Contamination of Groundwater and Associated Disease: Case Study from Khan Younis Governorate, Gaza, PNA

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Running Title: Contamination of drinking water

ABSTRACT

This study characterizes the current situation of drinking water in Khan Younis Governorate (Kh.Y.), Gaza, Palestine and correlates it with an associated heath problem. About 21 fresh water samples were collected from different water supply sites in Kh.Y. and analyzed for nitrate, chloride, total dissolved salts (TDS) and for fecal and total bacteria. The article also analyzes the environmental situation among the population in Kh.Y. and correlates it with the current health problems.

Chemical parameters indicate that only 3, 8 and 9 wells contained nitrate, Chloride and total dissolved salts (TDS) levels below the WHO standards respectively, whereas the remaining wells contained nitrate, chloride and TDS levels far above the WHO standards.

Furthermore, only 2 wells above all are complying with the WHO standards in a horizontal comparison (comparison of all standard to the same well). Biological parameters indicate that only 6 wells above all were contaminated with fecal coliform and total coliform. Data from the ministry of health indicate that disease cases are progressively increased from one year to the next one indicating a high health risk. This situation may have a correlation with the growing incidence of infectious and non infectious diseases. Improvement of water quality can be possible by implementing strong environmental initiatives such as pollution control measures and clean water act.

Key words: Water sampling sites, nitrate, chloride, TDS, fecal and total coliform.

1. Introduction

Gaza Strip is located in the southern part of Palestine, a semiarid land of total area of 365 km^2 which lies on the Mediterranean Sea. Water quality has become a major environmental concern due to the increasing population and the lack of natural resources. About 181 km^2 is considered as a cropland and it is dominated by poultry industry (Department of Agriculture, 1993). Waste water, industrial wastes, and dead chickens and animals are disposed in the agricultural land. Due to the growing population, many of the industrial units became among human houses and discharge its liquid wastes to the domestic waste pipe lines. The solid waste of these units is dumped in an open area close to water supply wells.

Furthermore, the application of municipal wastes as compost materials to the agricultural sector has become a common agricultural practice to provide nutrients to plants. This attitude may result in ground water contamination with metals or agricultural products with pathogens (Kaschl *et al.*, 2002).

Application of mineral fertilization (NPK) to the soil may significantly change the physicochemical properties of soil and consequently affect the movement of cations or anions in the soil profile and make threats to the surface or ground water (Izuno *et al.*, 1991; Longabucco and Rafferty, 1989). However, shortage of fresh water is perhaps the most crucial environmental problem and may have resulted with the deterioration of water quality due to the excessive use in agricultural and industrial activities. However, previous surveys of environmental problems showed a big concern on water (Safi 1998). Nevertheless, water resources are limited due to the geographical, geological and climatic conditions. Ground water is the only resource of water that can be used for drinking, industrial and agricultural activities. Rainfall in Gaza strip is the only source that may be used for ground water recharge. The annual rainfall ranged between 242-412 mm (Department of Agriculture, 1993).

There are 3 valleys in Gaza Strip, one is located in the northern part (Beit Hanon Vally), the second one is in Gaza city (Gaza Valley) and the third one is located in the southern Zone (Alsalqu Valley). These valleys are almost dry, and in some cases are used for sewage discharge.

Ground water is used for drinking, industrial and agricultural purposes. However, the intensive use of water may create a severe water contamination.

Furthermore, the improper liquid waste systems such as septic tanks, bad links to the sewage water networks; improper waste treatment may generate suitable breading sites for insects of public health importance such as mosquitoes and flies. This situation may create health problems to the population.

In addition, the irregular wastewater treatment plant and dumping liquid waste in the agricultural area may also create pathogenic sources that contaminate the water bodies and transmit diseases to the population. For instance, poor environmental management led to a serious diseases in the United Kingdom (UK), moreover, similarly the United State of America has created more recently the Environmental Protection Agency (EPA) to guide against illness imposed by poor environmental control (Bogg, 1969). The art of safe guarding the environment consists of minimizing the amounts of compounds reaching the water body or land surface and restraining as much as possible the pollutant generating sites by controlling their disposal habits. Heavy metals in the aquatic environment are a serious problem due to the possible toxicity to fish (Nelson et al., 1984), bio-concentration and build up in the food chain (Gavis and Fergusen, 1972), and the serious adverse health effects (Zemansky, 1974). Groundwater sources of the drinking water can have impacts from nitrates, pathogens, salts, and other contaminants from manure. Groundwater is typically more prone to contamination than surface water by nitrates, in particular. In fact, the EPA found that the nitrate is the most widespread agricultural contaminant in the drinking water wells and estimated that 4.5 million people are exposed to elevated nitrate levels from wells (USEPA, 1980).

Previous studies from Gaza water issues focused on ground water monitoring networks (Mogheir and Singh, 2002), evaluation of public concerns (Haddad and Bakir, 1998), ground water contamination (Al-Agha, 1995), a projection of the demand (Awartani, 1994) water situation in Gaza (Shawwa, 1994) and heavy metal contamination (El-Nahhal, 2006). Obviously, very little or no information are available on water quality and the associated diseases in Gaza strip.

This study focused on the characterization of water and the environmental situation in Kh.Y. and correlated it with the associated health diseases registered in Ministry of Health records .

2.Materials and Methods

Description of the study area

Kh.Y. is considered one of the largest governorates in Gaza, Palestine. It is located in the southern part of Palestine, very near to Egypt. The total area is about 117 Km2 . This area includes the surrounding cities such as Qarara, Bani Suhaila and Abasan, more details are shown in Table 1. Large number of people are living and working in the Kh.Y. Agricultural work and Agro-industry are considered the main jobs in Kh.Y that may enhance the overuse of ground water, application of fertilizers and pesticides, using wastewater for irrigation, and using animal wastes as an organic amendment to the agricultural soils.

Agricultural practices affect the natural ecosystem in different ways. For example, manure management of dairy cattle is an important source of ammonia emissions causing acidification and eutrophication (Amann et. al., 2007) while enteric fermentation of dairy cattle is a significant source of methane responsible for global warming (Crutzen et al., 1986).

Animal waste can have a negative impact on surface water, ground water, soil, and air. While there are many sources of water pollution, USEPA (2000) reported that agriculture is the leading source of impairment in the nation's surveyed rivers and lakes. Furthermore, nutrients and pathogens account for a large percentage of contaminants found in the nation's impaired waters (USEPA, 2000)

Regardless to the fact that manure can be a valuable fertilizer and soil conditioner, but in many cases, it is applied in excess of crop nutrient requirements. This problem has been of increasing concern as more concentrated feeding operations maintain greater numbers of animals.

2.1 Data Collection. Data on water consumption and wells distribution were collected from water authority by personal contact with scientists, water experts and decision makers in ministry of agriculture, chief officers in the united nation relief and work agency for the Palestinians (UNRWA), municipalities and local authority. Those people were met because they are responsible for water supply in different locations in Gaza. Detailed information on the distribution of wells and the quantity of water pumped are shown in Table 1.

2.2 Sampling sites. Several wells used for domestic consumption in different sites in Kh.Y were subjected to water sampling. The distance among wells varies between 2-3 km. The soil characteristics on the sampling sites are relatively similar with close hydraulic conductivity. Agricultural and industrial activities are similar around the sampling sites. Also the population densities around the sampling sites were very close to each other.

2.3 Water Sampling. Water samples were collected in May 2010. The volume of each sample was 20 ml collected in a plastic bottle directly from the well after 0.5 hour of water pump operation as described previously (El-Nahhal, 2006). Bottles were sealed and stored at room temperature and analyzed in the next day. Some samples were collected from sites and houses that receive water supply from the same site in order to evaluate the efficiency of the networks.

2.4 Sample preparation and analysis

Following the procedure described previously (El-Nahhal, 2006), anions concentration in a 1/10 and 1/100 dilutions of the original samples were determined with a DX-300 Ion Chromatography, (Dionex Corp., Sunnyvale, California) using AS9-SC analytical column and guard column. An anion micro-membrane suppressor and carbonate/bicarbonate buffer were used as eluting. Measurements were calibrated using special standards from Dionex and Altech. Average and standard deviation were calculated from duplicate samples.

2.5 Collection of health data

The data were collected from the annual published health reports in the last two year. Furthermore, several visits to the ministry of health were made to discuss the collected data. In addition, data were also collected from the published reports of the Palestinian central bureau of statistics (PCBS). The data were screened, cleaned and processed accordingly in a suitable statistical data processing program.

3. Results and Discussion

Water consumption and a number of wells in different locations of Kh.Y. are presented in Table 1. It can be seen that the total number of wells are 423. They are used for agricultural activities along with industrial and domestic purposes. This large number of wells indicates that Kh.Y. is an agricultural area. However, only 28 wells are used for drinking water.

Table 1. Distribution of land in Khan Younis Governorate

Location	Total area (Km2)	Agricultural area (Km2	Number of well
Mawassi	8	7.5	173
State land	24.652	10	23
Khan Younis city	28.036	16.5	182
Qarara and Bani Suhaila	18.5	8.8	14
Abasan	21.5	12.5	25
Khuza'a	4.312	2.8	6
Fukhari	11	9.8	-
Total	116	67.9	423

Adopted from Palestinian central bureau of statistics (Palestinian Central Bureau of Statistics, 2011).

Selected properties of drinking water in Kh.Y. are shown in Table 2. It can be seen that Nitrate level ranges between (31±3) – (394±23). Comparison of the WHO standard for nitrate level shows that only 3 wells named Rahma, Saa'da and Sharkia are in the acceptable range. Comparison of WHO chloride standard for the drinking water wells listed in Table 2 shows similar feature to Nitrate standards. Furthermore, TDS values in all wells are above the WHO limit indicating that the drinking water quality of the listed wells are not suitable for human consumption.

The biological contamination of drinking water (F and T coliform) indicates that 7 wells are contaminated with a considerable number of F and T coliform bacteria. This indicates the high health risk which is associated with the current drinking water. This high level of total and fecal coliforms contamination may be attributed to the improper sewage system in Kh.Y.. However, various levels of total and fecal coliforms have also been found in water samples collected from 20 groundwater wells located in the surrounding area of the wastewater treatment ponds of Beith Lahia and Gaza Strip (Melad, 2002). Similar risk factors were also reported in Palestinian refugee camps (Abu Mourad, 2004).

Table 2. Nitrate, Chloride,TDS, Fecal coliform and total coliform in the drinking water of Kh.Y.

Well name	Nitrate mg/l	Chloride mg/l	TDS mg/l	Fecal coliform	Total coliform
Amal	368±32	379±23	1416.5±41	ng	ng
Saa'da	342±22	833±16	2368.5±50	5	2
Ahraash	355±31	674±21	1928±25	ng	ng
Shaequi	208±	918±10	2669±71	ng	ng
Aia	394±23	834.5±17	2511±31	ng	ng
Shaaer	155±16	585±9	1513±56	ng	ng
Jadeed	128±24	1128±283	2344±212	ng	ng
Al-madeena	79±8	872.5±15	2498.5±45	1	20
Al-Markaz	150±21	744±73	2241.5±35	ng	ng
Al-Aqsa -	117±12	95±14	491.5±20	ng	ng
Al-Mawasi	99±11	105.5±5	388±13	ng	ng
Al-Satter 1	304±47	133±13	705.5±17	ng	ng
Al-Satter 2	189±50	119.5±7	578.5±30	ng	ng
UNRWA-S	210±10	106±50	440±32	ng	ng
UNRWA-N	153±3	161±20	609.5±65	ng	ng
Rahma	31±3	302±23	963.5±146	ng	ng
Islamic relief	116±27	562±11	1624±343	1	7
Turuk	304±97	412±19	1270±341	>100	>100
Al-Waledain	226±25	511±55	1420±118	>100	>100
Saa'da	49±5	75±5	243±17	3	12
Sharkia	46.5±6	68±2	218±13	ng	ng
WHO	45	250	1000	00	00

Furthermore, the microbiological aspect of drinking water is an important factor for the waterborne diseases. Accordingly, detecting bacterial indicators in the drinking water suggests a possible transition of a waterborne disease. Records from the ministry of health showed a progressive health disease associated with water contamination. Abu Mourad, (2004) reported intestinal parasites and diarrhea in Nuseirat refugee camp as a case study.

Recorded waterborne disease among the people of Kh.Y are shown in Table 3. The presented Data clearly demonstrate a progressive increase of waterborne diseases from year 2009 to year 2010. This may indicate an endemic disease in Kh.Y. Previous studies (Abu Mourad, 2004; Yassin et al., 2006) showed similar results in the heath records of another area of Gaza.

Table 3. Recorded waterborne diseases in Kh.Y.

Disease	2009	2010
Diarrhea (0-3 yrs)	35165	45249
Diarrhea(4y->)	19,588	24,501
Bloody Diarrhea	4970	5018
Food poisoning	94	105
Amibiasis	5636	7514
Enterbiasis	22	57
Ascarsis	220	232
Gardiasis	2581	3050
Strongiloidosis	7	8

The data in Table 3 clearly indicate the growing incidence of waterborne diseases recorded in Kh.Y. in years 2009-2010. These results are in agreement with the data in Table 2 which shows the biological contamination of drinking water wells as shown by the presence of F and T coliform in 6 wells out of 28, indicating severe contamination. Furthermore, the cancer cases registered in Kh.Y. in the year 2010 (Table 4) clearly indicate the high incidence of non-communicable disease. The high number of cancer cases may be correlated with the contamination of drinking water specially with the high levels of nitrate as shown in Table 2. It was believed that the high levels of nitrate was a cause of stomach cancer. For instance, historically nitrite and nitrate were considered harmful food additives and listed as probable human carcinogens under conditions where endogenous nitrosation could take place (Bryan et. al., 2012).

Table 4. Cancer cases registered in Khan Yunis Governorate in 2010

Cancer type	Number of cases
Thyroid	7
Breast	14
Brain	4
Cervical	2
Leukemia	5
Prostate	2
Lung	7
Lymphatic	1
Colon	7
Spine	1
Total	50

Furthermore, Holtrop *et al.* (2012) reported that the endogenous formation of the carcinogenic N-nitroso compounds (NOC) occurs in the human gut and nitrate levels and red meat are considered the most important sources. Chiu et al.(2012) examined the relationship between the nitrate levels in public water supplies and the risk of death from gastric cancer. They showed that the correlation between NO(3)-N exposure and the risk of gastric cancer development was influenced by Ca and Mg levels in the drinking water. This discussion strongly link the cancer cases in Kh.Y (Table 4) with the elevated nitrate levels in the drinking water (Table 2).

Accordingly, it is highly recommended that the young children and pregnant and breast-feeding women refrain from drinking unfiltered water.

Furthermore, the animal and chicken houses in Kh.Y are presented in Table 5, which strongly correlate the source of microbial contamination to the drinking water.

Table 5. Animal and chicken houses in Khan Yunis

Type of house	Number of houses	Population of animal	Estimated waste (ton/year)
Horse	28	480	1752
Donkey	26	530	1935
Caws	55	1330	4855
Camel	NA	372	1358
Goat	350	18168	NA
Chicken	470	NA	NA

NA= not available

It can be seen that Kh.Y. contains high numbers of various animal and chicken houses with large populations. It is also obvious that a large amount of waste are produced each year by their animals and can be used as an agricultural organic manure without any treatment. These animal wastes contain a high fraction of pathogens and pose risk to the human health. Our discussion is fully supported by previous reports (USDA, 1992; Jackson *et al.*, 1987) who demonstrated that animal wastes carry parasites, bacteria, and viruses, many of which have the potential to be harmful to the wildlife.

In addition, the contamination of water sources with animal waste may transfer pathogens to fish skin (Fattal *et al.*, 1992). Furthermore, over 150 pathogens in the livestock manure are associated with risks to the humans (CAST, 1992).

The number of horse houses and donkey houses are not too large in Kh.Y. comparing to the number of available donkey and horse houses. This suggests that there are officially registered houses and non-officially registered houses. Nevertheless, the most interesting issues here are the estimated wastes that may be generated from the animals. It can be seen that large quantities of wastes are generated by the animals. Furthermore, the contamination of groundwater with considerable levels of nitrate may occur due to the application of animal and/or swine manure (Krapac et al., 2002). This argument strongly supports our data in Table 2.

In addition, animal wastes may produce ammonia, methane and hydrogen sulfide due to the anaerobic degradation of organic waste (de Boer 2003) which attract some harmful insects that expose the population to health risk (Halden and Schwab, 2007).

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Conclusion

The current study clearly indicated the chemical and biological contamination of drinking water in Kh.Y. The study revealed the high level of the health risk associated with the nitrate levels in the drinking water. Furthermore, the biological contamination probably comes from the large numbers of animal houses among the population which may transmit pathogens to the local population via water or insects which may be attracted to the area due to the ammonia emission that may be resulted from biodegradation. The concern for drinking water quality is highly important when we consider the infants and the growing children. This chemical situation of drinking water in Gaza, Palestine may have a strong positive association with the current growing incidence of diarrhea in children and cancer cases. It is highly recommended to apply water quality act and pollution control measures so that to reduce the contamination and consequently the health risk to population. Improvement of this situation may be realized through the implementation of environmental rules in our daily life.

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