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The Influence of Fertilizers on Groundwater Quality in Gaza Strip

—Free Settlements on Khan Younis—Case Study

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Abstract

The Palestinian Ministry of Agriculture started the agricultural investment in some free settlements in Gaza strip since 2008. The proposed areas to be planted and the proposed crops were chosen randomly without any researches to study the expected adverse impacts of these agricultural projects on the environmental components. This research aimed at the groundwater aquifer in the proposed region physically and chemically by taking five water samples from water wells in the place. Represented groundwater samples taken from observation wells in the study area were tested in term of total dissolved solids (TDS), electric conductivity (EC), and (N-P-K) concentrations to be compared with the regulated groundwater standards. As a result of testing two fertilizers, it is found that the announced concentrations of (N-P-K) don't match the real results. The real results are less than the announced concentrations, especially for the phosphorus concentration which had a real result about half of the announced concentration for both fertilizers. Although the real concentrations of (N-P-K) in the used fertilizers are less the announced concentrations, slightly pollution is found in the groundwater aquifer. The groundwater testing results in five observation wells showed that the groundwater tends to be basic, high salinity ranged between 550 and 3500 μS/cm, and Total Dissolved Solids (TDS) results ranged between 330 and 2300. Nitrate results ranged between 65 and 160 ppm, whereas phosphorus and potassium results showed that all groundwater samples met the standards and didn't exceed them.

Keywords

Free Settlements, Khan Younis, Groundwater Aquifer Quality

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1. Introduction

Groundwater is the most important water resource on earth [1]. The quality of groundwater is generally under a considerable potential of pollution especially in agriculture dominated areas with intense activities that involve the use of fertilizers and pesticides [2] [3].

Groundwater is the main and sole water resource in the Gaza Strip. The aquifer is intensively exploited through more than four thousand illegal pumping wells, so that the aquifer has been affected by seawater intrusion in many locations in the Gaza Strip. It was estimated that approximately 150 Mm^3/yr water was pumped from about 4100 wells [4], of which about 90 Mm^3/yr water was used for irrigation and 60 Mm^3/yr was pumped for domestic and industrial uses from 100 municipal wells [5]. Salinity of the groundwater increases over time due to seawater intrusion and mobilization of incident deep brackish water caused by over abstraction of the groundwater. In most parts of the Gaza Strip, the chloride and nitrate content of domestic water exceeds the WHO guidelines [6].

Palestinian occupied lands in Gaza strip, which became free since 2005 after the Israeli withdraw, were partially used for agricultural purposes. The estimated areas of the free lands are 26,000 dunums (about 7% of the Gaza strip area), whereas the surrounding areas of the free settlements which also were occupied estimated about 52,000 dunums (about 14% of the Gaza Strip area). Totally, about 78,000 dunums are owned to the Palestinian government in the free settlements, and another 7.4% of the Gaza strip area are owned to Palestinian farmers since 2005 [7]. MOA started a group of agricultural projects in various areas in free settlements [8].

The two main used fertilizers are called (13-13-13) to indicate the percentages of the three main nutrients N = 13%, P_2O_5 = 13%, and K_2O = 13%, and (11-8-22) to indicate the percentage of the same nutrients [9].

Twenty six of water wells were created in free settlements; they discharge about 6 million m^3/year, and about 2.5 million m^3/year water is used for plantation projects. This water has characteristics of high quality. The chloride concentration is not more than 350 ppm in all free settlements [10].

2. Materials and Methods

2.1. The Study Area

The Gaza Strip is one of the most densely populated areas in the world (2638 people per km^2) [11].

The study area is the general administration lands in free settlements which located west of Khan younes governor. Its area is about 240 dunum, and the coordinates of the study area center are (x = 81011.061209, y = 2367011.684823) (**Figure 1**).

The study area contains small five wells into and surrounding its boundary, as well as five municipal wells are located around the study area. The irrigation process in study area depends on the fifth municipal wells, whereas the five groundwater wells can be used for small purposes such as drinking or washing. The five small wells can be used for groundwater observations.

The study area is planted by many types of plants and fruits, in this study, four types of plants and four types of trees are studied to observe the potential effects of their fertilizers on the groundwater aquifer.

2.2. Proposed Water Samples

Six water samples were collected to be tested chemically. Five of water samples were collected from observation wells located inside the study area or just beside it, whereas the sixth water sample was collected from the water irrigation reservoir which used to irrigate the agricultural lands inside the study case. The collected water samples were stored in appropriate bottles and transferred to Coastal Municipal Water Utility (CMWU) labs to be tested in the same day.

2.3. Water Tested Parameters

Group of chemical tests were proceeded to test the quality of water source which feed the study area, and some surrounding groundwater wells. It is worth mentioning that seven municipal water wells are used to irrigate this study area, all of them are collected in one huge reservoir that serves the whole area, thus one sample from the reservoir was enough to be tested in term of pH concentration, electric conductivity, and nitrogen-phosphorous-potassium concentrations. In the other hand five small groundwater wells are used for observations, one

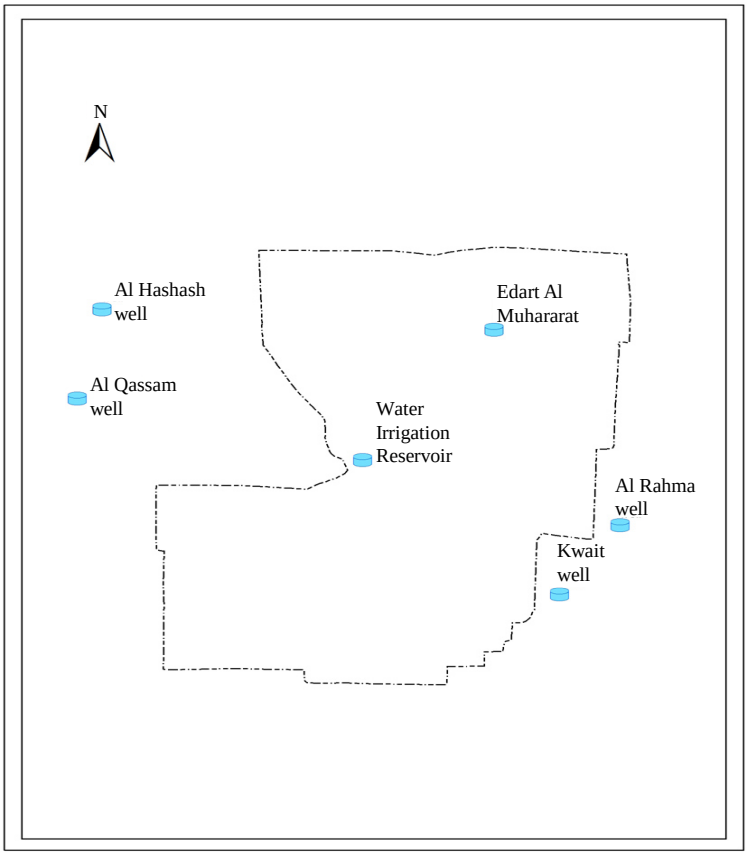

Figure 1. Water wells in the study area.

water sample was taken from each of the five observation wells to be tested in term of the same the same last mentioned parameters.

3. Results and Discussion

3.1. Fertilizers

The results of two types of fertilizers which contain mainly the nutrients (N-P-K) are shown in **Table 1**. The first fertilizer is called (13-13-13) to indicate the percentages of the three main nutrients N, P_2O_5, and K_2O respectively, and the second fertilizer is called (11-8-22) to indicate the percentage of the same nutrients. According to the chemical tests, results explain that the announced percentages are not true, and the real results are less than announced. In this paper, the real results were used for all calculations.

The quantity of fertilizers used for the four crops are shown in **Table 2** for plants and **Table 3** for fruits. These quantities are approximately estimated by the in charge engineer in the study area, they indicate the total quantity of both main fertilizers (13-13-13) and (11-8-22) used annually for each crop. Some of crops have one time life cycle per year such as pepper, whereas other crops have two life cycles or more in one year such as tomato (**Figure 2**).

Table 4 shows the quantities of pure main nutrients (N-P-K) used annually in the plants crops. It worth to mention that these quantities represent the pure nutrients feed by the chemical fertilizers only.

It is noted that cucumber land has more nutrients than other plants; it refers to the quantities of used fertilizers used annually for cucumber land and it is noted that cucumber land is planted two times annually, so that it has two rounds of fertilizers annually, whereas the pepper land has the lowest quantities of nutrients, it also refers to the annual quantities of used fertilizers for pepper land for one time annually (**Figure 3**).

In the other hand, **Table 5** shows the quantity of pure nutrients (N-P-K) used annually for tree crops. The quantities indicate the chemical fertilizers only.

Table 1. Results of chemical tests for used fertilizers.

Item	Announced 1st Fertilizer (%)	Real 1st Fertilizer (%)	Announced 2nd Fertilizer (%)	Real 2nd Fertilizer (%)
N	13	13.5	11	9
P as P_2O_5	13	4.5	8	4.5
K as K_2O	13	13	22	22

Table 2. Quantity of fertilizers used for the proposed crops.

Crop	Quantity of fertilizers used (kg/year/du)	
	13-13-13	11-8-22
Potato	60	0
Tomato	30	0
Cucumber	20	95
Pepper	20	0

Table 3. Quantity of fertilizers used for the proposed crops.

Crop	Quantity of fertilizers used (kg/year/du)	
	13-13-13	11-8-22
Orange	52	52
Plum	52	78
Mango	52	78
Apple	52	78

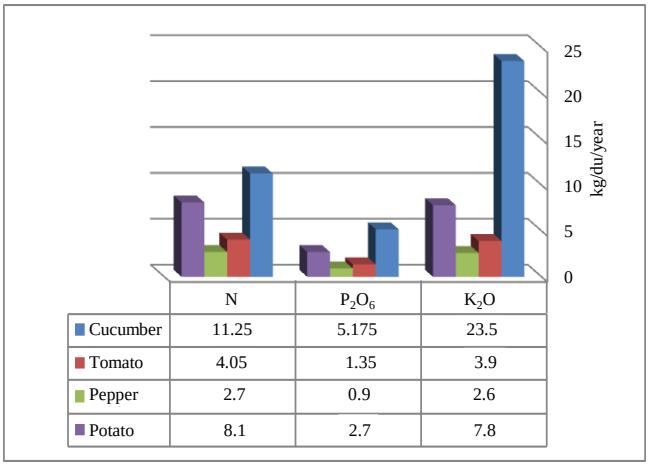

Figure 2. Quantity of pure nutrients used annually for the plant crops.

It is noted that Mango, Plum, and Apple lands have the same quantities of nutrients annually, this can be explained that these lands have the same type of fertilizers, and for two rounds annually, whereas the orange land has more nutrients than other fruit lands, it refers to the annual used quantities of fertilizers in the orange land.

3.2. Water Irrigation Source

The water source used for irrigation is taken from seven different groundwater wells located around the study area; the collected water is mixed before irrigation. **Table 6** shows the results of chemical potential pollutants in the water source used for irrigation.

It is found that the water source meet the Palestinian regulatory standards amended by Environmental Quality Authority in 2010.

Table 4. Quantity of pure nutrients used annually for the plant crops.

Nutrient		N		P_2O_5		K_2O	
		1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
Percentage		13.5%	9%	4.5%	4.5%	13%	22%
Cucumber (kg/du/year)	Fertilizer Quantity	20	95	20	95	20	95
	Nutrient Quantity	11.25		5.175		23.5	
Tomato (kg/du/year)	Fertilizer Quantity	30	0	30	0	30	0
	Nutrient Quantity	4.05		1.35		3.9	
Pepper (kg/du/year)	Fertilizer Quantity	20	0	20	0	20	0
	Nutrient Quantity	2.7		0.9		2.6	
Potato (kg/du/year)	Fertilizer Quantity	60	0	60	0	60	0
	Nutrient Quantity	8.1		2.7		7.8	

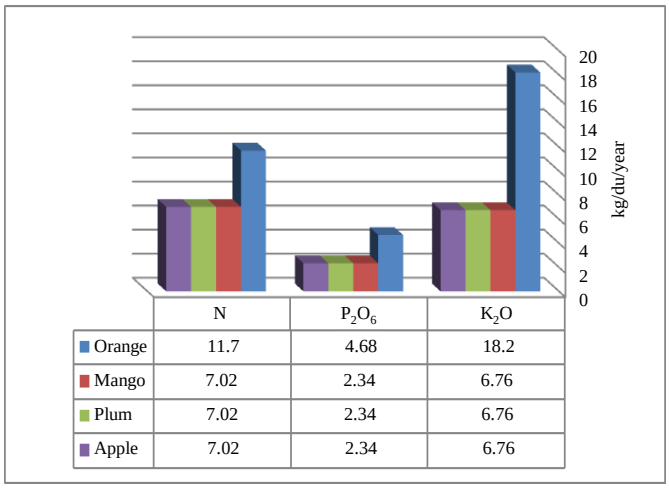

Figure 3. Quantity of pure nutrients used annually for the plant crops.

Table 5. Quantity of pure nutrients used annually for the fruit crops.

Nutrient		N		P_2O_5		K_2O	
		1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
Percentage		13.5%	9%	4.5%	4.5%	13%	22%
Orange (kg/du/year)	Fertilizer Quantity	52	52	52	52	52	52
	Nutrient Quantity	11.7		4.68		18.2	
Mango (kg/du/year)	Fertilizer Quantity	52	78	52	78	52	78
	Nutrient Quantity	7.02		2.34		6.76	
Plum (kg/du/year)	Fertilizer Quantity	52	78	52	78	52	78
	Nutrient Quantity	7.02		2.34		6.76	
Apple (kg/du/year)	Fertilizer Quantity	52	78	52	78	52	78
	Nutrient Quantity	7.02		2.34		6.76	

Table 6. Chemical and physical characteristics of water irrigation source.

Item	Result	Regulatory Standard
pH	7.250	6.5 - 9.5
EC (µS/Cm)	955	1500
TDS (mg/L)	500	1000
K (mg/L)	5	12
PO_4 (mg/L)	0	6.7
NO_3-N (mg/L)	17	70

Table 7. Chemical and physical characteristics of groundwater aquifer in the study area.

Well	pH	EC (µS/Cm)	TDS (mg/L)
Al-Rahma	8	3550	2270
Kwaiti	8.1	2240	1430
Edart Al-Muhararat	8.3	2670	1700
Al-Hashash	8.1	745	450
Al-Qassam	7.3	565	330
Standard Value	**9.5**	**1500**	**1000**
Well	**NO_3-N (mg/L)**	**PO_4 (mg/L)**	**K (mg/L)**
Al-Rahma	71	0.03	5.9
Kwaiti	96	0.04	3.9
Edart Al-Muhararat	65	0.01	6.9
Al-Hashash	164	0.19	2.9
Al-Qassam	160	0.19	1.9
Standard Value	**70**	**6.7**	**12**

3.3. Groundwater at Study Area

The groundwater at the study area is tested to evaluate if the chemical fertilizers pollute the near groundwater aquifer, **Table 7** shows the results of chemical and physical characteristics of five various wells are located in and around the study area, and compared with the regulatory standard value.

It is found the most chemical and physical characteristics such as pH, PO_4, and K meet the regulatory standard values, but the salinity of water in some cases does not meet the natural salinity standard as in Al-Rahma, Kwaiti, and Edart Al Muhararat wells, but it meets the standards in Al-Hashash and Al-Qassam wells. The nitrate concentrations also are higher than the natural range in all wells except Edart Al Muhararat. The groundwater potential pollution could be caused due to the random use of chemical fertilizers; this potential pollution could be expanded in the future.

4. Conclusions

The main goal of this study was to evaluate the groundwater aquifer in part of the free settlements areas using contaminants indicators. Five samples of groundwater were tested chemically in term of total dissolved solids (TDS), electric conductivity (EC), and (N-P-K) concentrations to be compared with the regulated groundwater standards and to check the effect of fertilizers on the groundwater aquifer, whereas another water sample collected from the water irrigation reservoir was tested to check the quality of water used for irrigation.

The groundwater testing results in five observation wells showed that the groundwater tends to be basic, and has high salinity values, and registers high TDS results. Nitrate results also exceeded the standard and thus referred to the usage of fertilizers over the study area. Phosphorus and potassium results showed that all groundwater samples met the standards and didn't exceed them.

To be concluded, six groundwater samples in the study area were tested, and by analyzing the chemical results, it is found that groundwater is polluted in term of nitrates and has a high salinity value which indicates that the random use of fertilizers in the study area is the main reason for this pollution.

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