baseline Study on Water Quality and Public Health - April, 2015

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**Legend**

**No3 mg/L 2010**

- ≤ 35
- 36 - 70
- 71 - 150
- 151 - 200
- 201 - 250
- > 250

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**Date: 4/22/2015**

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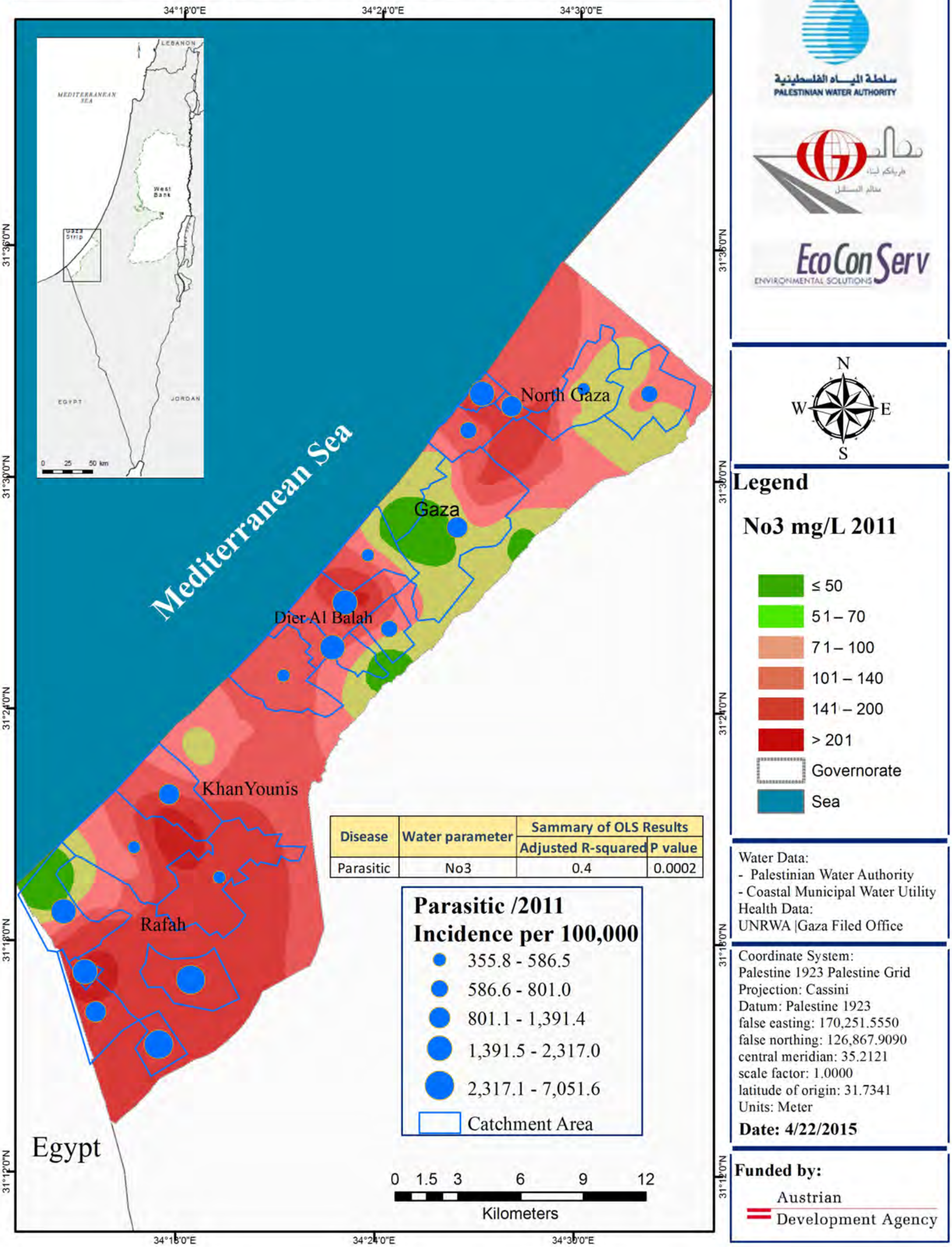
**Correlation between parasitic infestation incidence rate -UNRWA and average nitrate concentration for year 2011**

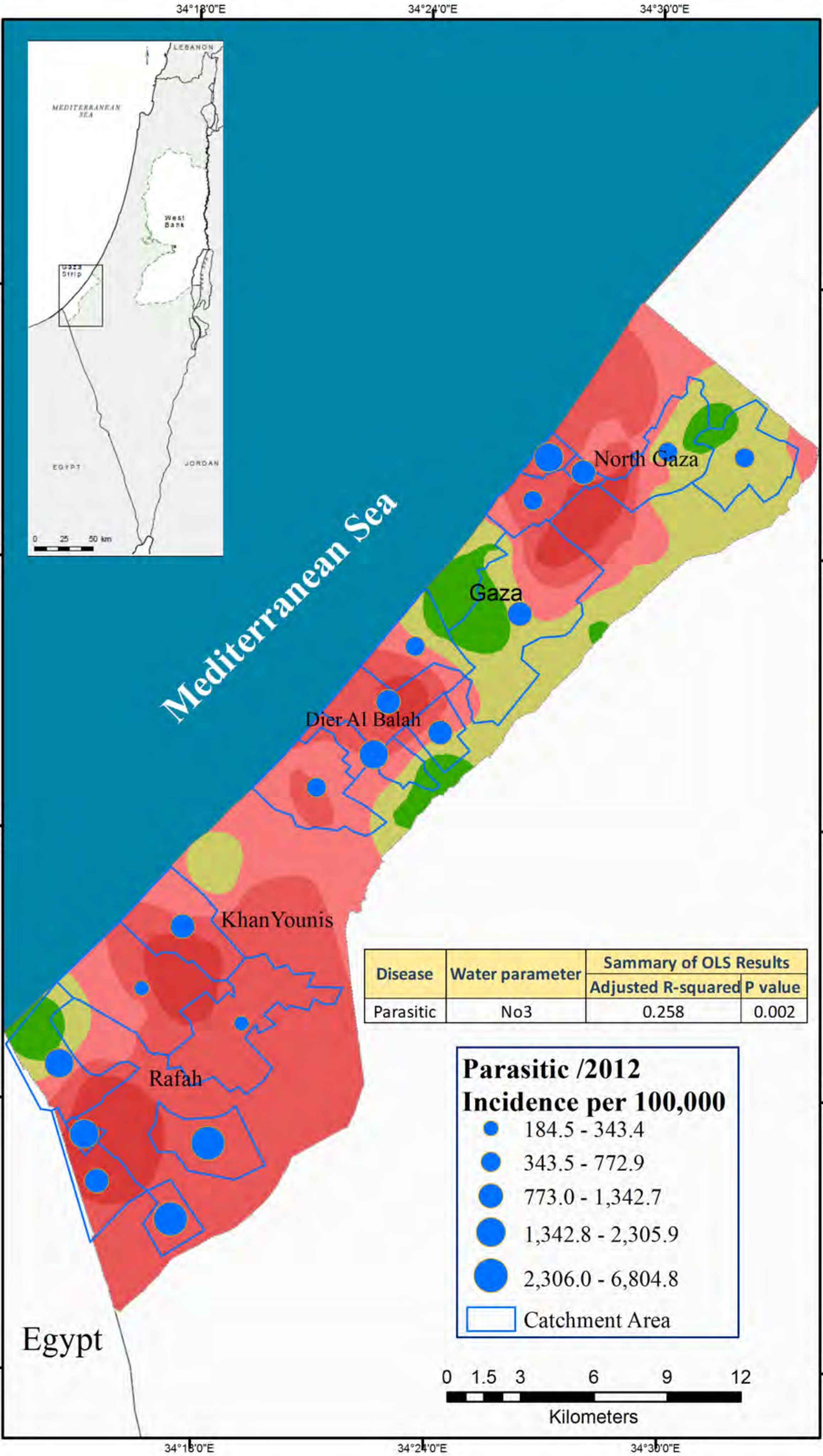
Baseline Study on Water Quality and Public Health - April, 2015




| Disease | Water parameter | Sammary of OLS Results | |
|---|---|---|---|
| | | Adjusted R-squared | P value |
| Parasitic | No3 | 0.4 | 0.0002 |

## Correlation between parasitic infestation incidence rate -UNRWA and average nitrate concentration for year 2012

Baseline Study on Water Quality and Public Health - April, 2015




| Disease | Water parameter | Sammary of OLS Results | |
|---|---|---|---|
| | | Adjusted R-squared | P value |
| Parasitic | No3 | 0.258 | 0.002 |

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**Legend**

**No3 mg/L 2012**

- ≤ 50
- 51 – 70
- 71 – 100
- 101 – 140
- 141 – 200
- > 201
- Governorate
- Sea

Water Data:
- Palestinian Water Authority
- Coastal Municipal Water Utility

Health Data:
UNRWA |Gaza Filed Office

Coordinate System:
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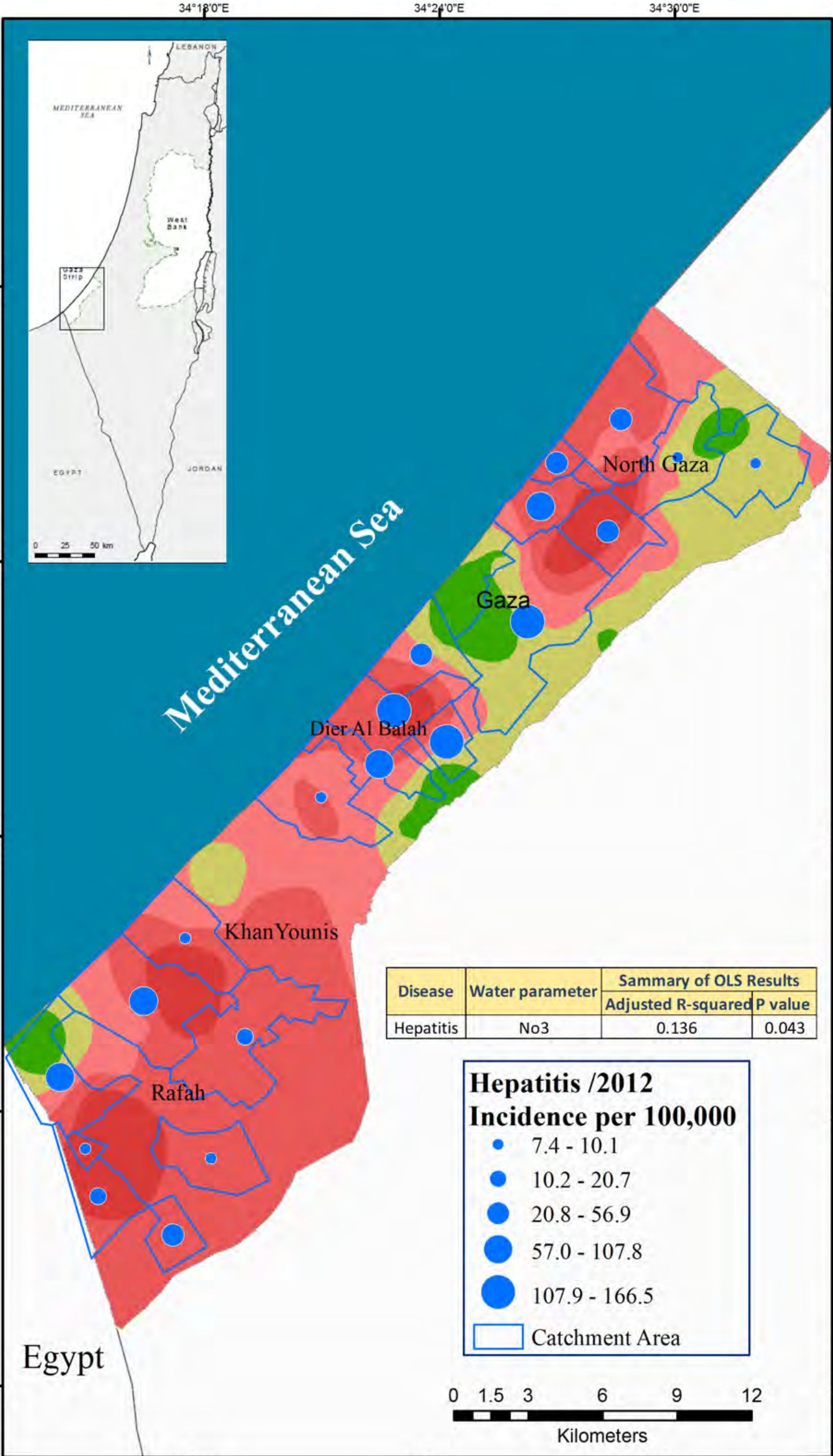
**Date: 4/22/2015**

**Funded by:**
Austrian
Development Agency

# Correlation between Hepatitis (A) incidence rate -UNRWA and average nitrate concentration for year 2012

Baseline Study on Water Quality and Public Health - April, 2015




| Disease | Water parameter | Sammary of OLS Results | |
|---|---|---|---|
| | | Adjusted R-squared | P value |
| Hepatitis | No3 | 0.136 | 0.043 |

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## Legend

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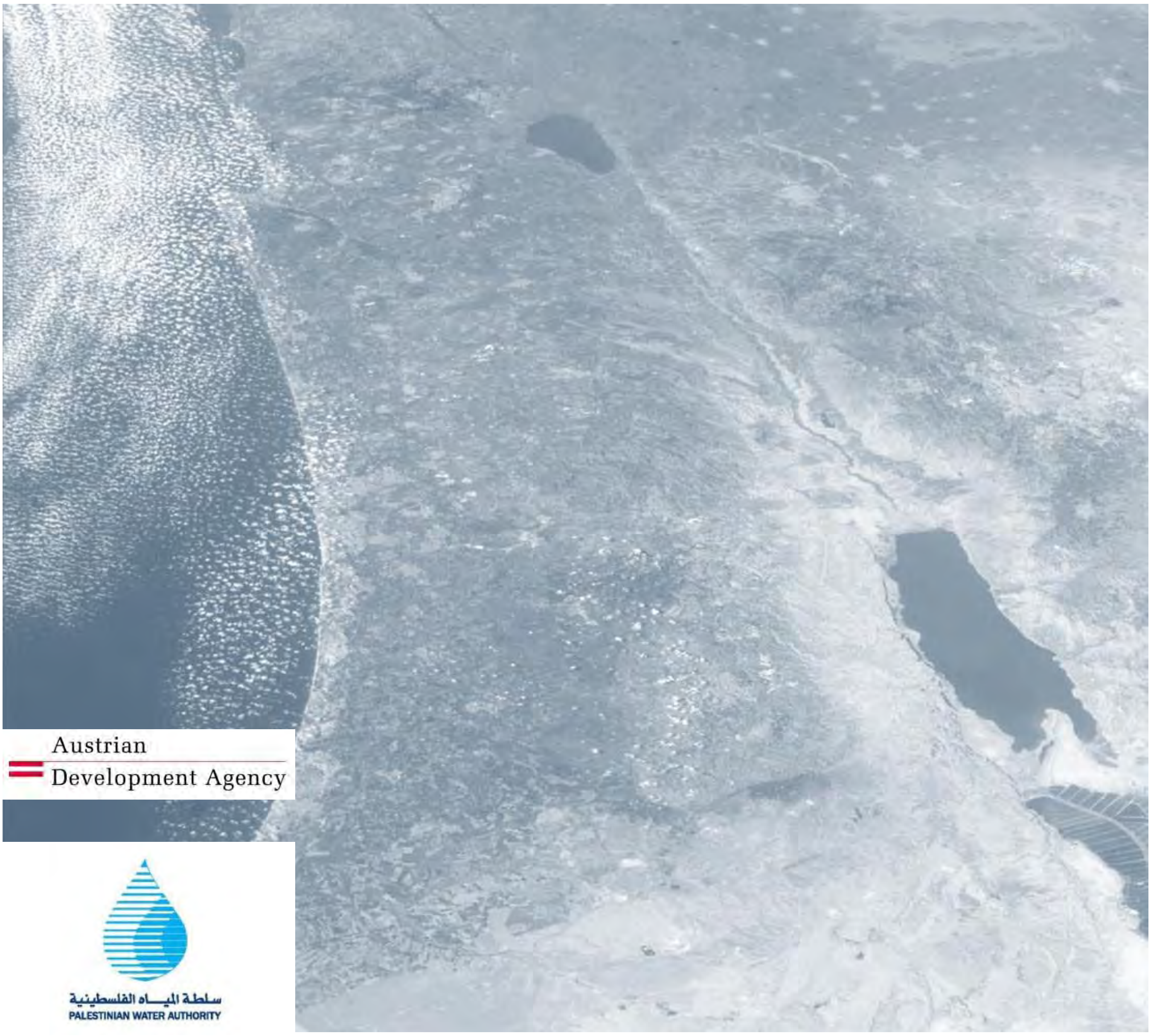
# ANNEX 4

## Literature Review



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سلطة المياه الفلسطينية
PALESTINIAN WATER AUTHORITY

# BASELINE STUDY ON WATER QUALITY & PUBLIC HEALTH

MARCH, 2015

# LITERATURE REVIEW | FINAL

**Submitted to**
Gaza Programme
Coordination Unit (G-PCU)
*Palestinian Water Authority (PWA)*

طريقكم لبناء معالم المستقبل

EcoConServ
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# LIST OF ABRIVIATIONS

| | |
|---|---|
| ADA | Austrian Development Agency |
| ANERA | American Near-East Refugee Aid |
| ASR | Age Standardized Ratio |
| BLL | Blood Lead Levels |
| Ca | Calcium (element) |
| Cl | Chlorides (element) |
| CMWU | Coast Municipalities Water Utility |
| Cr | Chromium (element) |
| CSO-G | Comparative Study of Options – Gaza |
| EPA | Environmental Protection Agency |
| EQA | Environmental Quality Authority |
| ER | Entity Relationship (Diagram) |
| FAO | Food & Agriculture Organization |
| Fe | Iron (element) |
| G-PCU | Gaza-Programme Coordination Unit |
| GIS | Geographic Information System |
| Hb | Hemoglobin |
| IDA | Iron Deficiency Anemia |
| INGO | International Non-Governmental Organization |
| K | Potassium (element) |
| KFW | Kreditanstalt fur Wiederaufbau |
| MCM | Million Cubic Meters |
| Mg | Magnesium (element) |
| Mg/L | Milligrams per liter |
| MOH | Ministry of Health |
| MOA | Ministry of Agriculture |
| Na | Sodium (element) |
| NIPH | Norwegian Institute of Public Health |

| | |
|---|---|
| NGO | Non-Governmental Organization |
| $NO_3$ | Nitrate |
| PA | Palestinian Authority |
| PCA | Plate Count Agar |
| pH | Power of Hydrogen |
| PHG | Palestinian Hydrology Group |
| PNIPH | Palestinian National Institute of Public Health |
| PWA | Palestinian Water Authority |
| RPI | Rolling Program of Interventions |
| RO | Reverse Osmosis |
| $SO_4^{2-}$ | Sulfate |
| Sr | Strontium (element) |
| OCHA | Office for the Coordination of Humanitarian Affairs |
| TDS | Total Dissolved Solids |
| UG | Universal Group for Engineering and Consulting |
| UNDP | United Nations Development Programme |
| UNICEF | United Nations Children's Fund |
| UNRWA | United Nations Reliefs and Work Agency for Palestine Refugees in the Near East |
| USAID | United States Agency for International Development |
| WHO | World Health Organization |

# EXECUTIVE SUMMARY

Based on reviewed available literature regarding two important themes; water quality and public health issues, this Literature Review aims at finding the possible relationships that link these two themes in the Gaza Strip. This review is part of a comprehensive Baseline Study on Water Quality and Public Health in the Gaza Strip, which is conducted to document the present public health status in relation to the existing water quality, showcased on GIS-based mapping. The study aims at establishing baseline information that link water quality to the public health and to explore the health impacts attributed to the existing poor quality of water in the Gaza Strip in order to suggest corrective strategies that decrease mortalities and morbidities attributed to water use. The comprehensive baseline study will be the copestone for a public health and water quality monitoring program. The review process heavily relied on the analysis of the secondary literature and elapsed approximately two months.

Gaza's 1.8 million residents depend on the Coastal Aquifer to supply them with water but overuse and contaminants seeping into the ground, in addition to restriction on using our water rights, are threatening this vital resource. United Nations agencies and the Coastal Municipal Water Utility (CMWU) estimate that the aquifer's supply of water, which is suitable for human consumption, will not be livable in just few years.

Exacerbating the problem is the decrepit state of Gaza's sanitation services. Due to the blockade imposed on the Gaza Strip for several years, many essential water, sanitation, and hygiene materials and equipment are facing continuous entry delays, which have further complicated the situation and pushed Gaza's water and wastewater systems to the edge of collapse, and also delay the construction of major project which can assist in facing the aquifer deterioration.

Lack of electricity, modesty of experience, scarcity of economic resources, and supplies of essential materials such as cement, pipes, spare parts and special electro-mechanical treatment equipment, in addition to the significant tension between Israel and the Palestinians over the ownership of water rights and adherence to agreements over water management constitute additional barriers. These factors have rendered the water and wastewater services unreliable and hazardous, which poses a formidable challenge for the population to obtain adequate clean water. Ninety eight percent of Gazans are connected to the municipal water network but supply is in complicated intermittent schemes and the quality is deteriorating, making its drinkability questionable. Currently, most households do not use municipal water supplies for drinking. Municipal water is considered unfit for domestic consumption due to high and rising levels of chlorides and nitrates; as high as six times the World Health Organization (WHO) standard levels. In fact, there are several parameters far over the limits recommended by the WHO and the Palestinian Water Authority Guidelines. WHO guidelines for drinking-water quality for chloride levels specify a maximum limit of 250 Cl mg/L compared to the Palestinian Water Authority Guidelines, which specify a maximum recommended limit of 400 Cl mg/L.

Moreover, fluorides can have toxic effects in both excess and deficiency as well. The level of fluoride in Gaza's drinking water ranges between 0.8–6.45 ppm. High doses of fluoride are highly toxic and may result in gastroenteritis, acute kidney poisoning, and various degrees of liver and heart damage.

The salinity of water wells increases in general as a result of continuous over-pumping of the aquifer's water and sea water intrusion resulted from that. The trend of increase varies from well to well based on the well location, abstraction rate and pumping duration. Salty water does not itself present a health concern, however, it is unacceptable as drinking water, and to a certain extent for personal hygiene as well.

Sewage is the biggest reason for groundwater contamination in the Gaza Strip. Only about 40% of the sewage generated in the Gaza Strip is properly treated. The percentage of population served by sewerage systems is 78.9%, leaving nearly half a million people unconnected to the sewage network and dependent on alternative means for excreta disposal.

Total and fecal coliforms are the most commonly used indicators for microbiological contamination. Reports show that 19% of groundwater, 27% of desalinated water and 20% of water network samples are microbiologically contaminated by total Coliform while 13%, 14% and 12%, respectively, are contaminated by fecal coliform bacteria.

Diarrhea is one of the most significant diseases that are attributed to poor sanitation and water contamination. Children suffering from diarrhea are more vulnerable to become malnourished which makes them even more vulnerable to other diseases such as acute respiratory infections. As detailed in this report, hepatitis and meningitis also constitute a major morbidity problem with high hospitalization costs. Generally, it is noticed that the incidence of water related diseases is increasing, particularly hepatitis, meningitis, and typhoid. In addition, parasitic infestation is still high, despite the measures that have been implemented to control parasitic diseases many decades' ago. Other sanitary related diseases such as skin diseases are on the rise, especially in areas with in adequate water supply. Regardless of its association with water use, the number of anemic and malnourished persons is also high, at several times greater than what is regarded as normal, according to the WHO standards. Also, the prevalence of cancer and congenital anomalies is constantly increasing.

Epidemiological studies into the relationships between the quality of water supply and human health in the Gaza Strip are limited, and when available, vary widely, as there are severe methodological difficulties involved in undertaking such studies. Nevertheless, there is sufficient international evidence to support the conclusion that improving water supply and sanitation can have a significant impact on human health. Serious information gaps are revealed through this review including lack of standardized definitions, limited national studies with adequate samples, and absence of data at a neighborhood level.

To tackle the multi-faceted challenges pertaining to water, there is a pressing need to design an integrated overall strategy for water in the Gaza Strip. The recommendations proposed in the literature predominantly stressed the overall need for improved and sustainable water resources. Many documents presented specific recommendations that could be of interest at the political level, including negotiating water rights with neighboring countries. Other recommendations were more technical and were appropriate for the service delivery level, such as the selection of sites for treatment, management of effluent and leachate, and strategies for monitoring water quality. Several documents stressed the need for construction and/or maintenance of the water delivery and sanitation infrastructure. Recommendations for the population level generally was gear towards the need for increased awareness regarding water quality, water safety, hygiene, and sanitary practices.

# BACKGROUND

Adequate sanitation, together with good hygiene and safe, reliable, affordable, and easily accessible water supply, are essential for good health. Widely, it is believed that improving water resources can improve health and reduce attributed death as well. In the Gaza Strip, water quality is affected by many different issues including soil/water interaction in the unsaturated zone due to recharge and return flows, mobilization of deep brines, sea water intrusion or.

In the absence of other significant water resources in the Gaza Strip, the aquifer is considered the main water supply source for all kind of human usage, which is currently facing a serious challenge in terms of quantity and quality. The available water quantities for the population in the Gaza Strip are inadequate due to the over-exploitation of the natural aquifer, and the water quality falls below the accepted international guidelines for potable water, which poses a risk on the public health of about more than 1.8 million people living in the Gaza Strip. This population is expected to grow at a rate of around 3.5% per year, and the domestic water demand is projected to grow from 91 million cubic meters per year (MCM) to more than 199 MCM in year 2035. Further to the lack of additional water resources, the situation is aggravated by the damaged or destroyed infrastructure due to the ongoing political conflict and blockade. The ongoing blockade of the Gaza Strip which has been intensified since 2007, has further complicated the situation and resulted in the delayed entry of many essential water, sanitation, and hygiene related materials. Also, the lack of electricity, limited experience and the scarcity of resources, in addition to the significant tension between Israel and the Palestinians over ownership of water rights and adherence to agreements over water management all these issues combined had negatively affected the quantity and quality of water supply for human use.

Currently, the issue of insufficient water for household usage is being dealt with through storage and strict rationing, yet the quality deterioration is still perceived as a major issue that cannot be addressed at a household level. Since most of the population in the Gaza Strip cannot afford to treat the water themselves, nor should they be expected to do so, they depend on the private water vendors for their drinking and domestic use, which, due to the improper handling and storage practices, poses a risk of contamination (UNDP, 2004; MOH, 2014). These factors have posed a formidable challenge for the population to obtain adequate clean water. Although these circumstances require more long term strategic interventions from the public health and water sectors, the current population of Gaza is still dependent on the existing water resources, despite the insufficient quantity and the bad quality.

PWA conducted a comprehensive study of options for an additional supply of water for the Gaza Strip (CSO-G). The study developed a rolling program of interventions involving nine projects that are inter-linked, and in combination form a coherent programme to address the critical issues in the water sector in Gaza. These projects include: establishment of a Gaza Programme Coordination Unit (G-PCU), introduction of an integrated water and health monitoring project, upgrading and/or provision of the domestic water distribution and supply network, enhanced levels of water imports from Israel to Gaza, introduction of short-term low-volume (STLV) desalination of sea water, phasing-in of higher levels of sea water desalination through the construction of two regional facilities, introduction and/or extension of pilot schemes for the reuse of treated wastewaters plants, accelerated completion of the major wastewater treatment plants, and finally, review of the use of water in the agricultural sector.

Thanks to the generous funding of the Austrian Development Agency (ADA), the Gaza-Programme Coordination Unit (G-PCU) at the Palestinian Water Authority (PWA) undertook this initiative by tasking Universal Group for Engineering and Consulting (UG), in cooperation with EcoConServ, to provide technical assistance to G-PCU's efforts in the implementation of the Rolling Program of Interventions for Additional Supply of Water for the Gaza Strip (TA-G-PCU), in Palestine.

## AIMS & OBJECTIVES

This review of the literature is part of a comprehensive study on water quality and public health, conducted to document the present public health status related to existing water quality and showcased on GIS-based mapping. The study aims at establishing baseline information that link water quality to the public health and to explore the health impacts attributed to the existing poor quality of water in the Gaza Strip in order to suggest corrective strategies that decrease mortalities and morbidities attributed to water use. **The scope of the study includes the following**;

- Review the existing studies.
- Develop a general water supply schematic diagram.
- Develop a comprehensive geo-database of the collected data.
- Conduct a GIS mapping study to develop a decision support system.
- Explore any possible correlation between water quality and water related diseases.

**In more specific terms, the literature review component of this study is mainly concerned with the following tasks;**

- Reviewing the existing studies on water quality and water related health threats in order to assess the status of water quality and its link to public health diseases.
- Comparing water quality parameters in Gaza with the international guidelines for water quality and usage
- Analyzing studies to identify gaps and extract evidence
- Looking for commonalities, evidence, trends, controversial issues and striking findings.
- Determining areas that need further in-depth investigations, analysis, and verification.

- Proposing practical recommendations on the usage of water in Gaza and on how the population in Gaza can mitigate health risks associated with the use of the available water.

# REVIEW METHODOLOGY

A multi-disciplinary review team lead by a public health expert and a water quality expert conducted the systematic review of the existing studies on water quality and public health in the Gaza Strip. Although the literature review has started before the brainstorming and consensus building meeting (held in mid-December of 2014), the outputs of the braining storming session (water quality parameters and public health diseases) to be applied on the GIS system have framed our literature review. In other words, the focus of analysis was on the list of diseases and the water quality parameters that have been identified as priorities by stakeholders. Nonetheless, extensive analysis of the existing literature was conducted to extract the crucial gaps in the quality of water used by the Gaza Strip inhabitants, the public health conditions related to water use, and the associations/linkages between the latter two themes. Records review also involved in-depth analysis of the content and verifications when needed. Wherever possible, empirical data was collected or re-analyzed to serve the purpose of this study. Also, documents' analysis involves collation of the best practices from the local and the international literature in order to learn from the experiences of other countries and to consider alternative models wherever possible. To obtain the needed information and reports from the concerned organizations, in consultation with PWA, letters were sent to these organizations who positively responded.

During the earlier stages of the project, the research team has conducted a preliminary review of the local literature, identifying themes to focus on based on the state-of-the art approaches in this field, and to develop questions/indicators to address in the review process. The basic assumption behind the latter approach is to be well-framed and yet flexible, rather than having an arbitrary literature review. Thus, this review process has yielded certain central questions evolved in accordance with the objectives of the study.

***The key questions that have been addressed by the review are;***

- What are the main sources of water people utilize in the Gaza Strip?
- What are the possible contaminations affecting human beings that are attributed to these sources? What are the risks associated with these resources?
- What are the main gaps in water quality?
- What are the main biological contaminants in water in the Gaza Strip? What are the main microbial diseases associated with water use?
- What are the main chemical contaminants in water? Which chemicals? What magnitude? What are the main chemical related diseases attributed to water in the Gaza Strip?
- Which areas and who are more affected and in which form?
- What are the baseline readings that we can use in the future for comparison purposes?

- Are there links between water quality and public health diseases?
- What are the main health impacts attributed to the poor quality of water in the Gaza Strip?
- What are the main conclusions that could be drawn from the literature regarding water supply and use?

After determining the questions to be addressed in the literature review process, we then assigned technical teams to conduct literature search on specific themes in more in-depth according to their areas of specialties and expertise. For instance, water experts conducted search for water quality standards, guidelines, water system processes, management, sources, treatment, storage, distribution, use, quality, and contaminants levels (bacterial and viral related contaminants which lead to disease such as diarrhea, salmonellosis, hepatitis, parasitic diseases, and chemical contaminants which cause fluorosis and lead poisoning) both locally and internationally. The international experts from EcoConServ had focused on reviewing the regional and international literature, while local experts from Gaza had focused on the locally conducted studies. Reviewers then performed an evaluation of the potential significance of contaminants occurrence on human health. The reviewers focused on studies conducted in Gaza in the past five years (2009 – 2013), however, they also included studies conducted beyond the specified period. Reviewers significantly benefited from the international literature in making comparisons, benchmarking, and learning lessons from other experiences. Information from the reviewed reports was summarized and organized in abstraction tables in accordance with the study questions/themes. The review process elapsed over approximately two and a half months.

The next step was summarizing the data and synthesizing the knowledge from the provided information. Extracted information had guided the development of this review report. Concisely, our approach has incorporated asking focused answerable questions for the purpose of finding evidence from the literature through systematic retrieval of the best available evidence and critical appraisal which aims to test the retrieved evidence for validity, relevance, and applicability, followed by making decisions for the practical applications of the review results to our study. The reviewed records have been appropriately filed and kept for decision trails logging and future audits if needed.

# RESULTS

## THE GAZA STRIP OVERVIEW

The Gaza Strip is a narrow band of land; it is 45 kilometers long and 6-12 kilometers wide with an area of 378 square kilometers (UNEP, 2009). It is located on the crossroad from Africa to Asia, making it a target for occupiers and conquerors over the centuries. It borders the Sinai Desert in the south, the Naqab Desert in the east and the Mediterranean Sea in the west (Nakhal, 2004) (Figure 1).

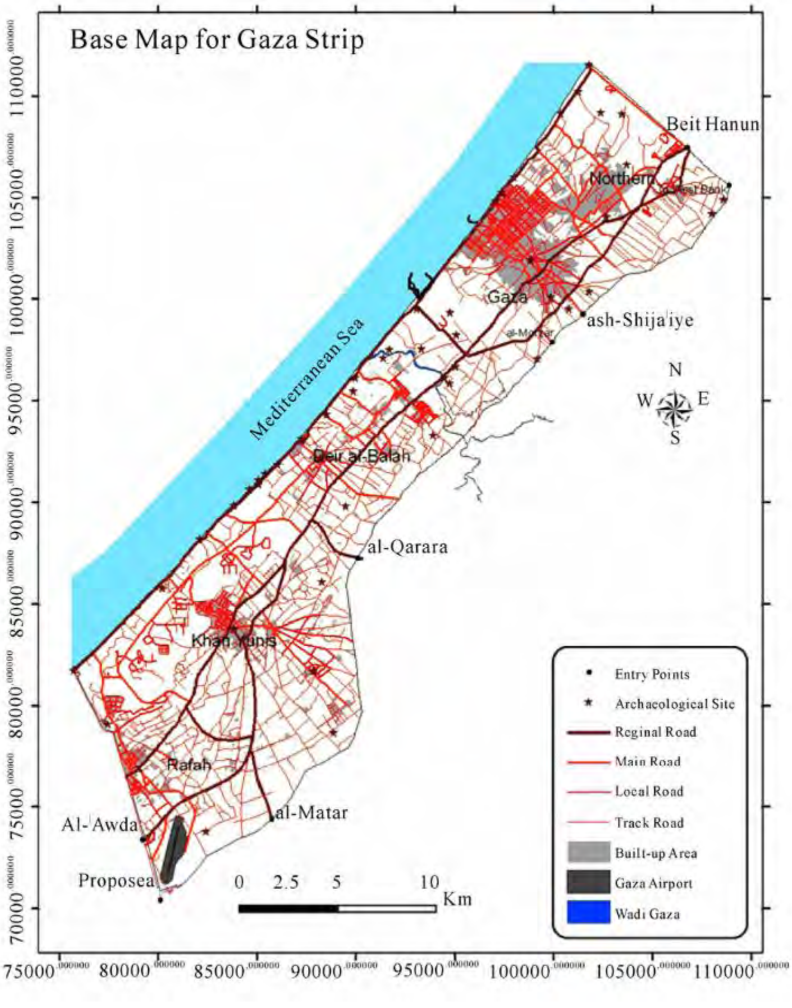


*Figure (1): Gaza base map (source: PWA, 2013)*

In 1948, the Gaza Strip had a population of less than 100,000 people. By 2007, approximately 1.4 million Palestinians lived in the Gaza Strip, of whom almost one million were registered with the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) as refugees (UNEP, 2009). The current population is estimated to be in excess of 1.8 million, distributed across five governorates. Gaza City, which is the biggest governorate, has 588,033 inhabitants (MOH, 2013). The majority of people (66.1%) are refugees and living inside and outside the eight recognized Palestine refugee camps, which have one of the highest population densities in the world (UNRWA, 2014). In 2035, the Gaza Strip is expected to reach 3.7 million inhabitants, which makes it one of the most rapid growing areas in the world (MOH, 2013). Age structure in the Gaza Strip is similar to that in many developing countries, where nearly half of the total population is under 14 years old (20% in UK). Children under 5 years old represent around 18% (MOH, 2014) who are usually more vulnerable to water related diseases.

Compared to other countries at a similar level of economic development, the Palestinian population's overall health status outcomes are relatively good partially due to the strong performance on most basic public health and Primary Health Care functions (MOH, 2014). Generally speaking, healthcare services were effective especially when comparing health outcomes in Gaza to those in the region. This is typically true regarding mortality indicators, infant mortality rate (less than 20 per 1000 live births), maternal mortality rate (less than 35 per 100,000 live births), immunization coverage (more than 95% for most vaccines ), causes of adults' deaths and so on (MOH, 2014). Physical access to services is generally acceptable in ordinary situation but it is usually challenged during emergency situations. Most basic services are satisfactory in terms of coverage and physical accessibility while the quality of care is questionable due to lack of appropriate standards and weak implementation of the already available ones. Also, access to advanced services remains a real challenge facing the health care system in Gaza.

The Gaza Strip is going through what is called "epidemiological transition" where, non-communicable diseases including heart diseases, cancer, hypertension, and cardiovascular diseases and diabetes mellitus, are gradually replacing the traditional enemies of infectious diseases as the leading causes of death. Recent health reports (MOH, 2014) indicate that in 2013, the leading causes of death are heart diseases (25.1%), cancer (13.0%), cerebrovascular diseases (8.8%), perinatal conditions (7.3%) and accidents (6.4%). However, communicable diseases such as diarrhea, hepatitis and meningitis constitute a major morbidity with high hospitalization costs. The Palestinians in Gaza are suffering from the double burden of poverty-related diseases and illnesses, such as malnutrition, anemia and sanitary related diseases which have been aggravated due to conditions associated with the current closure resulting in the deterioration of the sanitary conditions. This increases vulnerabilities and exposure of the population to health hazards.

PCBS report (2012) indicates that almost all households in the Gaza Strip (99.8%) were connected to the public electricity and water networks. However, only 30.1% of households were using public network for obtaining drinking water, the rest were using filtered water tanks or purchasing gallons (Save the Children and Map, 2012). The same source indicates that a kitchen, a bathroom, and a toilet were available in almost all (98-99%) surveyed households. Almost all households have had the basic household assets such as refrigerators (93.7%), TVs (98.7%), gas for cooking (95%), washing machines (96.2%) and basic furniture (Hamad, 2010; Pereznieto, et al 2014). Only 52% of houses in Gaza have had computers at the household and 12% owned a car (PCBS, 2012). Electricity outages have been prominent for many years in Gaza especially during the Israeli aggressions. Currently, at least, electricity if rationed for 8 hrs a day which could increase to 12 hrs if the situation improves. Before the most recent conflict in 2014, the hypothetical capacity for electricity supply was 242 MW while the actual supply available (generated and or provided) is much less. The demand in 2011 was 350 MW which is expected to rise to around 550 MW in 2017 (WHO, 2012).

Regarding housing density, it was 1.8 per room in 2010, in 53.8% of households, 1 to 2 persons were living per each room, in 32.9% of households, more than 2 persons were living in each room and in 13% of households more than three persons were living in each room (PCBS, 2010). Even before the most recent conflict in 2014, more than 71,000 housing units were needed in Gaza (United Nations -UN, 2012). In ordinary situations, around 60% of households suffer, or potentially may suffer, from food insecurity (MOH, 2014). Food insecurity prevails in Gaza despite the fact that food is often available at the local market, yet is priced out of reach for many poor households. Poor households spend approximately half of their income on food, leaving many households vulnerable to the negative impact of volatile food prices and income fluctuations. Similarly, 70% of households in Gaza reported receiving food aid mainly through UNRWA and international organizations. As of September 2013, the Ministry of Social Affairs (MOSA) provides regular assistance to around 57,000 families which has increased now to 67,000 families in September 2014; UNRWA supports 21,000 families, and other organizations financially support a large number of families. Around 40% of MOSA beneficiaries are female headed households.

The Gaza Strip contains 25 municipalities that provide the population with the water services (PWA, 2013). The main source of water in the Gaza Strip is the groundwater aquifer, and the Gaza people depend on it as the only source to provide them with water used for hygiene, agriculture, and to some extent for cooking, drinking, and industry. There are 213 groundwater municipal wells pumping water for domestic uses in the Gaza Strip, the operation of these wells are under the responsibility of the Coastal Municipalities Water Utility (CMWU), as well as the 25 municipalities which serve the population by pumping the water from these wells through the water networks for each municipality (PWA, 2013).

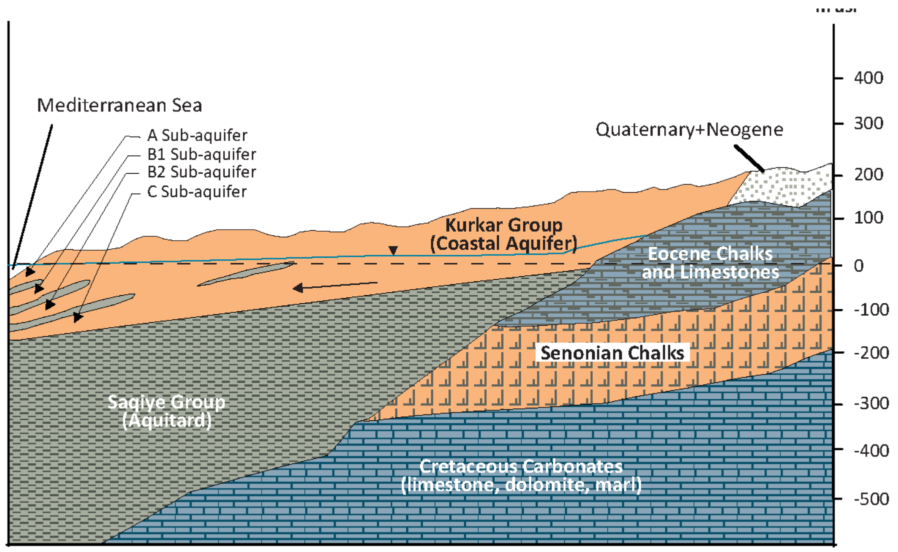


*Figure (2): Schematic Hydrogeological Cross-Section (PWA, 2012/ ECSAW, 2013)*

The complex political, demographic, urbanization, and socioeconomic context has in turn placed significant pressure on the environmental resources of the area, which led to a serious deterioration in water quality and quantity. Groundwater contamination of the main aquifer, shortage of water, and uncontrolled discharged of sewage at the subsurface are associated with over-extraction of the coastal aquifer, which in turn increases the salinity of the groundwater resources by way of seawater intrusion.

The UN report "Gaza in 2020, a Liveable Place?" issued in August, 2012 has highlighted that the Gaza aquifer will not be livable in just a few years. The report cites deteriorating infrastructure, schooling, health, and power as contributing to the worsening situation in Gaza (UN, 2012). The PWA further confirmed in 2013, that only 6.5% of the municipal wells that are pumping from the groundwater aquifer in the Gaza Governorates are matching with the WHO standards for drinking use. Furthermore, the situation is aggravated by damaged or destroyed infrastructure due to the ongoing conflict with Israel (CMWU, 2014).

Over more, the complex system of permits which the Palestinians must acquire from the Israeli authorities, and other authorities, to permit them to carry out water-related projects in the occupied Palestinian territories has delayed progress and rendered it more costly, and in many cases prevented the implementation of much needed water and sanitation projects (Amnesty International, 2009).

As a result of the growing population, the domestic water demand is projected to grow from 91 million $m^3$/year to 199 million $m^3$/year in 2035 (Norwegian Institute of Public Health-NIPH & Palestinian National Institute of Public Health-PNIPH, 2014). As highlighted by the reports, the situation in relation to water and sanitation for the Palestinians of Gaza is critical. With no perennial streams and low rainfall intensities, Gaza relies almost completely on the underlying coastal aquifer.

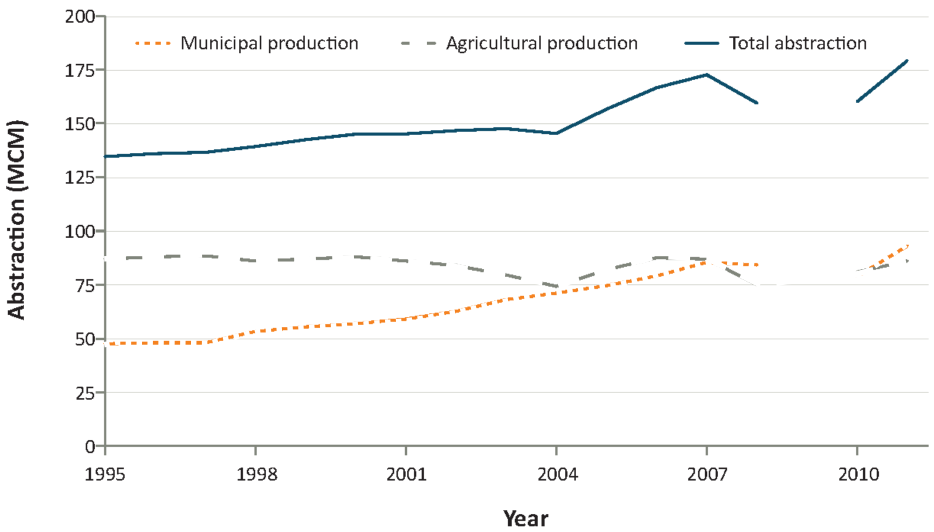


*Figure (3): Groundwater abstraction from the coastal aquifer basin in Gaza Strip (1995-2011) PWA, 2011*

## WATER SOURCE, ACCESS, AND QUALITY IN THE GAZA STRIP

The quality of water is affected by many different water sources including soil/water interaction in the unsaturated zone due to recharge and return flows, mobilization of deep brines, sea water intrusion or upcoming and disposal of domestic and industrial wastes into the aquifer (Ghabayen, McKee and Kemblowski, 2006).

In the regional struggle for this indispensable resource, the situation in the Gaza Strip stands out above all others.  Not only are the Gaza Strip water resources continually faced with the danger of severe deterioration, depletion, and draught, but also, the Israeli-imposed blockade of the Gaza Strip maintains illegal control over its surface drinking water basins and appropriates its subterranean reserves by pumping them into its settlements (Ramahi, 2013). The situation in the Gaza Strip is singular given its steadily increasing population and the lack of any kind of balance between the water available in its coastal subterranean reservoir and the needs of its population.

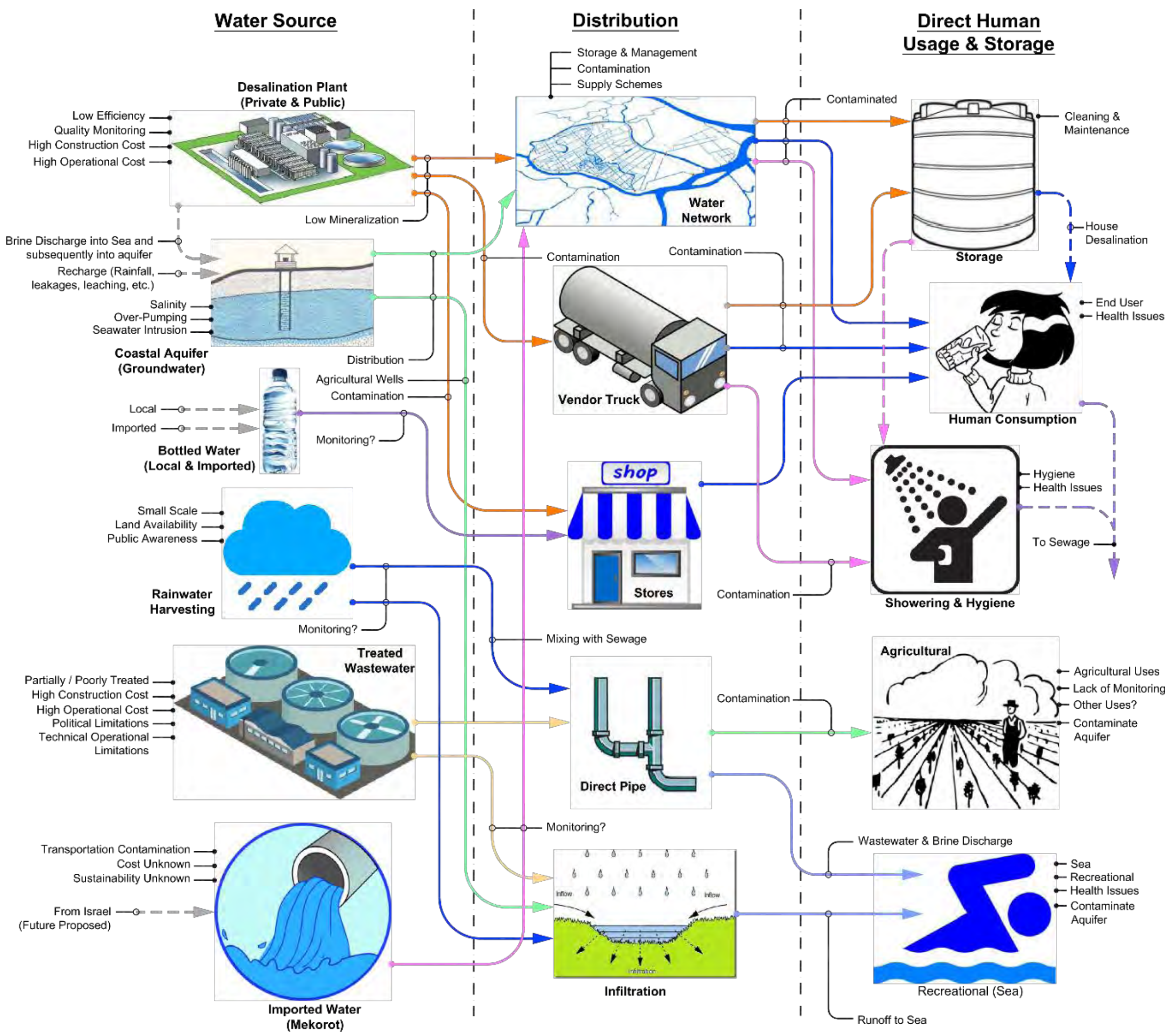


*Figure (4): Water Resources Schematic Diagram, UG 2014*

Available reports show that the Gaza Strip has four main sources of water: Coastal Aquifer (groundwater wells), desalinated water (Reverse Osmosis units "RO" and public desalination plants), bottled water (locally filtered, or imported from Egypt, Turkey, Israel, and the West Bank), and harvested rain water.

Figure 4 summarizes main sources of water people utilize in the Gaza Strip (Municipal aquifers, private-wells, desalinated water, bottled water, harvested rainwater, imported water through carrier lines fed from the Israeli side, and treated wastewater) and possible contaminations affecting human beings that are attributed to these sources with the risks associated with these resources. This schematic map is an outcomes of the Brainstorming and Consensus Building Meeting with Relevant Partners and national experts that was organized by the Consultant on 15th Dec., 2014.

This section provides a detailed description of the main sources of water in the Gaza Strip. It includes; primary means of delivery, availability, treatment, usage, and affordability.

## Coastal Aquifer

The coastal aquifer (groundwater wells) is the main water resource in the Gaza Strip, with the thickness of the water bearing strata ranging between several meters in the east and south-east to about 120-150m in the western regions and along the coast. Water from the aquifer is drawn from deep wells depending on the needs for domestic, agricultural, and industrial purposes. Of the approximately 2000 groundwater wells in the Gaza Strip, about 800 are out of service, many of which need maintenance, hindered by the Israeli blockade of materials, to resume pumping water again (Addameer Association for Human Rights, 2009).

Findings from the MAP and Save the Children 2012 study indicate that 73.5% of the total water samples that were tested by the MOH laboratories did not comply with the local accepted standards' specifications of safety of the drinking water. According to UN (2012) only 5-10% of the 150 water wells in the Gaza Strip that cover the domestic water needs of the population meet the international specification of safe drinking water, while 40% meet the acceptable specifications of safe drinking water according to the local standards.

The aquifer is recharged through different water sources, such as rainfall, water network leakage, wastewater collection system leakage, agricultural return flow, and recharge storm water ponds. The extraction from the coastal aquifer is estimated at 170 million $m^3$/year (2010) whereas the annual sustainable yield of the aquifer within the geographical boundary of Gaza is widely quoted as 55 million $m^3$/year (Daoud, et al. 2011).

For quality, it was found that 10% and 13% of the Gaza Strip area is under low and high vulnerability of groundwater contamination, respectively, while more than 77% of the area of the Gaza Strip can be designated as an area of moderate vulnerability of groundwater contamination (Almasri, 2008). In Khanyounis, the western area is especially vulnerable to contamination which ranges between high and very high due to the relatively shallow water table with moderate to high recharge potential, and permeable soils. In the eastern area of Khanyounis, and in the south-eastern part, vulnerability to contamination is moderate

(Baalousha, 2011), and low for the central and the eastern part due to the depth of water table. The highest risk of contamination of groundwater in the study area originates from the soil media (Al Hallaq and Abu Elaish, 2012). This implies that policy makers should established large seawater desalination plants in order to decrease pumping water in the Gaza Strip aquifer.

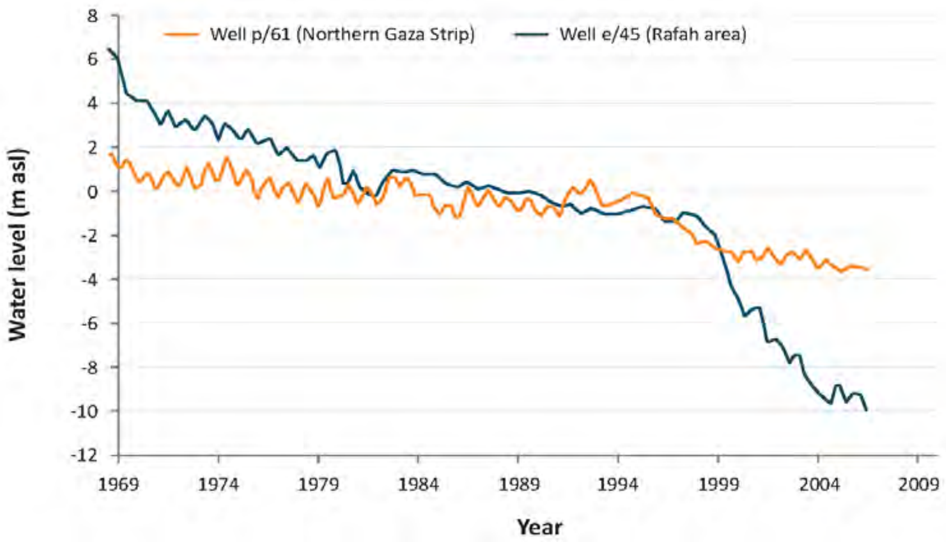


*Figure (5): Groundwater decline (1969-2007) PWA, 2011*

## Desalinated Water

Desalinated water has become an important source of drinking water in the Gaza Strip. Water desalination is a technical related process to solve the shortage in water resources with acceptable water quality. To address the increasing salinity in the water supply, the Palestinian Authorities (PA) has adopted desalination as a means of increasing the amount of potable water. This technology has been practiced in the Gaza Strip for the past 20 years, where four small scale brackish groundwater Reverse Osmosis (RO) desalination plants were constructed on water wells with a capacity of 45 $m^3$/hour each in the years 1991, 1997, and 1998 (Baalousha, 2006). The UN estimates that 80% of Gazans buy desalinated water, with some families paying as much as a third of their household income for it (Swinburne, 2013).

The prospects for seawater desalination capacity was determined to be 11 million $m^3$/year in 2012, increasing to 55 million $m^3$/year in 2017 and to 130 million $m^3$/year till 2035 (Ismail, 2003). In the Gaza Strip, as of January 2014, there were 18 neighborhood desalination plants providing safe drinking water for free to 95,000 people who come to fill their canisters at the plants (UNICEF, 2014). The United Nations International Children's Educational Fund (UNICEF) is operating 13 of these plants (Weibel and Elmughanni, 2009). Water desalination is restored by different water origins: there are seven public desalination facilities operated by the CMWU. Furthermore, there are at least 40 small scale private plants and more than 20,000 RO housing units that are often unregulated, from which most of the available desalinated drinking water is produced (NIPH and PNIPH 2014).

Typically, the water feeding into these units is chlorinated piped water that is stored in rooftop storage tanks. The desalinated water quality from these units varies. Generally, water from desalination plants is appropriate, both in terms of chemical and microbiological content (CMWU and PWA, 2009). On the other hand, due to a non-hygienic handling of the water in distribution, contamination has been detected in samples taken from distribution points and in samples taken from household storage tanks (CMWU and PWA, 2009). This implies that policy makers need to focus on monitoring programs for the private desalination plants and its delivery units (tankers and distribution points), encourage good water storage practices in households and schools, and develop evaluation schemes for the distributed water in order to pursue the compliance of these desalination plants to standards of water quality. Hence, close coordination between all parties involved in water issues is needed to confirm the implementation of this program in the Gaza Strip. Moreover, a strategy should be adopted by authorities to control the location of the small scale desalination plants' construction according to the groundwater quality to manage the local salinity problems.

## Bottled Water

Bottled water is considered another important water resource in the Gaza Strip. It might be domestically produced in the Gaza Strip (using the aquifer as a source) or imported from the West Bank, Egypt, Jordan, Turkey, or Israel.

Bottled water costs about $1 for three liters, meaning a monthly bill of hundreds of dollars for a family (Al-Banna, 2014). According to information provided by vendors of major stores in Gaza, 80% of the total amount of bottled water consumed in Gaza are imported, and percentages vary from 30% to 90% depending on the areas and economic status of the different areas throughout the Gaza Strip (NIPH and PNIPH, 2014). In addition, bottled water produced outside Gaza is tested and monitored before being permitted to be imported. The ongoing monitoring process to ensure the compliance and suitability of this water source for drinking is essential.

For quality, Al Tartory (2009) found that 12 desalination plants outlet water of 20 were contaminated with total coliform bacteria, and 6 desalination plants outlet water contaminated with fecal coliform bacteria. He also tested the water for Pseudomonas aeurginosa and fungi. Aish (2010) has recorded results which found that the level of bacterial contamination in the desalinated water was higher than that of the groundwater, which may be attributed to the bad quality of filters that may play a significant role in the formation of bacterial biofilms inside the filters. Another study, Aish (2013), found that the total coliform bacteria was detectable in 75% of locally bottled waters and in 45.4% of the imported brands (Aish, 2013). Thermotolerant coliform bacteria were respectively detected in 75% of indigenous and in 27% of imported bottled waters.

## Harvested Rainwater

Harvesting rainwater is another source of water which is not generally utilized by private households in Gaza (Massad, et al. 2011). Although, this could potentially be considered as a means of supplementing household water supplies by additional quantities. In the Gaza Strip, the manholes are opened in some cases in the winter season when runoff floods the streets, and storm water is connected to the main sewer networks leading to increase in the peak flow and hydraulic load on the treatment plants which are already suffering from hydraulic overflow that much exceeds their design capacity. This results in direct discharge of mixed raw sewage and storm water to the sea and groundwater, causing environmental and health hazards.

Rainwater is very low in mineral content, which may have a long-term health effect. There is also a risk of water being contaminated while being handled and stored in the households. Storm water runoff is also low in concentrations of chloride and nitrate (Hamdan, Troeger and Nassar, 2011). Gaza's could better utilize storm water meanwhile maintaining an adequate measures to ensure safety.

## Wastewater Reuse

Wastewater reuse is one of the sources used in the Gaza Strip to compensate the scarcity of water resources. Significant amounts of domestic wastewater are discharged to the sea after being partially treated. The sewer network coverage in the governorates of the Gaza Strip fluctuated from 40% to 90% (CMWU, 2010) with a weighted average of 71%. The potential quantities for reuse are about 109,000 $m^3$/day i.e. 40 MCM every year are available as new non-conventional water resources, and these quantities will increase with the expansion of area with the required sewer infrastructure.

However, the wastewater is partially treated, for example, the influent biochemical oxygen demand value in the Gaza treatment plant in year 2008 was 485 mg/L and was treated to reach 123 mg/L with a removal efficiency of 73% (CMWU, 2010). Many studies have demonstrated that a combined approach of recharge and irrigation of treated wastewater is the most effective option for reducing the water resource deficit in Gaza, and aquifer recharge has been identified as a crucial component of effluent reuse strategies (Kreditanstalt fur Wiederaufbau- KFW, 2005). However, treatment of wastewater to the level suitable for reuse needs capital investments, active institutional setup, and skilled water operators. According to KFW, 40 MCM per year based on 110,000 $m^3$ per day could be infiltrated in the zone of Gaza city and middle area of the Gaza Strip (KFW, 2005).

Wastewater reuse facilities consisting of primary treatment, biological treatment, and clarification processes have limitations in removing the biodegradable organic matter, fine colloids, and some dissolved inorganic matter (Huang, et al. 2006). Although soil can absorb most of the soluble pollutants in the reclaimed wastewater, it should be further treated before irrigating crops to avoid risks to the public and environment (Choukr-Allah 2011). To meet the standards of wastewater reuse and recharge, more advanced treatment such as ozonation before recharge to the soil aquifer treatment processes were used (Huang, et al. 2006).

A case study of application of reclaimed wastewater has been conducted in the Gaza Strip, where 10,000 $m^3$ were applied daily to three infiltration basins, and the water quality of neighboring groundwater wells were monitored. There was an impact on groundwater aquifer in both groundwater levels and groundwater quality. At the moment, aquifer recharge by treated wastewater in Gaza City area is not acceptable due to high nitrogen content in the effluent, 25 mg/L (KFW, 2005), which is higher than total nitrogen in the native groundwater in the area. Irrigation with treated wastewater in Gaza is still subject to major concerns because of potential hygienic and environmental problems (Yassin et al. 2008). Higher amounts of effluent reuse must be achieved in Gaza in order to reduce the current levels of groundwater withdrawal by the agricultural sector and mitigate the negative environmentally sound impacts after taking the needed safety measures.

The recommended guidelines by the Palestinian Standards Institute for treated wastewater characteristics according to different applications are listed in a table in Annex II.

## Water Resources Description

A detailed description of the water resources is shown in the table below.

*Table (2): Summary of main Water Sources in the Gaza Strip - UNICEF, 2010, PWA 2012/2014, IPNA 2014, and UG 2014*

| Water Resource | Primary Means of Delivery | Availability | Usage | Challenges |
|---|---|---|---|---|
| Coastal Aquifer (Groundwater) | Municipal pipelines and wells | Estimated groundwater extraction for year 2014 from the aquifer is 200 MCM annually; 98% of Gaza's residents are connected to the water network but supply is intermittent, with 39% of households reporting running water only 2-3 days a week; some areas not connected to network | 85%+ use network water for domestic purposes | Salinity, storage, supply intermittent scheme, quality (over abstraction & seawater intrusion), and limited quantities. |
| Imported Water (Mekorot) | Carrier lines mainly to Middle & East Khanyounis Areas ( potential to Gaza City ) | About 4.2 MCM/year ( potential to be increased to 9.2 MCM/year) | Directly pumped to municipal network | Political restrictions, water affordability, sustainability. |
| Desalination Plants (Public & Private) | Trucks; jerry cans | available for drinking water purpose and in educational/health care facilities | 73 – to 87% use desalinated water for drinking | Cost (capital & operation); Low mineralization, low efficacy, possible contamination with microorganisms if not handled or treated properly. |
| Bottled Water | Private sale; locally produced or imported from outside of Gaza | Available | No data | Cost, quality control, storage |
| Rainwater | Privately collected in rooftop tanks or external catchment areas | Limited due to poor infrastructure/regulations | Limited for agricultural usage mainly and some pilot projects | Small scale infrastructure, limited land for infiltration basin, monitoring, mixing with sewage |
| Treated Wastewater | Mainly for groundwater improvement using infiltration | Still under construction for major WWTP projects | Potential use for agricultural/ groundwater infiltration | Partially treatment, control & monitoring, operational cost |

## PWA & WHO GUIDELINES

The WHO guidelines for drinking-water quality for chloride levels specify a maximum limit of 250 Cl mg/l compared to the PWA Guidelines, which specify a maximum recommended limit of 600 Cl mg/l. Similarly, the WHO guidelines for nitrate levels recommend a maximum of 50 mg/l, compared to the PWA Guidelines, which recommend a maximum of 70 mg/l. The quality standards set by the WHO and the PWA for relevant drinking water quality parameters are presented. Values for some of the same parameters from the European Union water directive are also listed. The WHO recommends maintaining a chlorine residual of 0.2 to 0.5 mg/L in the distribution network to provide protection against pathogen intrusion in the event of breaches of physical and/or hydraulic pipe integrity (WHO 2011).

*Table (3): WHO & PWA Drinking Water Acceptability Standards*

| Indicator | Unit | PWA (2006) Max. Value | WHO Min/Max health based guideline value |
|---|---|---|---|
| **Biological** | | | |
| **Total Coliform*** | Colony/100ml | Absent | Absent ** |
| **Fecal Coliform** | Colony/100ml | Absent | Absent ** |
| **Fecal Streptococcus** | Colony/100ml | Absent | Absent ** |
| **Physical** | | | |
| **Conductivity** | mS/cm at 20º C | 400 | 400 |
| **Turbidity** | NTU | 4 | 5 NTU** |
| **Oder** | - | Absent | Absent |
| **Color** | True color units TCU | 15 | 15 |
| **Chemical** | | | |
| **pH** | pH | 6.5 - 9.5 | 6.5 - 9.5** |
| **TDS** | mg/l | 1500 | 1000 - 1200**<br>Min. 100, optimum level 250 – 500*** |
| **Nitrate** | mg/l as NO3- | 70 | 50** |
| **Ammonium** | mg/l as NH4- | 0.5 | 1.5** |
| **Chloride** | mg/l as Cl- | 600 | 250** |
| **Sulphate** | mg/l as SO4- | 400 | 250** |
| **Calcium** | mg/l as Ca+2 | 100-200 | Min. 30*** |
| **Magnesium** | mg/l as Mg+2 | 150 | min. 10, optimum level 20-30*** |
| **Sodium** | mg/l as Na+ | 200 | 200** |
| **Potassium** | mg/l as K+ | 12 | 12 |
| **Fluoride** | mg/l as F+ | 1.5 | 1.5** |
| **Alkalinity** | mg/l as CaCO3 | 400 | 200** |
| **Hardness** | mg/l as CaCO3 | 600 | 200** |

** PWA - Requires 95% of samples to be completely free from contamination, while the remaining 5% must contain less than 5 colonies/100ml.*
*** WHO (2004) Guidelines for Drinking-water Quality 3rd Edition. WHO, Geneva. WHO (2008) Guidelines for Drinking water Quality. 2nd Addendum to Third Edition. WHO, Geneva*
**** WHO (2005a) Nutrients in Drinking Water, November, Geneva.*

# MAIN SOURCES OF WATER POLLUTION IN THE GAZA STRIP

## Sewage

Sewage is the biggest reason for groundwater contamination in the Gaza Strip. It is estimated that around 38 MCM of sewage are produced annually across Gaza's residential areas (Ramahi, 2013). More than 400 $m^3$/day of sewage aerobic sludge and 5000 $m^3$/year of anaerobic sludge are randomly disposed in the Gaza Strip, creating several environmental and health hazards (Nassar, Smith and Afifi, 2009). WHO showed that 30 of the examined sites of Gaza sea were contaminated with animal and human feces and an additional 25% are contaminated with animal faeces only (WHO, 2008). The extent of seawater pollution varies according to the quantity and quality of the pollutants. However, the problem of seawater pollution is acknowledged worldwide (Bartram and Ress, 2000). In the Gaza Strip, UN estimate that per day 50,000 to 80,000 cubic meters of untreated and partially treated wastewater are discharged into the Mediterranean Sea since January 2008, threatening the environment in the region (UN, 2009).

Recreational water, also generally contains a mixture of pathogenic and nonpathogenic microbes derived from sewage effluent; industrial process; farming activities and the wild life in addition to any truly indigenous microorganisms. As such, these levels of sewage contains many pathogens such as bacteria, viruses, and harmful parasites. These objects may find suitable environment and pose a significant threat to the safety and sustainability of the subterranean reservoir given the situation of persistent and extreme erosion which this complex system is exposed to. This mixture can present a hazard to the bathers where an infective dose of pathogen colonizes a suitable growth site in the body and leads to a disease (WHO, 1998).

The World Bank reported in 2009 that the three existing wastewater treatment plants in Gaza work discontinuously (World Bank, 2009). Damaged sewage infrastructure can often not be repaired due to the ongoing Israeli blockade. It leads to delays in repairs and lack of electricity and fuel which would be necessary to operate the wastewater treatment facilities. In addition, International Committee Red Cross confirms that destroyed sewage systems not only sent wastewater flooding into the clean-water networks but also into the environment, worsening the risks to public health. This aggravated an already serious situation resulting from the fact that the Gaza Strip had previously been discharging nearly 100,000 cubic meters of wastewater into the sea every day (International Committee Red Cross, 2014). This implies that policy makers need to reinforce regulations of sewage disposal. Also, establishing a proper sewage system in the Gaza Strip represents a priority. Minimizing the interruption of the water supply to prevent sewage leaks into the water pipes through the negative pressure is essential.

## Solid Waste

This is the non-liquid remains that result from domestic human activities as well as agricultural, industrial, commercial, and craft activities. The Gaza Strip is facing the problem of solid waste for several reasons: increasing number of population, the lack of materials and resources needed for appropriate solid waste management and years of Israeli occupation of the Palestinian Territory.

According to the report "Development of a National Master Plan for Hazardous Waste Management for the Palestinian National Authority" (EL-Hamouz, 2010), Gaza produces approximately 803 ton/year of hazardous waste and 4 ton/day of infectious health care waste, of which 38% is recovered from household waste fees (10 NIS per household per month). The disposal of this enormous amount of waste requires significant and expensive capabilities to overcome with and produces conditions of significant environmental danger and risk as well as posing a real threat to groundwater reserves. Local authorities do not possess the suitable or adequate capabilities to fully overcome this problem, and despite great effort, it is true that very often there are delays in the transport of waste on a regular daily basis. This results in a proliferation and spread of insects and rodent infestations as well as the emission of toxic gasses detrimental to public health. Additionally, the fermentation of large amounts of waste and its transfer underground is such that contaminated and toxic substances reach the groundwater reserves (Ramahi, 2013).

Findings from the Abu Al kumboz's (2002) study illustrates serious knowledge deficit of the various kinds of industrial and medical hazardous waste and inadequacy of managerial related issues such as planning, presence of legislation, coordination and so on. This implies that the concerned authorities in the Gaza Strip should develop urgent integrated national solid waste management plan. This plan needs to promote waste minimization and material recycling. Also, authorities should promote the appropriate solid waste management cycle including collection services, segregation, handling and final disposal. In addition, developing new sanitary landfill sites should be established.

## Chemical Fertilizers & Pesticides

Pesticides by their nature are toxic and are designed to kill unwanted organisms. Most act by interfering with biochemical and physiological processes which are common to a wide range of living systems. The widespread use of pesticides inevitably leads to a mixture of pesticides being present in water sources.

Pesticides are considered priority pollutants in Gaza and, with the expanding use of greenhouses; Palestinian agriculture is becoming increasingly dependent on chemical pesticides and fertilizers. Large quantities of pesticides are used in Gaza Strip and the quantities are increased annually, theses large numbers of pesticides are used for controlling different types of pests (Nahhal and Radwan, 2013).

Pesticides affect humans, either immediately or in the long run. As an example, methyl bromide, which is used extensively in Gaza, causes fetal deformations, eye infections and dermatitis. Also, heavy misuse of pesticides in the environment correlated with the growing incidence of cancer (Safi, 2002). Organ chlorine pesticides used in Gaza cause breast cancer (Aronson et al., 2000). Finding from Safi, Abu Mourad and Yassin (2005) study confirmed that illness among pesticide workers who are exposed to organo-phosphorus can occur with trivial reductions in cholinesterase. Designing and implementing policies to regulate the use of pesticides is essential.

## INTERNATIONAL AND LOCAL GUIDELINES FOR DRINKING WATER QUALITY

Based on the WHO guidelines for drinking water quality, water supply for the public should take basic factors into consideration different parameters. Those parameters are mainly summarized with five words: Quality, Quantity, Accessibility, Affordability, and Continuity. Table (3) summarizes these guidelines. The Guidance levels for radionuclides in drinking-water in WHO Water Quality Standards is summarized in Annex III.

The following paragraphs summarize to mean parameters used in both physical and chemical assessment for water quality, mainly used as potable water.

### Physical Assessment

Odor and taste are the primary criteria consumers use to judge the quality and acceptability of drinking water. Taste and odor in drinking water can be naturally occurring or the result of chemical contamination and may also develop during storage and distribution due to microbial activity (WHO, 2006).

Temperature is primarily an aesthetic criterion for drinking water. It is an important parameter for many physical and chemical water treatment applications. In some literature, temperature increases in summer occurrences of total coliform-positive samples have been reported. Coliform positive samples occur more frequently when the distribution system water temperature is above 15º Celsius. PWA acceptable temperature range is 8º -25º Celsius.

Turbidity is usually caused by the presence of fine suspended matters such as clay, silt, colloidal particles, and other microscopic organisms. Turbidity can have a significant effect on the microbiological quality of drinking water. High turbidity can both interfere with the detection of bacteria and viruses. Turbidity should not exceed 5 Nephelometric Turbidity as per both the WHO and PWA standards.

### Chemical Assessment

Power of Hydrogen (pH) is a measure of the hydrogen ion concentration of water. It is recommended to monitor the pH in order to establish baseline water quality in the distribution system. The pH of water in the distribution system is an important factor in nitrification activity. A reduction in pH can be an indication of problematic biofilm growth. For example, a decrease in pH can result from growth of sulfur-reducing bacteria such as Thiobacillus. These bacteria generate hydrogen ions which lowers the pH. Both the WHO and PWA standards range of pH is of 6.5 to 8.5.

Chlorides (Cl) are compounds of chlorine with other elements or radical present in nearly all natural waters. There is a wide range of concentration but the most abundant concentration is with sodium (Na) (NaCl, common salt). The chloride concentration is far over the limits recommended by the WHO and PWA Guidelines. The WHO guidelines for drinking-water quality for chloride levels specify a maximum limit of 250 Cl mg/L compared to the PWA guidelines, which specify a maximum recommended limit of 600 Cl mg/L. The average Cl levels observed in wells vary from 50 mg/L to 11476 mg/L, which is far over the recommended maximum in both sets of guidelines.

Nitrate ($NO_3$) is an inorganic chemical composed of nitrogen and oxygen. Nitrate contamination of drinking water usually results from runoff of agricultural fertilizers or from human or animal wastes. The nitrate levels is far over the limits recommended by the WHO and PWA Guidelines, the WHO guidelines for nitrate levels recommend a maximum of 50 mg/L, compared to the PWA Guidelines, which recommend a maximum of 70 mg/L. The average nitrate levels observed in Gaza wells ranges from 8 mg/L to 528 mg/L, also over the recommended limits from both guidelines.

Increased fluoride pollution above the normal levels of 0.7 – 1.2 ppm causes osteomalacia as well as staining and erosion of teeth, particularly in children. Centre for Health Research, part of Gaza's Department of Health in 2013, found that the level of fluoride in Gaza's drinking water range between 0.8 – 3.8 ppm. It also found that there was an increase in the incidence of fluoride poisoning in areas where increased concentrations of fluoride have been recorded. High doses of fluoride are highly toxic and may result in a diseases (Rimawi, 2013).

For Sulfate ($SO_4^{2-}$), most of the wells in Gaza have concentrations exceeding the permissible the WHO standard. The highest levels of $SO_4^{2-}$ were in Khan Younis and the southeast, where the average concentration is 380 mg/L. In 2010, Abbas et. al., examine 58 wells in the Gaza Strip which shows the highest average values of SO4 were in Rafah (307 mg/L), while the lowest average values were in North area (56 mg/L). So, the most of the wells in north area had SO4 levels less than the WHO standard (250 mg/L). The 28% of the wells monitored showed sulfates concentration above the WHO standard. The percentage of wells which exceed the WHO standards for sulfates doubled compared to previous study carried out by Shomar (2002).

For Total Dissolved Solids (TDS), groundwater in most of the Gaza Strip exceeds the WHO and PWA TDS standard, which is 1000 mg/L. The TDS and electrical conductivity maps show similar patterns as both parameters indicate the concentration of dissolved solids in water. The high TDS value in the eastern parts of Khan Younis (3000-4000 mg/L) makes water in the area undrinkable. More than 50% of the sampled groundwater showed TDS of more than 2000 mg/L. (Shomar et.al. 2010). The lowest average values of TDS were measured in the North area (1560 mg/L), while the highest average value of TDS were estimated in Gaza area, 4538 mg/L, (Abbas et., al, 2010).

Most of the cations Calcium ($Ca^{2+}$), Magnesium sulfate ($Mg^{2+}$), $Na^+$ and $K^+$ ,known as Light Metals, show concentrations higher than the WHO standards of 50, 30, 200 and 10 mg/L, respectively. Dissolved calcium and magnesium in water are the two most common minerals that make water "hard". Based on the water hardness classification of 0 to 60 mg $CaCO_3$/L as soft, 61 to 120 mg $CaCO_3$/L as moderately hard, 121 to 180 mg $CaCO_3$/L as hard, and more than 180 mg $CaCO_3$/L as very hard, most groundwater in Gaza is hard to very hard. As water hardness is determined primarily by $Ca^{2+}$ and $Mg^{2+}$, not surprisingly, the areas with highest levels of $Ca^{2+}$ and $Mg^{2+}$ also have the hardest water. The average concentration of $Ca^{2+}$ was 93 mg/L while the average concentration of $Mg^{2+}$ was 48 mg/L. Areas between Gaza and the northern region and middle region wells showed the highest levels of both $Ca^{2+}$ and $Mg^{2+}$ and the results were 262 and 128 mg/L, respectively. The lowest $Na^+$ levels were found in the north, and the highest levels were in the areas of Khan Younis and Rafah. Most wells had average value of $K^+$ that was less than 5 mg/L; however, few wells showed levels of $K^+$ more than 15 mg/L (Shomar et.al. 2013).

Maximum value of Na was measured in Gaza and it was 3625 mg/L; the minimum value of this one was estimated in North area and it was 44 mg/L. Most of wells analyzed for K showed the average value more than 5 mg/l. The highest average value of K was measured in Gaza (14 mg/L), followed by the aver-age value of K in Rafah. The minimum value of K was estimated in Middle area and it was 0.4 mg/L. The Rafah wells showed the lowest average values of calcium (126 mg/L), while the region of Gaza well had the highest average value of Ca (205 mg/L). The North area wells showed the lowest average values of Mg (109 mg/L), while the region of Gaza well had the highest average value of Mg (225 mg/L) (Abbas et. al., 2013).

The concentrations of Iron (Fe), Chromium (Cr) and Zinc (Zn), and other Heavy Metals, were detected in all wells of the Gaza Strip at concentrations lower than the WHO standards of 300, 50, and 3000 Micrograms per Liter (μg/L), respectively. The average concentrations of Fe, Cr and Zn in the groundwater of Gaza were 30, 75 and 15 μg/L, respectively (PWA, 2014). Screening of heavy metals in 157 wells in the five Gaza governorates showed values below the WHO standards except for Fe, Cr and Strontium (Sr) (CMWU, 2012). In 2013, research present that 100% of the wells sampled have a higher concentration of Aluminum to the WHO standard of 200 μg/L. The lowest average values of all were measured in Middle area and in Khan Younis (both with 351 μg/L), while the highest average values were estimated in North area (439 μg/L) this one was estimated in the same area and it was 2.7 μg/L. As mention all sampled wells showed values below the WHO standards except for Fe, Cr and Sr. However, it is important to have more specific information about the concentrations, particularly for Sr, as infants and young children who ingest too much Sr can develop Sr rickets, a deformity of the long bones in the legs. This implies that policy makers should establish regular test programs for heavy metals, including Sr, as high concentrations could be of health concern. A screening for heavy metals should be performed within a time interval to monitor the situation. An interval of five years should be sufficient as these parameters are regarded as relatively stable. Since some heavy metals can leak out from the distribution system materials, including taps, samples from the taps at the household level also should be included in a screening for heavy metals.

## Biological Assessment

Safe drinking-water, as defined by the guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Those at greatest risk of waterborne disease are infants and young children, people who are debilitated or living under unsanitary conditions and the elderly. Safe drinking-water is suitable for all usual domestic purposes, including personal hygiene (WHO, 2006). Pathogenic organisms of concern include bacteria, viruses and protozoa; the diseases they cause vary in severity from mild gastroenteritis to severe and sometimes fatal diarrhea, dysentery, hepatitis, cholera or typhoid fever (Tartoray, 2009).

Waterborne gastrointestinal infections remain one of the major causes of morbidity and mortality worldwide (World Health Organization, 2002b; World Health Organization, 2003a).

The most important microbes causing infections or epidemics through drinking water include the bacteria Campylobacter spp., Escherichia coli, Salmonella spp., Shigella spp., Vibrio cholerae and Yersinia enterocolitica, viruses such as: adeno-, entero-, hepatitis A- and E-, noro-, sapo- and rotaviruses and the protozoa: Cryptosporidium parvum, ,Cyclospora cayetanensis, Entamoeba histolytica, Giardia duodenalis and Toxoplasma gondii and the helminthes nematode Dracunculus medinensis (World Health Organization, 2004).

The gastrointestinal system are found in water, and some of these organisms may, under certain circumstances, cause disease in humans. Such organisms include the protozoan Naegleria fowleri, a number of bacteria, including Pseudomonas, Klebsiella and Legionella spp, and some species of environmental Mycobacteria (ADWG, 2004). Infection is the main, but not the only, problem associated with microorganisms in drinking water. For instance, certain algae and bacteria can produce toxins that affect humans; the toxins may remain in the water even when the organisms responsible have been removed. Other 'nuisance organisms' can cause problems of taste, odor or color, or promote deposition and corrosion.

There are a wide variety of micro-organisms (pathogenic and not pathogenic) that may be found in water. Although, some of the non-pathogenic micro-organisms may cause the water to taste and smell strange to the consumer, and hence, cause them to avoid it, the principal concern for biological contamination is the potential contamination by pathogens, which may cause infectious diseases, depending on the infectious dose and host susceptibility. These pathogens include viruses, bacteria, protozoa, and helminth eggs or larvae. (WHO & UNICEF, 2012). Generally, drinking water that is contaminated with human or animal faeces form the greatest microbial risks. Table (4) lists different pathogens with evident public health effects. (WHO & UNICEF, 2012)

*Table (4): Examples of pathogens transmitted through drinking-water (WHO & UNICEF, 2012)*

| Pathogen | Health significance | Persistence in water supplies | Resistance to chlorine | Relative infectivity | Important animal reservoir |
|---|---|---|---|---|---|
| **Bacteria** | | | | | |
| Campylobacter jejuni | High | Moderate | Low | Moderate | Yes |
| Pathogenic E. coli | High | Moderate | Low | Low | Yes |
| Enterohaemorrhagic E. coli | High | Moderate | Low | High | Yes |
| Salmonella typhi | High | Moderate | Low | Low | No |
| Other salmonellae | High | May multiply | Low | Low | Yes |
| Shigella species | High | Short | Low | High | No |
| Vibrio cholerae | High | Short to long | Low | Low | No |
| **Viruses** | | | | | |
| Adenoviruses | Moderate | Long | Moderate | High | No |
| Enteroviruses | High | Long | Moderate | High | No |
| Hepatitis A virus | High | Long | Moderate | High | No |
| Hepatitis E virus | High | Long | Moderate | High | Potentially |
| Noroviruses | High | Long | Moderate | High | Potentially |
| Rotaviruses | High | Long | Moderate | High | No |

| | | | | | |
|---|---|---|---|---|---|
| **Protozoa** | | | | | |
| Entamoeba histolytica | High | Moderate | High | High | No |
| Giardia intestinalis | High | Moderate | High | High | Yes |
| Cryptosporidium hominis/parvum | High | Long | High | High | Yes |
| **Helminths** | | | | | |
| Dracunculus medinensis | High | Moderate | Moderate | High | No |
| Schistosoma species | High | Short | Moderate | High | Yes |

In the Gaza Strip, due to the deteriorating political situation and infrastructure, as well as, the overloaded wastewater treatment plants and lack of electricity to operate them, leakages from wastewater sewage to the coastal aquifer resulted in the presence of faecal coliforms, detergents and elevated nitrate concentrations (Shomar, 2009).

Sewage is one of the biggest causes of groundwater contamination in the Gaza Strip. Although a survey in 2011 showed that more than 75% of households are connected to a wastewater network, there remains few communities that rely mainly on cesspools for their sanitary needs. Water samples collected from groundwater wells surrounding wastewater treatment ponds and sewage leakage areas showed high levels of total and faecal coliform counts (NIPH & PNIPH, 2014). Moreover, the level of contamination in the water supply networks was found to be higher than that in wells, occurring mainly in winter and summer seasons. (Yassin, 2006)

Total and faecal coliform counts have also been found in imported and domestic bottled water in the Gaza Strip. Water tests conducted in 2013 in Gaza found that about 47% of locally bottled water and 13% imported bottled water were contaminated with either pseudomonas, total coliforms or faecal coliforms (NIPH & PNIPH, 2014). Faecal coliform contamination may cause giardiasis, diarrhoeal diseases, and hepatitis A (Yassin, 2006).

*Table (5) Microbiological quality of drinking water samples in Gaza Strip. (Al-Khatib, 2009)*

| **Test** | **Water from rain-fed cisterns** | | **Groundwater (network)** | | **Desalinated water** | |
|---|---|---|---|---|---|---|
| | Number of samples | Percentage of non-compliant samples (%) | Number of samples | Percentage of non-compliant samples (%) | Number of samples | Percentage of non-compliant samples (%) |
| Total Coliform | 1056 | 8.6 | 2802 | 15.5 | 525 | 15.2 |
| Fecal Coliform | 1056 | 3.9 | 2802 | 7.1 | 515 | 7 |
| Fecal streptococcus | 150 | 0.7 | 378 | 4.8 | 197 | 1 |
| Pseudomonas[a] | NA[b] | NA | 113 | 21.2 | 184 | 6.5 |
| Cholera | NA | NA | 51 | 0 | NA | NA |

[a] *Pseudomonas test is carried out for drinking water samples from hospitals and swimming pools only.*
[b] *NA: No tested samples.*

## IMPACT OF WATER ON HUMAN HEALTH

The quality of water and its impact in the Gaza Strip cross cuts two entities; the PWA which is concerned with the water quality from the water resource itself, and MOH which is responsible for quality of water after being supplied to the consumers. There is a difference between the type, number, intensity, and results of the tests conducted by the two entities as the quality of supplied water for different purposes could be hindered during the transmission from the water source to the consumer due to the presence of pollutants in addition to the deteriorating water networks.

Safe water, adequate sanitation together with good hygiene are fundamental to good health. Improvements in one or more of these three components of good health can greatly reduce the rates of morbidity and the severity of various diseases and improve the quality of life of people, especially children, in developing countries (Merchant, et al. 2003). Lack of proper sanitation causes diseases, as was first noted scientifically in 1842 in Chadwick's seminal "Report on an inquiry into the sanitary condition of the laboring population of Great Britain" (Chadwick, 1842). Ninety-four percent of this disease burden is attributable to the environment, including risks associated with unsafe water, lack of sanitation and poor hygiene. The lack of clean water and improper sanitation has caused many diseases. Therefore, sanitation is very important for maintaining good health (George, 2008). Microbial microorganisms and chemical contaminants which get access to drinking-water and distribution systems could have an effect on water quality and then have a negative impact on human health.

*Table (6): Microbial and chemical hazards that can be found in finished drinking-water, pipe biofilms and distribution systems (WHO, 2011).*

| Microbial Hazards | | | |
|---|---|---|---|
| **Bacteria** | **Viruses** | **Parasites** | **Fungi and years** |
| Campylobacter | Noroviruses | Cryptosporidium | Aspergillus flavus |
| Escherichia coli | Rotaviruses | Entamoeba histolytica | Stachybotrys chartarum |
| Vibrio cholera | Enteroviruses | Giardia intestinalis | Pseudallescheria boydi |
| Salmonella typhi | Adenoviruses | Cyclospora cayetanensis | Mucor |
| Shigella | Hepatitis A | Acanthamoeba | Sporothrix |
| Legionella spp. | Hepatitis E | Naegleria fowleri | Cryptococcus |
| Non-tuberculous | Sappoviruses | | |
| **Chemical Hazards** | | | |
| Aluminium, antimony, arsenic, barium, benzo(a)pyrene, cadmium, chromium, copper, cyanide, disinfection byproducts (including trihalomethanes, haloacetic acids and N-nitrosodimethylamine), fluoride, iron, lead, mercury, nickel, pesticides, petroleum hydrocarbons, selenium, silver, styrene, tin, uranium, vinyl chloride | | | |

In the Gaza Strip, bacteria, viruses, and protozoa microorganisms which spread through contaminated drinking water can cause many diseases, for example (diarrheas, dysenteries, salmoellosis, hepatitis, giardia, and amoeba histolytic). Microorganism and diseases spread by the fecal oral route (water borne diseases) can be caused by bacteria (salmoellosis, typhoid fever and cholera), viruses (viral gastroenteritis and hepatitis- A), and protozoa (amoebic dysentery and cryptosporidiosis) (Melad, 2002). In addition, PWA (2014) confirms that waterborne diseases resulting from trace contaminants in the water are on the rise, including acute diarrhea, parasite infections, liver and kidney diseases, and methemoglobinemia.

## CHEMICAL CONTAMINANTS

Chemical water quality is generally of lower importance as the impact on health tend to be chronic long-term effects and time is available to take remedial action. As aforementioned, various sources are suspected of causing water pollution in the Gaza Strip. These primarily include wastewater, overuse of fertilizers and agricultural pesticides, and solid waste that might produce toxic substance (Almasri, 2008).

### Chloride

Levels of chloride concentration vastly exceed reasonable limits; internationally accepted safe levels are 250 mg/litre. The major parts of the aquifer have a Cl concentration ranging between 600-2000 mg/l, while along the coastal line Cl concentration exceeds 2000 mg/l and can reach more than 10,000 mg/l at some spots due to effect of the seawater intrusion. PWA (2014) status report stated that 24.6% of them have chloride concentration less than 250 while the remaining (75.4%) exceeds the WHO chloride level. A study conducted by the Palestinian Water Authority found that according to 'Anjut' standards, Gaza's water is alkaline as a result of its high levels of chloride. Moreover, high concentrations of chloride can lead to water reacting with the metal pipes it is carried in and corroding them and causing serious damage to the industrial sector (Rimahi 2013, PWA 2014).

In a recent PWA evaluation of water quality and based on the result analyses of chloride concentration of the different wells in Gaza Strip a three chloride contour maps have been prepared showing the change of the chloride concentration for three years intervals (2008, 2010 and 2012) for the purpose of showing the degradation trend (Figure 6). It is clear that area of fresh water is demolished and /or reduced significantly with time as a result of intensive pumping as well as the deficit in the water balance. Where, the magnitude of fresh groundwater body decreased in the North and southern parts of Gaza Strip which is originally characterized by fresh groundwater (CL < 250 mg/l). The effect of sea water intrusion has clear influence in the Western part of the Gaza Strip along the shore line especially in both the Western Gaza and Khan Younis governorates. Where, the Chloride concentration is in the range of more than 2000mg/l and to about 8000mg/l in some wells. In 2012, seawater intrusion phenomenon has reached to more than 2 km in land of Gaza City aquifer.

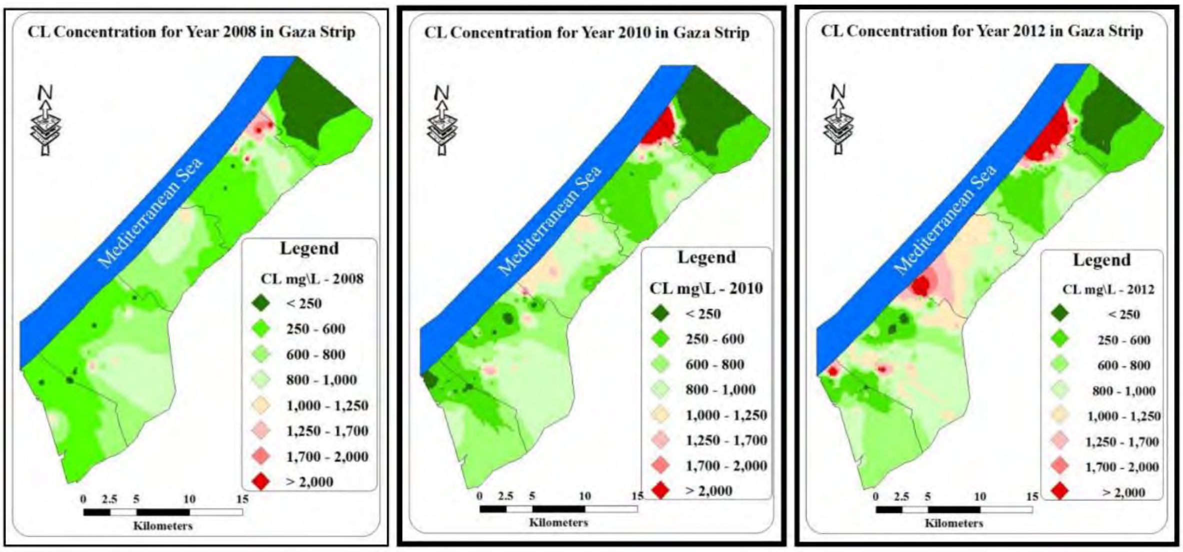


*Figure (6): Chloride concentration maps for year 2008, 2010 and 2012 in Gaza Strip (PWA, 2013)*

**Chloride Concentration Prediction with Time for Year 2017 and 2022**

Based on the water quality graphs magnitude as well as the attitude, taking in consideration the current abstraction status, the abstracted groundwater quality has been predicted by PWA for the years of 2017 and 2022 (Figure 7). It is clear that with the absence of alternative water resources in the short-term, there will be a real catastrophic water situation in the Gaza Strip.

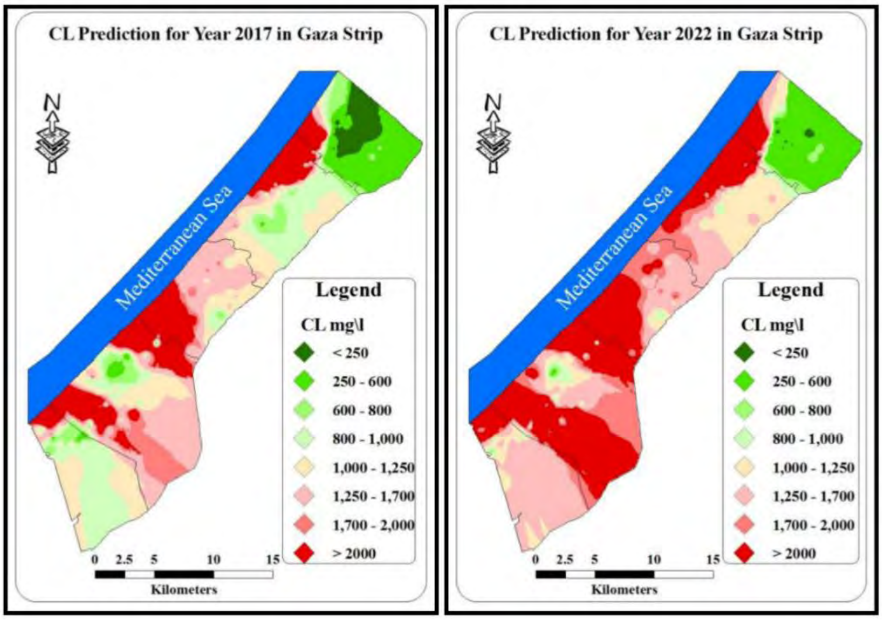


*Figure (7): Prediction chloride consternation (2017 and 2022) in Gaza Strip (PWA, 2013)*

## Nitrates

High nitrate levels in water can cause methemoglobinemia or blue baby syndrome, a condition found especially in infants under six months and stomach cancer in adult. In the body, nitrates are reduced to nitrites. The nitrites react with Hemoglobin (Hb) in the red blood cells to form methaemoglobin, affecting the blood's ability to carry enough oxygen to the cells of the body (Shomar, 2012). The Hb of young infants is more susceptible to methemoglobin formation than that of older children and adults. Other groups potentially susceptible to methemoglobin formation may include pregnant women and people deficient in glucose-6-phosphate dehydrogenase or methemoglobin reductase (WHO, 2011). The high methemoglobin level was strongly associated with nitrates concentrations in drinking water wells and the highest mean methemoglobin level was in Khan-Younis, where the highest mean nitrate concentration was recorded in drinking water (Abu Naser, Ghbn and Khoudary 2007). This implies that drinking wells need to be assessed periodically especially if pregnant women or infants consume the extracted water well water and if found contaminated with nitrate, other water source should be used like other safe drinking wells, bottled water, water purification apparatus which can clean water from nitrate, such as ion exchange, reverse osmosis. Also education family for exclusive breastfeeding for infants under 6 months old, use of uncontaminated wells.

## Fluoride

Excess fluoride above the normal levels may lead to dental, skeletal fluorosis or osteomalacia, the latter being a disease characterized as staining and erosion of teeth, particularly in children (Petersen and Lennon, 2004). However, lack of fluoride may cause dental caries, a weakening of the teeth, thus in some circumstances fluoride may be added to the drinking-water supply. A high prevalence of dental fluorosis has been identified among children in the Gaza Strip (78.0%) (Abuhaloob and Abed, 2013). The acceptable concentration of fluoride in water is in part related to climate, as in warmer climates the quantities of water consumed are higher thus leading to a greater risk of fluoride related problems as overall intake increases. Susceptibility of individuals to fluorosis may also be determined by renal impairment (WHO, 1996).

A high positive correlation was found between fluoride concentrations in groundwater and the occurrence of dental fluorosis (Shomar, et al. 2004). The prevalence of dental fluorosis was 60% in the same source (ibid); it was the highest in Khan Yunis (94%), followed by in Rafah (82%). In addition, strong statistically significant associations between renal failure and fluoride level were reported (Mokhamer, 2009). This flags the importance of putting this issue on the agenda of policy makers and developing an appropriate prevention strategy to reduce the fluoride intake and the use of fluoride-containing dental products for children under the age of 5.

## Lead

Lead and its compounds can enter the environment at any point during mining, smelting, processing, use, recycling or disposal (Patil, et al. 2007). Health risks are increasingly associated with environmental exposures to lead emissions from the wide spread use of lead in industrial set up (Gidlow, 2004). Lead has been shown to cause adverse effects on several organs and organ systems, including the hematopoietic, nervous, renal, cardiovascular, reproductive, and immune system and is mutagenic in mice (Patil, et al. 2007). Clinical symptoms of lead toxicity are restlessness, fatigue, irritability, sleep disturbance, headache and difficulty in concentrating, decreased libido, abdominal cramps, anorexia, nausea, constipation, and diarrhea. In general, the number and severity of symptoms worsen with increasing Blood Lead Levels (BLL). Lead causes proximal renal tubular damage, characterized by generalized aminoaciduria, hypophosphatemia, with relative hyperphosphaturia and glycosuria accompanied by nuclear inclusion bodies, mitochondrial changes, and cytomegaly of the proximal tubular epithelial cells (Rastogi, 2008). Long-term exposure to lead can cause nephropathy, and colic-like abdominal pains. It may also cause weakness in fingers, wrists, or ankles. In pregnant women, high levels of exposure to lead may cause miscarriage. Chronic, high-level exposure has been shown to reduce fertility in males (Golub, 2005).

Lead can cause kidney damage and nervous system impairment. The population of the Gaza Strip who lives in precarious conditions, in direct contact with soil/water/air, is exposed at risk of coming into contact with poisonous substances through the skin, respiratory and through food (agricultural products). Drinking water is one of the major sources of human exposure to lead. Lead particularly targets the nervous system, blood and kidney distal motor neuropathy and possibly seizures and coma. Infants and small children are more sensitive to the effects of lead, which moreover is transported through the placenta to the fetus. According to the environmental research of Dr Zahid Qari' reported in Middle East Monitor (2013), "the particular increase in the level of lead causes anaemia and haemoglobin deficiency of the blood as well as damage to the kidneys, liver and brain not to mention renal colic, gout, inflammation of the kidneys and chronic renal failure." It also causes hepatic hepatitis and may develop into fibrosis and oesophageal varices and increases stomach and duodenal acidity.

In 2003, Bura'I found that 80.4% of children in Northern governorate of Gaza Strip have BLL below 5 μg/dl. Those who have a BLL between 5-9.9 μg/dl were 17.4%. Elevated BLL of children was found to be significantly associated with some occupational exposures of the child sponsor such as removal of paint or varnish while inhabitants still in the dwelling, working in Brass/Copper foundry work or plating, renovating homes and soldering electric parts (Bura'I, 2003). In addition, Lubbad, et al. (2010) inform that the most common self-reported symptoms among gasoline station workers in the Gaza Strip were neurological symptoms including headache, fatigue, irritability, concentration difficulties, and sleep disturbance. After one year's age, Safi (2011) demonstrated statistical significant relationship between BLL among children and battery recycling, radiator repair and other lead sources; household distance from exposure sources including smelter, battery manufacturing and recycling and gas station; occupational exposure including painting works; child feeding, and day care. Health impacts including child general health, child's need of frequent medical care, and anemia.

Childhood lead poisoning prevention policies should be initiated and implemented. Provide anticipatory guidance to parents of all infants and toddlers about preventing lead poisoning in their children. Removal of all nearby battery recycling and manufacturing plants/smelters, and auto radiator repair workshops located in the middle of highly populated urban areas, markets and dwelling zones is highly recommended. Finally, decision-makers should introduce public awareness and educational programs to child sponsors and parents about the risk factors associated with lead poisoning and sources of lead exposure and its impact on human health.

## BIOLOGICAL CONTAMINANTS

Poor microbiological quality is likely to lead to outbreaks of infectious water-related diseases and may causes serious epidemics to occur. Microorganisms from human or animal excreta is the main source of microbiological contamination, which reaches humans through contaminated water from wastewater, landfills, or wastewater treatment stations, causing serious health problems. These microorganisms include bacteria, viruses and parasites that occur naturally in the gut of humans and other warm-blooded animals. Detection of these microorganisms' indicators in drinking water means the presence of pathogenic organisms that are the source of diseases in many of the cases (Abudaya, ELRamlawi and Hararah, 2013).

### Diarrheal Disease

Diarrheal disease is a leading cause of child mortality and morbidity in the world (between six months and five year). Diarrheal diseases were the highest self-reported diseases among residents in the Gaza City. Such diseases were more prevalent among people using municipal water than people using desalinated water and water filtered at home for drinking (Yassin, Amr and Al-Najar, 2006). In 2010, the UNICEF and PHG concludes that on average, due to poor water quality and hygiene practices, 20% of households had at least one child under the age of five who had been infected with severe diarrhea in the four weeks prior to the survey; locally (Beit Hanoun) this ratio can rise up to 38% (UNICEF 2010). In 2011, Abouteir, et al study shows variables that were independently predictive of diarrhea: public water access, poultry or rabbits at home, and presence of cooker at home.

Children under five with diarrhea episode within the last two weeks (incidence) range from 12% (Maram, 2004) to 23% (PCBS, 2004). NECC reports indicate that among those presenting to NECC clinics, 16% were suffering from diarrhea and is regarded as high. In a study conducted by Save the Children after the Israeli aggression (2008/2009) in certain vulnerable areas in the Gaza Strip, the incidence of diarrhea was high amongst the children surveyed; 38% reported diarrhea in the previous two weeks (Thurstans and Sibson, 2010). Environmental and political factors such as closures, incursions and the destruction of the infrastructure could explain the high incidence of infectious diseases and diarrhea. Contextual and environmental factors—such as disruption of the water infrastructure, poor quality of water, electricity cuts, lack of tools — play key roles in the increasing the incidence of infectious diseases such as diarrhea.

Diarrheal diseases was classified into diarrhea less than 3 years, diarrhea more than 3 years and bloody diarrhea. A total of 65296 cases of diarrhea among children less than three years old were reported to the epidemiology department with an incidence rate of 41.5% representing a similar incidence rate with the year 2012 where a total of 64830 cases were reported with an incidence of 41.1%. Since the year of 2006, there are a continuous increase in the incidence, which could be attributed to deterioration of infrastructure. The highest incidence (34.5%) of reported cases was in North governorate followed by Khan Younis governorate with an incidence of 28.8%. For diarrhea among patients more than 3 years, a total of 35284 cases were reported during the year 2013 with an incidence rate of 2.28%, while a total of 39390 cases were reported during 2012 with an incidence of 2.8%. The highest notification of cases was from North governorate (40.02%) compared to other governorates. During the same years, a total of 8555 cases of bloody diarrhea were reported with an incidence rate of 503/100.000 population representing a mild decrease compared to the year 2012 where a total of 9384 cases were reported with an incidence of 570/100.000. From the year 2006 to 2010, there were a continuous decrease of reported cases (General Directorate of Primary Health Care Preventive Medicine-Epidemiology Department, 2013).

UNRWA epidemiological bulletin (2015) shows a constantly increasing trend in the last three years (watery diarrhea) with a fluctuation in the incidence according to the contextual situation (Figure 8). Measures to control diarrhea should be established at both preventive and therapeutic level. Promoting the quality of drinking water, housing conditions and improving sanitations are important strategies.

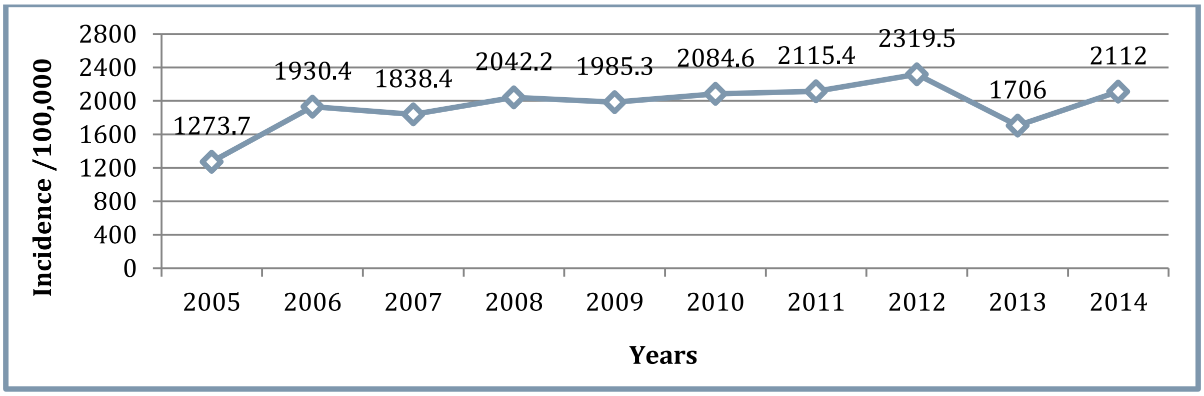


*Figure (8): Secular of watery diarrhea among age group < 3 years 2005-2014 UNRWA report*

## Parasites

Parasites such as A. lumbricoides, G. lamblia and E. histolytica are some of the expected major dangerous contaminants found in the wastewater of Gaza City and can be used as indicators in seawater (Al Zain and Al Hindi, 2005). Parasites are considered as a main pathogenic pollutant in many cases, where they have been recently detected several times in many studies. In 1979 Abed pointed to the high prevalence of parasites among the Palestinian children in Jabalia village (Abed, 1979). However, since that till now; parasitic infestations remain prevalent with negative consequences on nutritional status. In 2000, Al Agha and Teodorescu found 50% of children in Beit Lahia in the Northern Gaza Strip were suffering from parasites and helminths. In the same area, it was found that 72.9% of school children were suffering from parasitic infection (Al Zain and Al Hindi, 2005). Abu Mourad (2004) pointed that the highest prevalence of intestinal parasites (24.1%) was found among children aged 1-4 years. The prevalence of intestinal parasites among school children in Beit labia villages and Jabalia refugee camp was 28.9% (Kanoa, et al. 2006). This percentage is congruent with the findings obtained by similar studies carried out in Gaza Strip (Yassin et al., 1999; Sharif, 2002; AL-Hindi, 2002; Al-Zain and AL-Hindi, 2005).

More recently, findings from the American Near East Refugee Aid (ANERA, 2010) study indicate that 30% of the stool analysis tests done to anemic patients were positive with parasitic infestations; 19% of the total stool analysis tests were positive for GardiaLambia (NECC, 2010; ANERA, 2010). Similar findings were found in studies conducted at NECC (NECC, 2012; NECC, 2013). In 2012, Hilles study found that that the percentage of the parasitic contamination was 48.1% of the seawater samples, 40.4% of the wet sand samples and 34.6% of the dry sand samples of the shoreline region of the Gaza City (Hilles, 2012). In food handlers, the overall prevalence of parasites was 24.3% and the most common protozoan parasite was Entameba histolytica/dispar (Al-Hindi, et al. 2012).

In the years 2013, high parasitic infection rates were recorded in Gaza City with Giardia lamblia, Ascaris Lumbricoides and Entamoeba histolytica being the most frequent (Abudaya, ELRamlawi and Hararah, 2013). It is recommended that food handlers should be subjected to regular medical examination that includes stool analysis.

These parasitic infections can cause long-term effects such as anemia, retarded growth and mental disorders (CMWU and InfraMan, 2007). The situation of intestinal parasitic infection in the Gaza Strip is still a problem, probably due to gaps in sanitation, water population, crowdedness, bad hygienic habits, and poor health education (Al Hindi and El Kichaoi, 2008).

## Hepatitis A

Viral hepatitis is one of the most serious health problem globally, with some variation from one type to another and from country to another. It caused by several viruses that differ in clinical presentation, risk of chronicity, transmission, and means of prevention. In Palestine the most common are hepatitis A, hepatitis B and hepatitis C. It remain the major causes of morbidity among reportable infectious diseases in the refugee population of the Gaza Strip (UNRWA, 2011).

In the year 2013, General Directorate of Primary Health Care Preventive Medicine-Epidemiology Department show a continuous increase of reported number of cases compared to the previous years. During 2013, a total of 1248 hepatitis 'A' cases were reported with an incidence of 73.3 per 100.000 population while during 2012, a total of 1010 cases (61.4 per 100.000 population) were reported and 423 cases (26.6 per 100.000 population) in the year 2011. The highest incidence rate per 100.000 population of reported cases in the year 2013 was reported in the Khan Younis governorate. The UNRWA epidemiological bulletin indicate different finding which showed that the prevalence data for the Gaza Strip revealed that the rates of water- and food-borne infections such as hepatitis 'A' is 81.0 in 2008, 73.1 in 2009 and 36 in 2011, 52 in 2012 and jumped to 59 in 2013 per 100,000 in Gaza Strip (23.7 per 100,000 in the (UNRWA, 2014).

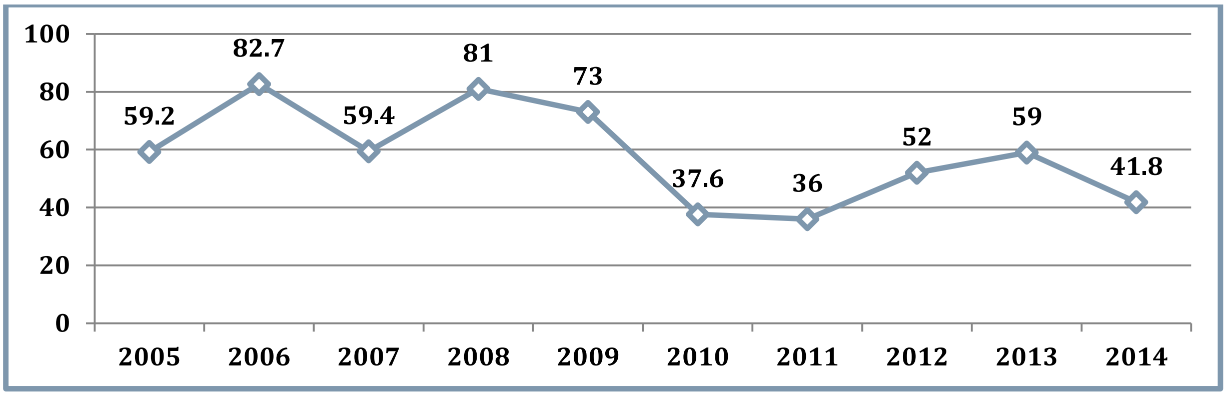


*Figure (9): Incidence rate of reported viral hepatitis per 100,000 served population, 2005-2014 UNRWA Report*

## Typhoid Fever

For typhoid fever, it is a common worldwide bacterial disease transmitted by the ingestion of food or water contaminated with the feces of an infected person, which contains the bacterium Salmonella enterica subsp. enterica, serovar Typhi. The rate of typhoid fever among the served refugees (per 100,000) in the Gaza Strip was 10.6 in 2008 and 12.4 in 2009 and jump to 15.2 in 2010, then decline to 2.7 in 2014 per 100,000. The incidence of Typhoid fever shows an increasing trend, indicating an obvious deterioration of the quality of drinking water due to bacterial contamination of aquifer (UNRWA, 2014).

Salmonella are found worldwide in both cold-blooded and warm-blooded animals, and in the environment. They cause illnesses such as typhoid fever, paratyphoid fever, and food poisoning (Ryan and Ray, 2004). In the GS, salmonella was found in chilled (19.2%) and frozen poultry (18.8%) and fresh, chilled and frozen poultry that had total plate count exceeding level accepted by Palestinian Standard were 2.4%, 21.9%, and 3.8 respectively with average of 5.5% (Humaid, 2006).

In 2009, Mourad assess food hygiene and safety among cake bakeries in suburbs of Gaza governorate which shows that 82.2% workers mentioned that workers, tools, ingredients are the source of microbial contamination. Also found that microbial analysis showed that the number of contaminated samples 148 (85.5%), 30 (17.3%), 94 (54.3%), 29 (16.8%), 20 (11.6%) and 11 (8.7%) with TBC, S. aureus, coliforms, E-coli, mold and O. Those show the necessitates that workers should be trained in the field of food safety before getting the work, the authority of food safety should emphasis on implementing Hazard analysis and critical control points in cake plant and Palestinian cake standard should be established.

In addition, findings imply that policy makers need to reinforce measures to control water related diseases. The later measure may include enacting laws and regulations regarding inspection and surveillance of poultry and other food items for food borne pathogens particularly Salmonella. Automated poultry slaughterhouses, raise awareness of persons dealing with poultry processing for adopting good hygienic practices and improving outdoor environment are recommended.

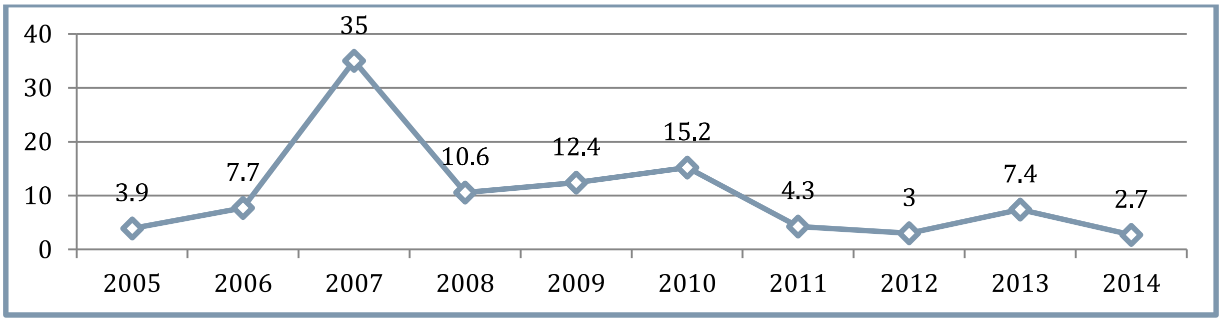


*Figure (10): Incidence rate of reported typhoid fever per 100.000 served population*

## Meningitis

Meningitis is an infection that involves the membranes overlying the brain and spinal cord (meninges) and the causative agents vary greatly among the different age groups (Sáez-Llorens and McCracken, 2003). Meningitis has a high prevalence in developing countries, with associated mortality and risk of severe residual neurological problems. There are several different causes of meningitis like bacteria, virus or fungus infection (Ginsberg, 2004).

It is widely believed that meningitis is a serious infectious disease related to bad sanitary and housing conditions. The disease was prominent among children less than 5 years with a proportion of 79% of the entire cases. In particular, the incidence is higher among children less than 2 years old with a proportion of 47.4% of the total cases (Abu Shaban, 2003) and the most common type in the Gaza Strip is viral (aseptic) meningitis that is increasing by time while meningococcal meningitis forms the lowest proportion of the diseases. Other bacterial types such as pneumococcal and Haemophilus influenza is more common than meningococcal.

In Gaza Strip these diseases are endemic with seasonal and governorate variations. As seen on Figure 11, the yearly incidence of Neisseria Meningitides diseases in years 2004-2011 fluctuated between "6.8 to 10" per 100.000 population. In the years 2012-2013, the incidence rate registered a continuous decrease compared to the previous years. In the year 2013, a total of 84 cases were reported of Neisseria Meningitides diseases with an incidence of 4.9 per 100.000 population wile in the year 2012,a total of 103 cases were reported with an incidence of 6,3 per 100.000 population (General Directorate of Primary Health Care Preventive Medicine-Epidemiology Department-MOH, 2013).

In the UNRWA (2015) reported a significant rate of this dangerous disease that show incidence of meningitis was 0.3 per 100,000 served population and increased to more than 4 in 2013 and 2014 (UNRWA, 2015). However, all the cases with meningitis are treated in hospitals rather than UNRWA or MOH PHC centers.

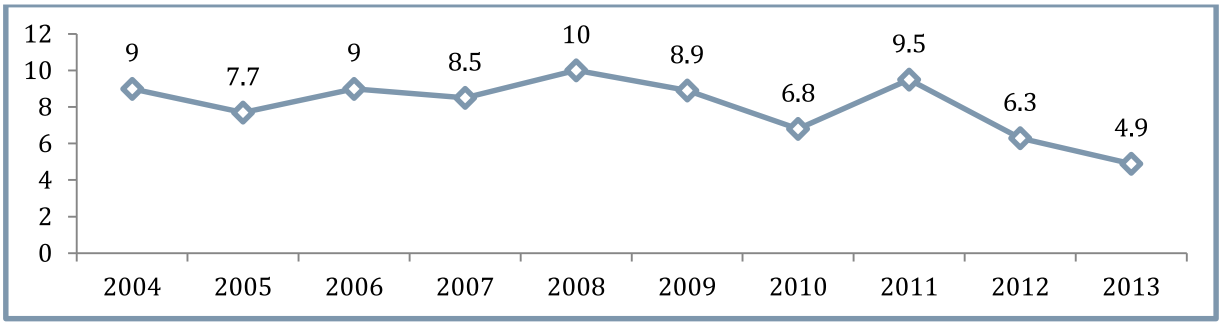


*Figure 11: Annual incidence rate per 100,000 of Neisseria Meningitides diseases in Gaza Strip, 2004-2013*

## OTHER HEALTH PROBLEMS POTENTIALLY RELATED TO POOR QUALITY OF WATER

### Malnutrition

Although the prevalence of the different types of malnutrition is fluctuating up and down in Gaza, there is a consensus that the prevalence is high. Chronic hardship cases, increased socioeconomic vulnerability, bad hygienic conditions, political conflict, lack of awareness and low education level are among the recognized risk factors for the development of malnutrition and anemia (World Vision, 2009). Recurrent pediatric infections such as diarrhea are also predisposing factors for malnutrition and anemia. In 2011, El Qouqa, et al. indicates that malnutrition and water supply were independently associated with infection, and malnutrition was identified as the main risk factor for yersiniosis. This implies that policy maker need more attention to strengthen measures to control infectious diseases such as meningitis, provide health education, improve surveillance, strengthen public health measures such as water safety, flies control, sanitary improvement, awareness.

Results from nutrition assessments indicate a worrying increase in the number of malnourished cases particularly among children and pregnant women in the last years. The most dominant form of malnutrition is stunting reflecting chronic exposure to malnutrition. The prevalence of moderate and severe (below -2 Z score) stunting (chronic malnutrition) among children under 5 years old ranges from 10-15% (World Vision, 2009; NECC 2010-2015); five to seven times more than what is considered as acceptable by the WHO in a normally nourished population. Wasting which reflects recent exposure to nutritional deficiencies is usually more reported during crises and conflicts (Hamad and Johnson, 2010). The prevalence of moderate and severe wasting is around 4% in Gaza (NECC, 2010; NECC 2011). Regarding the prevalence of underweight it ranges from 6 to 8%. Underweight which reflects an intermediate exposure to malnutrition (mid way between recent and long term exposure) is more prominent among non-urban with no consistent specific gender affection. There is a dearth of research about adults anthropometric measurements; however, underweight is estimated at less than 2%; meanwhile, more than 30% of women attending MCH services are overweight or obese (Al-Quds University and Johns Hopkins University 2003; El-Majdalawi, 2008; MOH, 2014).

## Anemia

With a constantly increasing trend, Iron Deficiency Anemia (IDA) is reported to affect nearly half of children under five years of age (World Vision, 2009; NECC, 2010, NECC, 2015). With slight variations among studies, there is consistency in the literature that IDA represents a chronic major public health problem in the GS. Despite the intensive efforts, public health programs failed to significantly reduce the level of anemia. Also, anemia inversely correlates with age with younger children being more affected (around 70% among children 6-12 months). This constitutes a real challenge as at this stage the brain and body development are at its highest speed. Results from nutrition assessments indicate a high prevalence of anemic pregnant women. Some studies at MOH and UNRWA point that around 40% of pregnant women are anemic. In a study conducted at the School of Public Health (Nour, 2013) the revealed prevalence was higher (81%). Also, according to the database of NECC, more than 80% of the examined blood samples pertaining to pregnant women, the Hb was below 11gm/dL within the course of pregnancy.

## Cancer

The cancer registry of the MOH indicates that there is an increasing trend of oncology related diseases among children under 5 years old. The number of cases increased from 60 cases in 2000 to 70 cases in 2008 (MOH, 2010). The prevalence (the specific rate by million) among male children per million population increased from 84.8 in 2000 to 132 in 2007 and to 129 in 2008. Data pertaining to 2009 hasn't been processed yet. The most prevalent oncology was leukemia with an increasing number of reported cases especially among males (MOH, 2010).

Regarding the spread of cancer in Gaza, in the Lancet, it is mentioned that in 2005, the reported number of new cancer cases in Gaza is 32.7 per 100 000; 45% of all cases were in men and 55% in women. During the period between 1998 and 2008, a total of 7412 invasive cancer cases were registered in the Gaza Strip Cancer Registry. The crude cancer incidence rate for all the population was 49.2 per 100,000 persons which is higher than the previously reported figures. The age-adjusted cancer incidence rate for all the population for 1998-2008 was 105.5 per 100,000 persons (MOH, 2010). Cancers ASR per 100,000 in Gaza is similar to the rates reported in Arab countries as Jordan, Oman, Tunisia, and Morocco, but is higher than the rates reported in Saudi Arabia and the United Arab Emirates. The most common site for cancer for males is cancer lung with an incidence rate of 5.8 and ASR 16.4 per 100,000 persons. For females and as expected, cancer breast is the most common forming 30% of all cancers among women. The cancer breast incidence rate is 15.6 per 100,000 persons and the ASR is 33.1. Colo-rectal cancer is reported with incidence rate of 4.9; the second most common cancer among women. The ASR for women colorectal cancer is 10.9 per 100,000 persons. Leukemia among males is increasing.

The most recent available data show that the number of the new cancer cases diagnosed in 2013 according to MOH is 1414 cases; mostly breast cancer, colo-rectal, lymphoma and thyroid which combined accounted for 47% of all the cases diagnosed in 2013. The increase in the incidence of cancer calls for more proactive steps in prevention and control of cancer and responding to increased demand for oncology services including early screening, radiotherapy palliative care and surgery. There is clear variations cross governorates in the prevalence of cancer which might reflect different exposures to risks.

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## Congenital Anomalies & Disability

The trend of congenital anomalies which are usually associated with death and disability is clearly increasing among infants especially after the Israeli aggression in 2008/2009; increased from 4.7 per 1000 live birth in 2008 to 9.6 in 2009 and 8.8 in 2010. Also, it is important to note that some congenital anomalies are discovered later on life; the reported figure reflects obvious or serious anomalies discovered at birth. Data obtained from MOH pertaining to 2011 and 2012 are not reliable (MOH, 2014). A study conducted by Naim et al (2012) in Al-Shifa Hospital, revealed that the incidence of major structural birth defects (BD) by clinical diagnosis is 14/1000. Specific BDs are more represented in Gaza, as polycystic kidney, usually due to recessive autosomal mutations. Regarding disability, the total number of disabled in the Gaza Strip was found to be 40379 (2.85%) of the population-excluding mental related disability (MOH, 2014). Of them, 36% are children less than 18 years. The most common disabilities among children are motor, visual, auditory and multiple disabilities. Contextual factors such as poverty, environmental pollution and bombardments are among the frequently reported reasons for disability. Also, Israel has admitted the use of dangerous and internationally forbidden weapons during bombardments on Gaza such as white phosphorus. The New Weapons Committee from the Center for Research on Globalization have undertaken a research on biopsies and tissue samples taken from wounds invoked during Israeli military attacks and the OCL on Gaza, the following citation has been quoted from a report issues on 15 May, 2010 by Global Research Group:

> *"The following elements were found in quantities well beyond normal: Aluminum, titanium, copper, strontium, barium, cobalt, mercury, cesium, tin, lead, uranium, arsenic, manganese, rubidium, cadmium, chromium, and zinc nickel".*

## Skin Diseases

Skin disease is a common problem; it is always assumed that the prevalence of skin diseases in developing countries is very high, and that infestations and skin infections are endemic. In study conducted by Naim (2006) shows that skin conditions are very common in children and half of them are affected. The prevalence of skin diseases is higher among males than females. Pityriasis alba and pediculosis lice had the highest prevalence rates of all skin disorders (23.5%, 9.5% respectively). Males had a higher frequency of pityriasis alba than did females, But females had a higher frequently of head lice than did males. There is a strong significant differences in presence of Pityriasis alba and pediculosis lice among males and females Other diagnoses were eczematous diseases 4.2% followed by infectious diseases and scabies. The study has revealed that the top five skin disorders on the list are: pityriasis alba, Pediculosis Lice, Eczematous Diseases, Infectious Diseases and Scabies.

MOH (2014) report indicates that Gaza children suffer from a variety of infectious diseases including skin diseases such as scabies and dermatitis. NECC database revealed that in 2012, more than half of children presented to NECC clinics were having any kind of respiratory infections. It is recommended that adequate preventative measures and functional surveillance system to be established.

### Kidney Diseases

The number of patient's visits for dialysis care in 2011 was more than 50,000 sessions. Currently, around 500 patients are regularly undergoing kidney dialysis (twice or three times weekly) and 166 patients are receiving cytotoxic drugs after undergoing kidney trans-implantation (MOH database). The total number of artificial kidney units is 104 (MOH, 2012b). There were no association found between nitrate concentrations in groundwater and the occurrence of renal failure (Shomar, et al. 2004). Also Abu-Odah (2013) inform that water was not risk factors for developing renal failure.

## GAPS IN THE LITERATURE

This literature review exercise enabled us to pinpoint some important gaps related to the availability of credible information about water quality and its links to public health diseases. Mostly, the available studies had focused on certain districts/areas that were selected based on the researcher convenience and/or interest. Very few studies were conducted at the Gaza Strip or at the national level. It was noticed that the few available large scale studies are donors-led and funded. Mostly, research studies in this field are externally initiated and donors' dependent.

Data available at the concerned organizations such as MOH are usually reported as aggregated data; at the governorate level. No data is available at the community or neighborhood level which impairs the ability of programs to address the specific vulnerabilities In other words, there are gaps in obtaining consistent information from neighborhoods and districts.

The status of research in water and health sectors in Palestine is not different than other sectors, as most research studies are descriptive, usually academic in nature, and not necessarily reflecting the national needs and priorities. Almost no operation research studies (action research) have been conducted on water quality with the aim of providing practical solutions for the prevailing problems. There is a dearth of research on the appropriateness of interventions and measures related to ensuring safe use of water at the community level. The use of research in decision making in not institutionalized within the organizational culture of organizations in Gaza.

Concepts, parameters and indicators are ill-defined in Gaza. Organizations widely vary in how they interpret and define these important parameters. Of the necessary steps that stakeholders should contribute to is developing a consensus about basic parameters, indicators and their definitions, data collection methods and sources, data processing, storage and use. This would enable the better use of information for decision making.

Much work is required to improve the process to ensure better quality of routine information system particularly data management processes. In Gaza, the process of data management (collection, processing and analysis) requires improvement. There are no national data management procedures document that guides the process across the different organizations. No assessment of data quality (on the basis of the Data Quality Assessment Framework) has been conducted so far. There is also a need to work on standardization of data and improving the inter-operability between the various information systems. This entails the necessity of using data dictionary, development of a metadata dictionary and the identification of a minimum data set which all stakeholders can report on.

Records are usually available at the concerned facilities; however, it lacks consistency, accuracy and completeness. The status of the archiving system, documentation and reporting is not in accordance with appropriate documentations. Reporting is mainly administrative and ad hoc in nature with minimal feedback. Still repetitive, incomplete and not accurate documentation are dominating the overall picture. Interestingly, most organizations started computerizing their services such as UNRWA and less likely MOH and municipalities. Still, a challenge is how to coordinate and integrate these efforts into a consolidated national strategy for information sharing among the concerned stakeholders.

Coordination among the information holders is weak. Promoting coordination among the various stakeholders for purposes of data collection, analysis and information sharing is crucial to guarantee the provision of relevant, accurate and timely information for decision making. The authors of this report noticed a wide diversity in data, a reluctance of organization to share information and too much not necessarily bureaucracy. Therefore, it is essential to support a culture to disseminate, share and use information as a tool for decision making and to stimulate evidence-based practice. Information units need further technical, financial and managerial support.

Areas that require further focus include identifying the national prevalence and incidence of water quality related parameters and diseases associated with water use. Because mostly routine health information system reports about those who present to health facilities; still many masked cases could be available at households who require a community survey to uncover. Still gaps in information related to water sources, water for drinking and the contribution of the water sources to the water use do exist. For instance, there is a gap in knowledge related to desalination at houses, bottled water, use of agriculture wells for drinking and the associated risks of using these water sources. National studies with adequate samples about risk factors for possibly water related diseases which constitute public health problem such as anemia, malnutrition, hepatitis, meningitis and cancer are needed. It is also important to gather data about the availability of light and heavy metals in water. There is dearth of information about diseases related to the recreational use of water. Studies tackling the links between public health diseases and water use should be given a priority. Operational and action research related to water use constitute a priority as these can't be imported and are usually country specific.

# CONCLUSION & RECOMMENDATIONS

## CONCLUSIONS

Although it is well established that the Gaza water resources situation is critical, we believe this to be the first systematic review of the available published evidence of the water quality situation in Gaza Strip that links water quality to the public health.

The main conclusions that could be drawn from the literature regarding water supply and use is that the water situation in Gaza is dire. The Coastal Aquifer, Gaza's sole fresh water resource, is polluted by the infiltration of raw sewage from cesspits and sewage collection ponds and by the infiltration of seawater (itself also contaminated by raw sewage discharged daily into the sea near the coast) and has been degraded by over-extraction. The water quality will be worsening in the next few years and the aquifer will not be able to cover the population's water needs, where the water quality will not able to be used for any purposes (domestic, agriculture, or otherwise). Only 3.8% of the groundwater pumped from the domestic wells in Gaza Governorates match with the WHO standard for drinking use.

The result of the literature review and review of water quality parameters prove that there are many obstacles to having sufficient, sustainable, reliable, and acceptable quality water for various usage in the Gaza Strip. The exhausted coastal aquifer will not be a possible source of water for many more years. The literature review also substantiated that the water available for consumption and irrigation in the Gaza area is generally substandard to both the WHO & PWA limits, particularly due to increasing salinity and nitrates content. The current water resources are insufficient in both quantity and quality to meet the needs of the population in many areas and will not improve if the current situation is not urgently improved. It must be stressed that only long term, large scale solutions will be sufficient to address the water crisis in the Gaza Strip, a fact of which experts are well aware. If the high extraction rate continues the aquifer will dry up in a few years considering a serious cone of depression in Rafah area exceeding 19m.

Seawater intrusion has become a fact, and it was observed in many locations along Gaza coastal line as a result of the over pumping as well as the un-equilibrium of the hydraulic system. Most of the coastal area and with a distance of about 2-3 km in land is affected by the sea water intrusion phenomena with some degree. The main factors controlling the sea water intrusion magnitude and attitude is by the wells location, total penetrated depth and the pumping capacity. With the continuation of the over-pumping, the sea water intrusion influence will expand in land with time to cover more area and wells.

For years communicable diseases were the main cause of death in developing countries. Most of the communicable diseases are preventable. The literature highlights two epidemiological features related to communicable diseases in GS; a decline in the incidence of the fatal vaccine preventable diseases and a marked increase of the environment related diseases; particularly diseases associated water use. In other words, although the control of dangerous infectious diseases has been maintained with no reports of fatal vaccine controllable diseases; still meningitis, hepatitis, diarrhoea and others are common diseases with high morbidity rates.

What complicates the situation more is that the GS population is suffering from poverty and sanitary-related diseases and illnesses, such as diarrhea, meningitis, hepatitis, diphtheria and skin diseases, malnutrition, anemia as well as diseases associated with civilization, stress and environmental pollution. In other words, the GS is going through what is called "epidemiological transition" with a shift from communicable diseases to no-communicable ones with higher rates of cancer, cardiac and renal diseases.

Although studies that link water quality with public health diseases are limited, still evidence exists to support the assumption that water quality is strong risk factor for the development of public health diseases. Studies in the Gaza Strip that have investigated the association between human health and water quality showed significant relationships among the two themes. Still, there is need for a stronger evidence at the GS to illustrate the relationship between the two designated themes. Hopefully, this baseline study fills the information gap in this field through demonstrating the factual relationships between water quality and public health diseases.

## RECOMMENDATIONS

The recommendations proposed in the literature predominantly stressed the overall need for improved water resources. Many documents presented specific recommendations that could be of interest at the political level, including negotiating water rights with neighboring countries. Other recommendations were more technical and were appropriate for the service delivery level, such as the selection of sites for treatment, management of effluent and leachate, and strategies for monitoring water quality. Several documents stressed the need for construction and/or maintenance of the water delivery and sanitation infrastructure, including pipelines. Recommendations for the population level frequently addressed the need for increased awareness regarding water quality, and hygiene and sanitation practices, including the regular cleaning of rooftop tanks.

With regard to the public health, although much of the recommendation concerning this particular study has been addressed and negotiated at the Brainstorming and Consensus Building Meeting held in mid-December of 2014, there is much room for improvement. From proper data collection, to commissioning targeted prioritized needs-based national level studies, to unifying the operational definitions of the parameters, most of the issues that are faced in the field of public health analysis centralize around the efficiency, accuracy, and timeliness of the collected data. Public health decisions can only be formulated correctly if the input information is accurate and readily available. The actual methods of analysis do not need improvement, however, the direction the analysis and the studies undertake can use some improvements by means of well-aware, well-informed, and prioritized thinking.

The following specific recommendations are based on systematic literature review outcomes and can be summarized for:

## Public Health Data Collection, Availability, and Usage

1) Perhaps most importantly, we recommend a substantial improvement to the data collection and accessibility process. Data at the MOH should be collected accurately and in timely fashion at community and neighborhood levels, and proper records should be filed for easy access to facilitate the ability of programs to address specific vulnerabilities in the future. The make well-informed decisions, readily available, easily obtained, and accurate data are crucial. This will require reform in the way the MOH carries out its daily duties on the daily basis, and the decision should involve the relevant stakeholders.
2) We need to advise the stakeholders to start commissioning targeted prioritized needs-based national level studies that address the concerns and needs of the local population, and that aim at finding practical, tangible, and measurable solutions.
3) We also need to standardize the operational definitions of the parameters and indicators on a national level, or to comply with an existing international guideline. Organizations can no long afford to vary in how they interpret and define these important parameters. Of the necessary steps that stakeholders should contribute to is developing a consensus about basic parameters, indicators and their definitions, data collection methods and sources, data processing, storage and use. This would enable the better use of information for decision making.

## Private Desalination Plants

1) A safety and monitoring program for the private desalination plants and its delivery units (tankers and distribution points) includes chemical and microbiological analysis should be enhanced, developed, and intensified for the evaluation of the product and distributed water in order to pursue the compliance of these desalination plants to conditions and terms of water quality. Close coordination between all parties involved in water issues is needed to confirm the implementation of this program in Gaza Strip
2) Low content of minerals concern may be applicable for Gaza. This requires to consider the guidelines for desalination water treatment, specifying the minimum content of the relevant elements such as calcium and magnesium and TDS.
3) Disinfection of desalinated tank water and advice on mitigation of risks associated with home storage of water should be considered in a public campaign
4) A strategy should be adopted to control the location of the small scale desalination plants' construction according to the groundwater quality to manage salinity problems in the Gaza Strip.
5) Short term solution and large seawater desalination plants should be established in order to decrease pumping water in the Gaza Strip aquifer.

## Bottled Water

1) As the microbiological quality of water bottled distributed and consumed in Gaza is currently unclear, better monitoring to ensure the compliance of this water source should be conducted

## Quality

1) It is important to strengthen cooperation between all parties that working on water issue in Palestine as the Water Authority, Environmental Quality Authority, Ministry of Health, Ministry of Agriculture, Municipalities, and water legislation research institution " the water research center ". Also local and international NGO's working in water field.
2) The PA should regulate water quality from private suppliers and encourage good water storage practice in households and schools/health centers. The PA should also set appropriate standards where none exist. Child- friendly water and sanitation facilities should be developed and promoted, particularly in schools and youth centers.
3) Wells, which are located in seawater intrusion zones, must stop pumping to reduce the deterioration in these zones and prevent the expansion of the phenomenon of seawater intrusion.
4) The pumping rate of many domestic wells should be reduced in order to delay the significant water quality degradation and the reduced pumped quantity to be compensated by drilling new wells in selected areas. Commitment to PWA recommendation in terms of pumping rate for each well.
5) The Gaza Strip cannot continue depending on the groundwater as the only source to cover their water needs for all purposes where new water resources such as seawater desalination and reclaim of wastewater use.

## Re-Use

1) High degree of effluent reuse must be achieved in Gaza in order to reduce the current levels of groundwater withdrawal by the agricultural sector and mitigate the negative environmentally sound impacts

## Public Awareness

1) A public awareness campaign should be conducted relating to the importance of clean drinking water and hygiene. This should include information to private water vendors regarding chlorination and hygienic transport as well as individuals on the importance of safe water storage at the household level. Safe water should be provided to infants to ensure that they do not suffer the adverse effects of water contamination.
2) The public awareness and knowledge of socio-economic dimensions of nitrate pollutions and its related consequences are important and imperative for farmers who used over application of N-fertilizers to avoid further water quality & public health problems.

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# ANNEX I – Included Published Literature

| No. | Author | Year | Name of Article/Book | Publisher | Focus |
|---|---|---|---|---|---|
| 1 | Basem Shomar, Sami Abu Fakher, & Alfred Yahya | Dec., 2009 | Assessment of Groundwater Quality in the Gaza Strip, Palestine Using GIS Mapping | J. Water Resource and Protection, 2010, 2, 93-104 | Water Quality |
| 2 | Abdallah Bashir, & Adnan M. Aish | March, 2013 | Bacteriological Quality Evaluation of Bottled Water Sold in the Gaza Strip, Palestine | International Water Technology Journal, IWTJ, Vol. 3 – No. 1, March 2013 | Water Quality |
| 3 | Yunes Mogheir, & Mohammed Aiash | Sept. 2013 | Evaluation of Gaza Strip Water Situation and Water National Plans Using International Water Poverty Index (WPI) | International Journal of Emerging Technology and Advanced Engineering, Vol. 3, Issue 9, September 2013 | Water Quality |
| 4 | Gül Özerol | May, 2013 | Introduction to a “Complicated Story”: The Role of Wastewater Reuse to Alleviate the Water Problems of Palestine | Kapak Konusu | Water Quality |
| 5 | Mazen T. Abualtayef, et al | April, 2014 | Microbial water quality of coastal recreational water in the Gaza Strip, Palestine | BIOSCIENCE, Vol. 6, No. 1, pp. 26-32, May 2014 | Water Quality |
| 6 | Omar El - Omwasi | Sept. 1999 | Nitrate contamination of ground water and methemoglobinemia in Gaza Strip | Omar El –Omwasi, UNRWA Field laboratory services officer- Gaza | Water Quality |
| 7 | Husam Al-Najar | Aug. 2011 | The Integration of FAO-CropWat Model and GIS Techniques for Estimating Irrigation Water Requirement and Its Application in the Gaza Strip | Natural Resources, 2011, 2, 146-154, September 2011 | Water Quality |
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# ANNEX II – Recommended Guidelines by the Palestinian Standards Institute for Treated Wastewater Characteristics

| Quality parameter (mg/1 except otherwise indicated) | Fodder Irrigation | | Gardens, playgrounds, Recreational | Industrial Crops | Groundwater Recharge | Seawater Outfall | Land-scape | Tree | |
|---|---|---|---|---|---|---|---|---|---|
| | Dry | Wet | | | | | | Citrus | Olive |
| **BOD** | 60 | 45 | 40 | 60 | 40 | 60 | 60 | 45 | 45 |
| **COD** | 200 | 150 | 150 | 200 | 150 | 200 | 200 | 150 | 150 |
| **DO** | > 0.5 | > 0.5 | > 0.5 | > 0.5 | > 1.0 | > 1.0 | > 0.5 | > 0.5 | > 0.5 |
| **TDS** | 1500 | 1500 | 1200 | 1500 | 1500 | - | 1500 | 1500 | 500 |
| **TSS** | 50 | 40 | 30 | 50 | 50 | 60 | 50 | 40 | 40 |
| **pH** | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 |
| **Color(PCU)** | Free | Free | Free | Free | Free of colored matter | Free of colored matter | Free | Free | Free |
| **FOG** | 5 | 5 | 5 | 5 | 0 | 10 | 5 | 5 | 5 |
| **Phenol** | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 1 | 0.002 | 0.002 | 0.002 |
| **MBAS** | 15 | 15 | 15 | 15 | 5 | 25 | 15 | 15 | 15 |
| **$NO^3$-N** | 50 | 50 | 50 | 50 | 15 | 25 | 50 | 50 | 50 |
| **NH-N** | - | - | 50 | - | 10 | 5 | - | - | - |
| **O.Kj-N** | 50 | 50 | 50 | 50 | 10 | 10 | 50 | 50 | 50 |
| **PO-P** | 30 | 30 | 30 | 30 | 15 | 5 | 30 | 30 | 30 |
| **Cl** | 500 | 500 | 350 | 500 | 600 | - | 500 | 400 | 400 |
| **SO** | 500 | 500 | 500 | 500 | 1000 | 1000 | 500 | 500 | 500 |
| **Na** | 200 | 200 | 200 | 200 | 230 | - | 200 | 200 | 200 |
| **Mg** | 60 | 60 | 60 | 60 | 150 | - | 60 | 60 | 60 |
| **Ca** | 400 | 400 | 400 | 400 | 400 | - | 400 | 400 | 400 |
| **SAR** | 9 | 9 | 10 | 9 | 9 | - | 9 | 9 | 9 |
| **Residual $Cl^2$** | - | - | - | - | - | - | - | - | - |
| **Al** | 5 | 5 | 5 | 5 | 1 | 5 | 5 | 5 | 5 |
| **Ar** | 0.1 | 0.1 | 0.1 | 0.1 | 0.05 | 0.05 | 0.01 | 0.01 | 0.01 |
| **Cu** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **F** | 1 | 1 | 1 | 1 | 1.5 | - | 1 | 1 | 1 |
| **Fe** | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 5 |
| **Mn** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Ni** | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| **Pb** | 1 | 1 | 0.1 | 1 | 0.1 | 0.1 | 1 | 1 | 1 |
| **Se** | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| **Cd** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Zn** | 2 | 2 | 2 | 2 | 5 | 5 | 2 | 2 | 2 |
| **CN** | 0.05 | 0.05 | 0.05 | 0.05 | 0.1 | 0.1 | 0.05 | 0.05 | 0.05 |
| **Cr** | 0.1 | 0. 1 | 0.1 | 0.1 | 0.05 | 0.5 | 0.1 | 0.1 | 0.1 |
| **Hg** | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| **Co** | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 1 | 0.05 | 0.05 | 0.05 |
| **B** | 0.7 | 0.7 | 0.7 | 0.7 | 1 | 2 | 0.7 | 0.7 | 0.7 |
| **FC(CFU/100ml)** | 1000 | 1000 | 200 | 1000 | 1000 | 50000 | 1000 | 1000 | 1000 |
| **Pathogens** | Free | Free | Free | Free | Free | Free | Free | Free | Free |
| **Amoeba & Gardia (Cyst/L)** | - | - | Free | - | Free | Free | - | - | - |
| **Nematodes (Eggs/L)** | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |

# ANNEX III – Guidance Levels for Radionuclides in Drinking Water

| Radio nuclide | Guidance level (Bq/l)[a] | Radio nuclide | Guidance level (Bq/l)[a] | Radio nuclide | Guidance level (Bq/l)[a] | Radio nuclide | Guidance level (Bq/l)[a] |
|---|---|---|---|---|---|---|---|
| $^{3}$H | 10 000 | $^{71}$Ge | 10 000 | $^{105}$Rh | 1 000 | $^{129}$Cs | 1 000 |
| $^{7}$Be | 10 000 | $^{73}$As | 1 000 | $^{103}$Pd | 1 000 | $^{131}$Cs | 1 000 |
| $^{14}$C | 100 | $^{74}$As | 100 | $^{105}$Ag | 100 | $^{132}$Cs | 100 |
| $^{22}$Na | 100 | $^{76}$As | 100 | $^{110m}$Ag | 100 | $^{134}$Cs | 10 |
| $^{32}$P | 100 | $^{77}$As | 1 000 | $^{111}$Ag | 100 | $^{135}$Cs | 100 |
| $^{33}$P | 1 000 | $^{75}$Se | 100 | $^{109}$Cd | 100 | $^{136}$Cs | 100 |
| $^{35}$S | 100 | $^{82}$Br | 100 | $^{115}$Cd | 100 | $^{137}$Cs | 10 |
| $^{36}$Cl | 100 | $^{86}$Rb | 100 | $^{115m}$Cd | 100 | $^{131}$Ba | 1 000 |
| $^{45}$Ca | 100 | $^{85}$Sr | 100 | $^{111}$In | 1 000 | $^{140}$Ba | 100 |
| $^{47}$Ca | 100 | $^{89}$Sr | 100 | $^{114m}$In | 100 | $^{140}$La | 100 |
| $^{46}$Sc | 100 | $^{90}$Sr | 10 | $^{113}$Sn | 100 | $^{139}$Ce | 1 000 |
| $^{47}$Sc | 100 | $^{9}$Y | 100 | $^{125}$Sn | 100 | $^{141}$Ce | 100 |
| $^{48}$Sc | 100 | $^{91}$Y | 100 | $^{122}$Sb | 100 | $^{143}$Ce | 100 |
| $^{48}$V | 100 | $^{93}$Zr | 100 | $^{124}$Sb | 100 | $^{144}$Ce | 10 |
| $^{51}$Cr | 10 000 | $^{95}$Zr | 100 | $^{125}$Sb | 100 | $^{143}$Pr | 100 |
| $^{52}$Mn | 100 | $^{93m}$Nb | 1 000 | $^{123m}$Te | 100 | $^{147}$Nd | 100 |
| $^{53}$Mn | 10 000 | $^{94}$Nb | 100 | $^{127}$Te | 1 000 | $^{147}$pm | 1 000 |
| $^{54}$Mn | 100 | $^{95}$Nb | 100 | $^{127m}$Te | 100 | $^{149}$pm | 100 |
| $^{55}$Fe | 1 000 | $^{93}$Mo | 100 | $^{129}$Te | 1 000 | $^{151}$Sm | 1 000 |
| $^{59}$Fe | 100 | $^{99}$Mo | 100 | $^{129m}$Te | 100 | $^{153}$Sm | 100 |
| $^{56}$Co | 100 | $^{96}$Tc | 100 | $^{131}$Te | 1 000 | $^{152}$Eu | 100 |
| $^{57}$Co | 1 000 | $^{97}$Tc | 1 000 | $^{131m}$Te | 100 | $^{154}$Eu | 100 |
| $^{58}$Co | 100 | $^{97m}$Tc | 100 | $^{132}$Te | 100 | $^{155}$Eu | 1 000 |
| $^{60}$Co | 100 | $^{99}$Tc | 100 | $^{125}$I | 10 | $^{153}$Gd | 1 000 |
| $^{59}$Ni | 1 000 | $^{97}$Ru | 1 000 | $^{126}$I | 10 | $^{160}$Tb | 100 |
| $^{63}$Ni | 1 000 | $^{103}$Ru | 100 | $^{129}$I | 1 | $^{169}$Er | 1 000 |
| $^{65}$Zn | 100 | $^{106}$RU | 10 | $^{131}$I | 10 | $^{171}$Tm | 1 000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $^{175}Yb$ | 1 000 | $^{210}Pb^{b}$ | 0.1 | $^{231}U$ | 1 000 | $^{243}Am$ | 1 |
| $^{182}Ta$ | 100 | $^{206}Bi$ | 100 | $^{232}U$ | 1 | $^{242}Cm$ | 10 |
| $^{181}W$ | 1 000 | $^{207}Bi$ | 100 | $^{233}U$ | 1 | $^{243}Cm$ | 1 |
| $^{185}W$ | 1 000 | $^{210}Bi^{b}$ | 100 | $^{234}U^{b}$ | 1 | $^{244}Cm$ | 1 |
| $^{186}Re$ | 100 | $^{210}Po^{b}$ | 0.1 | $^{235}U^{b}$ | 1 | $^{245}Cm$ | 1 |
| $^{185}Os$ | 100 | $^{223}Ra^{b}$ | 1 | $^{236}U^{b}$ | 1 | $^{246}Cm$ | 1 |
| $^{191}Os$ | 100 | $^{224}Ra^{b}$ | 1 | $^{237}U$ | 100 | $^{247}Cm$ | 1 |
| $^{193}Os$ | 100 | $^{225}Ra$ | 1 | $^{238}U^{b,c}$ | 10 | $^{248}Cm$ | 0.1 |
| $^{190}Ir$ | 100 | $^{226}Ra^{b}$ | 1 | $^{237}Np$ | 1 | $^{249}Bk$ | 100 |
| $^{192}Ir$ | 100 | $^{228}Ra^{b}$ | 0.1 | $^{239}Np$ | 100 | $^{246}Cf$ | 100 |
| $^{191}Pt$ | 1 000 | $^{227}Th^{b}$ | 10 | $^{236}Pu$ | 1 | $^{248}Cf$ | 10 |
| $^{193m}Pt$ | 1 000 | $^{228}Th^{b}$ | 1 | $^{237}Pu$ | 1 000 | $^{249}Cf$ | 1 |
| $^{198}Au$ | 100 | $^{229}Th$ | 0.1 | $^{238}Pu$ | 1 | $^{250}Cf$ | 1 |
| $^{199}Au$ | 1 000 | $^{230}Th^{b}$ | 1 | $^{239}Pu$ | 1 | $^{251}Cf$ | 1 |
| $^{197}Hg$ | 1 000 | $^{231}Th^{b}$ | 1 000 | $^{240}Pu$ | 1 | $^{252}Cf$ | 1 |
| $^{203}Hg$ | 100 | $^{232}Th^{b}$ | 1 | $^{241}Pu$ | 10 | $^{253}Cf$ | 100 |
| $^{200}Tl$ | 1 000 | $^{234}Th^{b}$ | 100 | $^{242}Pu$ | 1 | $^{254}Cf$ | 1 |
| $^{201}Tl$ | 1 000 | $^{230}Pa$ | 100 | $^{244}Pu$ | 1 | $^{253}Es$ | 10 |
| $^{202}Tl$ | 1 000 | $^{231}Pa^{b}$ | 0.1 | $^{241}Am$ | 1 | $^{254}Es$ | 10 |
| $^{204}Tl$ | 100 | $^{233}pa$ | 100 | $^{242}Am$ | 1 000 | $^{254m}Es$ | 100 |
| $^{203}Pb$ | 1 000 | $^{230}U$ | 1 | $^{242m}Am$ | 1 | | |

[a] Guidance levels are rounded according to averaging the log scale values (to $10^{n}$ if the calculated value was below 3 x $10^{n}$ and above 3 x $10^{n-1}$).

[b] Natural radionuclides.

[c] The provisional guideline value for uranium in drinking-water is 30 pg/l based on its chemical toxicity for the kidney (see section 8.5).