GIS MAPPING OF GROUND WATER WELLS AND LAND USE STUDY OF THE EOCENE AQUIFER ZONE IN PALESTINE

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Abstract

This research presents the results of filed work conducted by the author in the Eocene aquifer zone as part of the PADUCO-GDSS project. The task was to investigate the number of wells, rate pumping ground water wells and land use in the Eocene aquifer study area.
A structure questionnaire was designed which include information about the coordinates, depths, operation status, rate of pumping, water network, sewer network and on-ground potential source of pollution such as industrial activities, farms, and landfills. The questionnaire also, included some items about land use which covers about 17 main classes such as paved streets, residential & industrial buildings, agricultural irrigated and non-irrigated lands, greenhouses, wadies and forests.
A list of more than 312 ground water wells along with potential on-ground source of pollution, spatial maps were prepared for the Eocene aquifer zone. The results and data of this field work was necessary for modeling of the Eocene Aquifer, groundwater quantity and quality, and to develop a ground water decision support system (GDSS) for Eocene Aquifer.

Keywords: GIS mapping, source of pollution, land use, Eocene Aquifer,

1. Introduction

In the Middle East, fresh water is considered one of serious and disputed issues due to the semi-arid weather and scarcity of rain. Palestine is considered as one of the countries suffering from scarcity of surface water and ground water. However, due to rising population, ground water has become essential to supplement drinking water demands. This limited resource has been overexploited and the quality and quantity has been deteriorated.
The Palestinian-Dutch Cooperation on Water (PADUCO-2), is one of the projects funded by the Netherlands Representative Office in Ramallah-Palestine. The project aims at promoting cooperation between Palestinian and Dutch researchers on water researches and to benefit from the Dutch experience in this field. One of the integrated research projects under PADUCO-2 is the project titled: Development of a groundwater decision support system for optimal management of pumping and for the protection of groundwater quality (GDSS), for the Eocene Aquifer Zone. The main objective of the GDSS project is are (1) to optimally determine the pumping rates and (2) to set up zones of quality protection.
Geographic Information System (GIS) coupled with the Global Positioning System (GPS) offers an ideal tools for integrating spatial and attribute data on natural resources and environment, and for subsequent generation of optimal land use plan on surface and ground water [D.P. Rao, 2000]. Groundwater quality mapping can be a powerful tool for the planners to make decisions to improve the groundwater quality in contaminated regions. The spatial mapping of ground water level and quality, are also useful to for planners to identify suitable zone for pumping for irrigation and domestic purposes.

2. Objectives and Methodologies

The main objective of this research is to present the results of 6 field visits conducted by the authors to the Eocene Aquifer study area, the visits aims to document all necessary information about the groundwater wells. The results of this study was necessary to other stages of the PADUCO-GDSS project to develop a quality and quantity model and to develop a ground water decision support system (GDSS) for Eocene Aquifer. The methodology to accomplish the task of the research are as follows:

① A structures questionnaires was developed to facilitate collection of data about the wells in the study area.

② Conduct Several field visits, the GPS and orthophotos was used for the characterization of the current land uses

③ GIS (ArcMAP) was used for the characterization of the spatial distribution of on-ground activities and chemical existence in groundwater aquifers and for all the wells, springs, and potential distribution of water supply for agriculture and domestic uses

④ Development of topographic map, land use map, spatial maps for active wells, closed and suspended wells, and on-ground potential source of groundwater contamination.

3. Literature Review

The Eocene Aquifer and Study Area

The Eocene Aquifer is underlying Jenin governorate in Palestine. Topography of the Jenin district can be divided into three areas, the eastern slopes, the mountain crests and the western slopes. The eastern slopes are located between the Jordan Valley and central highland. They are characterized by steep slopes, which contribute to forming young wadis. The mountain crests form the watershed line and separate the eastern and western slopes. The altitude ranges on average between 500 and 650 meters above sea level. The western slopes, characterized by gentle slopes, have elevation ranges between 100 and 400 meters above sea level [ARIJ, 1995].

The Eocene aquifer is composed mainly of limestone and chalk, which form the ground water water-bearing formations (aquifers), separated relatively impermeable beds of chalk, clay, and marl (aquitards). The ground water potential of northeaster aquifer system was estimated to be around 140 MCM/yr. [PHG, 1996].

The Eocene aquifer is one of the major groundwater aquifer in Palestine. It is located in the northeastern part of the West Bank covering areas of both Jenin and Nablus Districts. The flow direction within the aquifer is from the south to north and northeast. The development of the groundwater within the Eocene aquifer is very important for the Palestinian water supply. The people in Palestine utilizes the Eocene ground water from domestic and agricultural uses. The outcrop area of the Eocene aquifer is about 520 km2. [H. Tubeileh et. al., 2006]. Figure 1. illustrate the Eocene Aquifer study area.

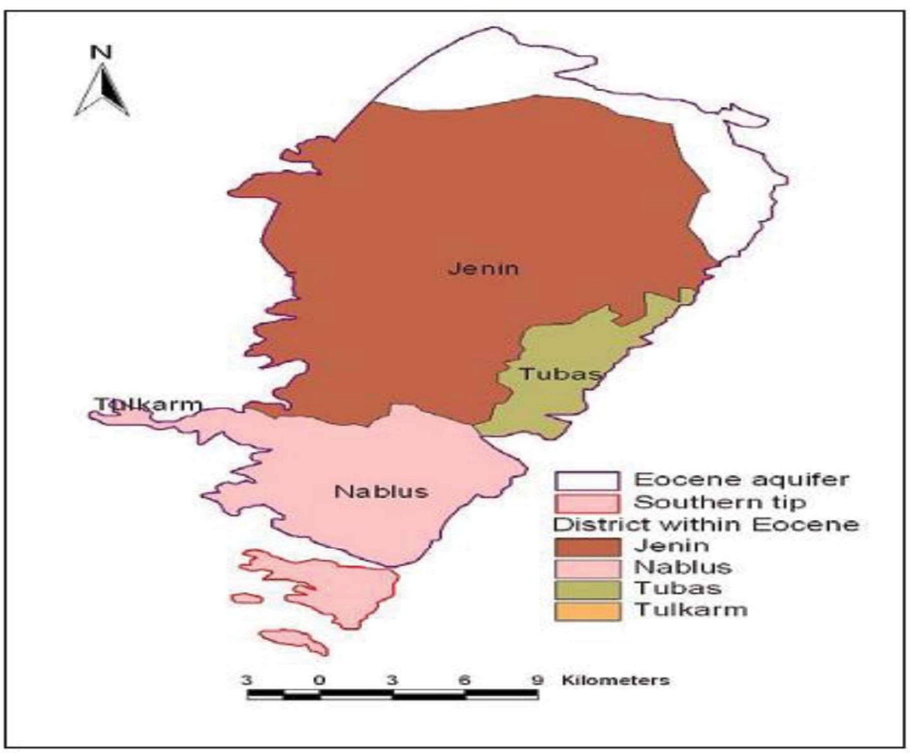

Figure 1. The Eocene Aquifer

M. Juaidi (2008), prepared a MSc. Study in which focuses on the quantification of groundwater recharge for the entire West Bank and for each aquifer using the soil moisture (SMD) method. The SMD method is the most applicable method for recharge estimation under arid and semi-arid conditions. Model Builder of GIS was utilized to facilitate the recharge quantification and to efficiently account for the spatiality inherent in recharge.

Chowdary and Giridhar (2015), presented the results of study of groundwater quality by using GIS technique. The spatial distribution of groundwater quality parameters was studied after rain water recharge in Jntuh Campus. The authors artificially recharged 5 wells with 9 injection wells at different locations, to recharge into the confined and unconfined aquifers. Different Physico-Chemical water quality parameters were tested for sample collected from the injection wells. Spatial analysis has been developed by using GIS from the physic-chemical parameters and compared with BIS:105000, 1991 standards.

Venkateswaran and Ayyandurai (2015), used the GIS technique to model the groundwater potential zoning in upper Gadilam River Basin-Tamil Nadu. The authors used an integrated approach of remote sensing and GIS ; different thematic maps like geology, geomorphology, lineament and lineament density, drainage , drainage density and slope maps has been prepared from topographic maps, for the study area. The authors developed a composite groundwater potential map as very high, high, medium, low and very low based on the groundwater availability in the study area.

Chikodzi , D. and Mutowo, G. (2014), presented results of modelling the variation in groundwater potential within Zimbabwe. The input parameters used in their study were, lithology, groundwater productivity, slope, and depth to groundwater, faults, groundwater storage and their relationship. The author concluded that, using known groundwater determinants as input parameters, the Geographical Information System (GIS) can be used to accurately map the spatial variation in groundwater potential.

Khadri and Moharir, (2014), presented the results about using the GIS to monitor the groundwater quality. The GIS was used for the spatial analysis and it is powerful tool for representation and analysis of spatial information related to water resources. The major water quality parameter such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), the Total hardness, Sulphates and Calcium have been analyzed. The final integrated map showed three priority classes such as High, Medium and Low groundwater quality zones of the study area and provides a guideline for the suitability of groundwater for domestic purposes.

Rawal D. Vyas A. and and Rao S.S (2016) presented results of a study about the application of GIS in establishing the basic parameters of soil, land use and the distribution of water logging over a period of time and the groundwater modelling identifies the groundwater regime of the area and estimates the total recharge to the area due to surface water irrigation and rainfall and suggests suitable methods to control water logging in the area.

4. Ground Water Wells in the Eocene Aquifer Study Area

A survey of the ground water well in the Eocene Aquifer has been conducted. A structured questionnaire was prepared which consist of different question related to the freshwater sources and consumption, wastewater generation and discharge methods. Also, the questionnaire included some information collected related to the ground water wells such as, coordinates, depth, rate of daily discharge (pumping), water quality. At least 6 field visits were made during 3 months to cover the whole Eocene study area which is about 520 km^2. A total of 312 wells were visited and their information was recorded. Figure 2. shows an overlay spatial map for 312 ground water wells recorded during 6 field visits, superimposed on topography map developed for the Eocene Aquifer study area.

5. Land Use in the Eocene Aquifer Study Area

Land use maps were developed for Eocene Aquifer study area. The land use is classified into 17 classes. Table 1. presents the estimated total areas of each class. Figure 3. shows a spatial map of the ground water wells and Land cover in the Eocene Aquifer study area.

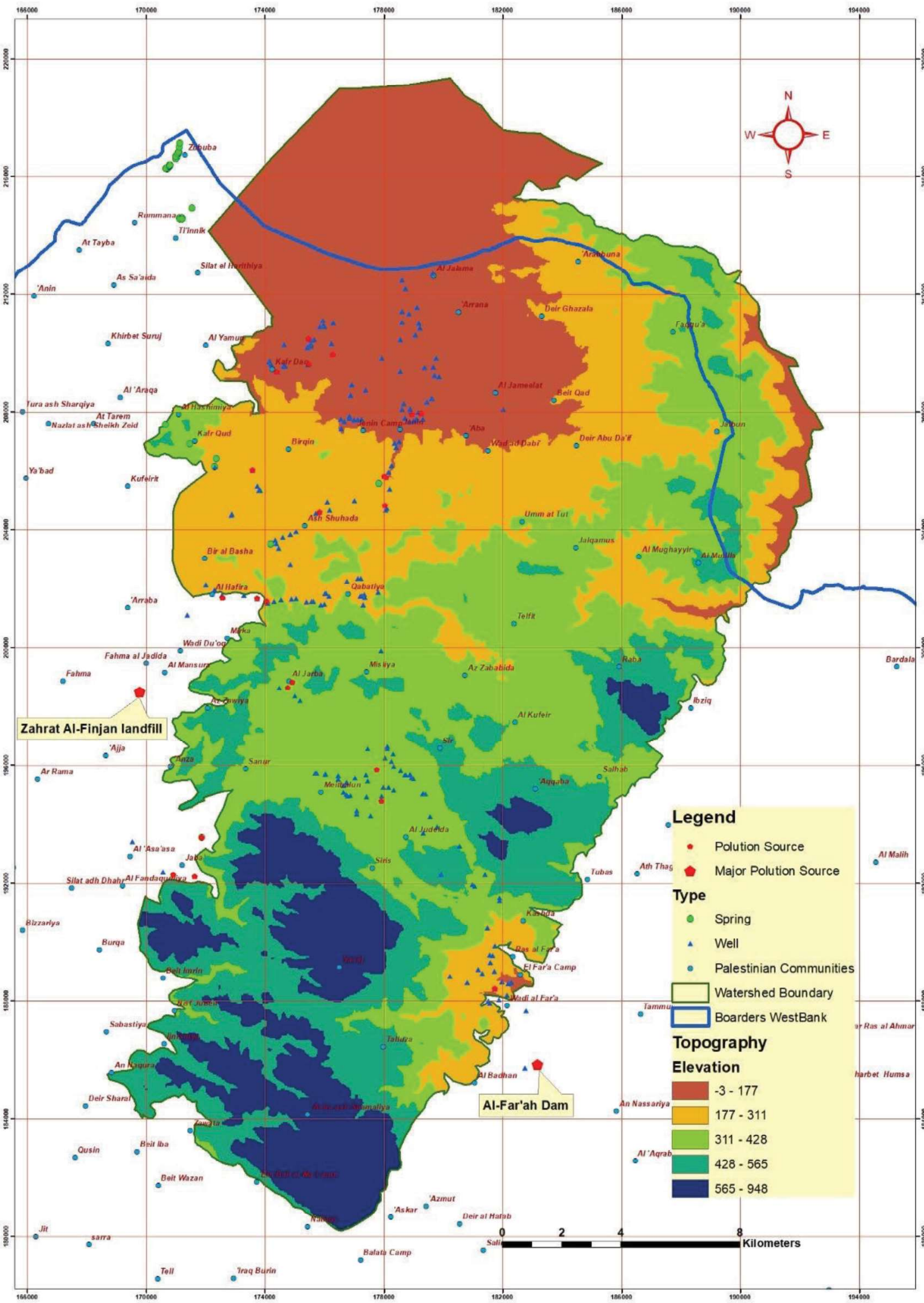

Figure 2. Groundwater Wells and Topography of the Study Area

Table 1. Summary of Land use in the Eocene Aquifer study area

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OID	landuse2	Count_landuse2	Sum_area	Sum_area_km2
0		3	0	0
1	Agricultural irrigable areas (crops)	1631	75731414.0345	75.731414
2	Agricultural irrigable areas (trees)	1447	39789689.4633	39.789689
3	Agricultural irrigated areas (crops)	483	55703160.5956	55.703161
4	Agricultural irrigated areas (trees)	72	1044982.06781	1.044982
5	Buildings or (normal) Urban areas	4391	19063978.71	19.063979
6	Buildings or intensive use Urban areas	638	6292860.87297	6.292861
7	Dirt road	1621	4718309.45601	4.718309
8	Farms	2	1172.679947	0.001173
9	Greenhouses	1709	3234667.51287	3.234668
10	Paved Roads system	637	6185491.38277	6.185491
11	Quarry	49	2211319.62168	2.21132
12	Rainfed areas (flat or terrace)	1	2275.204852	0.002275
13	Scattered buildings (not covered by above building areas)	1451	4747471.13009	4.747471
14	Sewage wadies	1	1643.537718	0.001644
15	Shrub lands	1395	187306425.07	187.306425
16	Trees (not irrigated) with terrace fields	669	44252415.0966	44.252415
17	Trees (not irrigated) without terrace fields	452	13449516.6367	13.449517

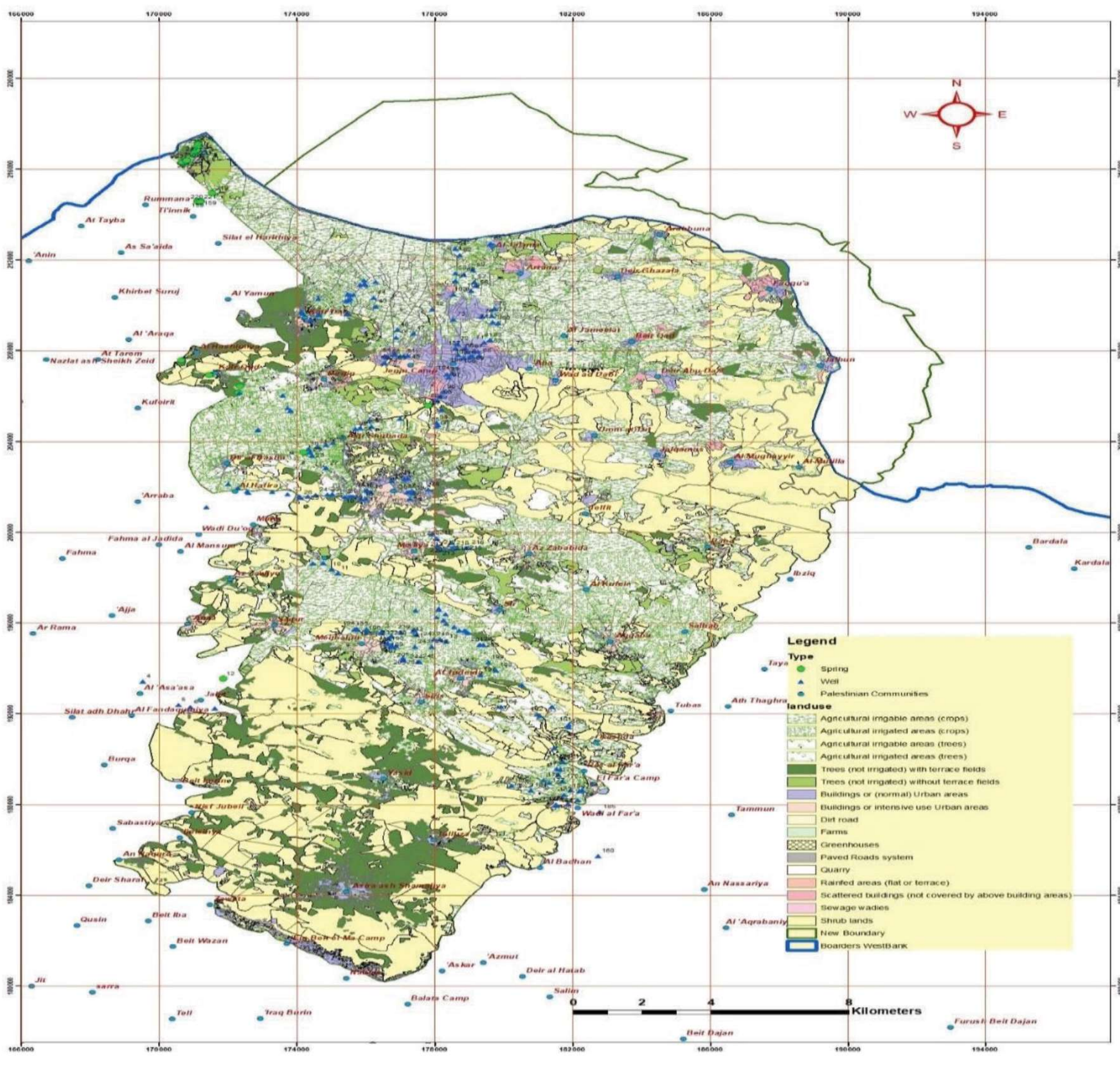

Figure 3. Spatial map of the ground water wells and Land cover in the Eocene Study Area.

6. Closed or Suspended Ground Water Wells

During field visit, the authors cited about 26 closed and suspended wells. The coordinates of all wells are recorded and, and spatial map is developed as shown in Figure 4. It should be noted many communities use the closed and suspended wells to discharge sewer water, as we informed by some people. Therefore, all the closed and suspended wells are considered as direct on ground potential sources of contamination for ground water in the Eocene Aquifer zone, and this misconduct should be monitored and stopped by the authority.

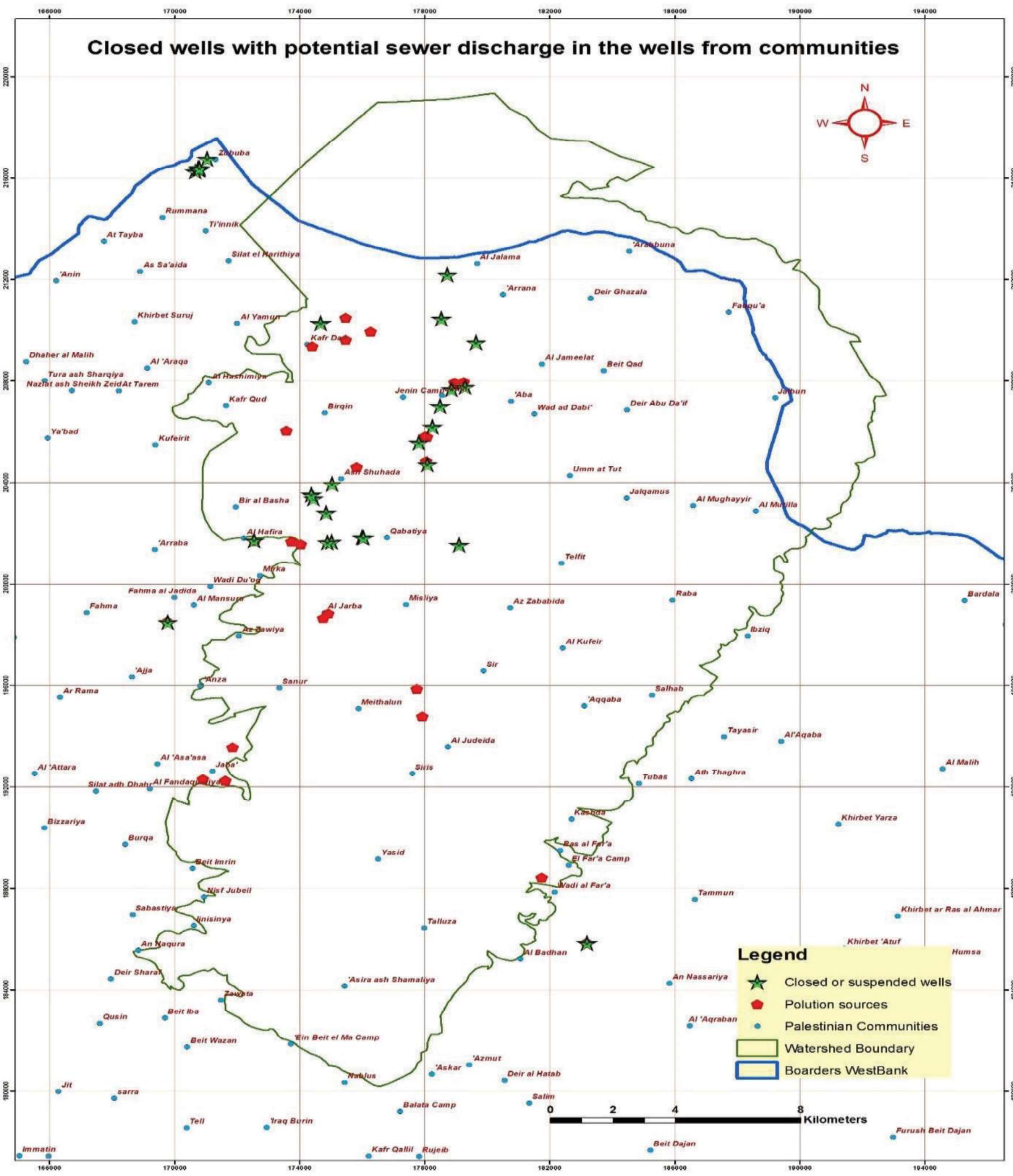

Figure 4. Spatial map of closed or suspended wells in the Eocene Aquifer study area.

7. On-Ground Source of Pollution

ARIJ (2015) conducted two important survey for the liquid and solid waste in the west bank. The study covered more than 600 industrial facilities. In the Eocene Aquifer area (Jenin governorate), the study covered about 74 facility. Table 2. shows the relationship between original and liquid effluent categories as reported by ARIJ. The discharge of liquid waste from the different industries (treated and untreated) was estimated for different governorates in the West Bank including the Eocene Aquifer study area – Jenin Governorate.

Table 2. Relationship between Original and Liquid Effluent Source Categories [ARIJ, 2015]

Original Source Category	Water Category
Manufacture of motor vehicles, trailers and semi-trailers	Metal
Manufacture of other non-metallic mineral products	Mineral
Manufacture of other Non-metallic mineral products	Mineral
Manufacture of other non-metallic mineral products and Manufacture of basic metals	Mineral
Manufacture of paper and paper products	Paper
Manufacture of rubber and plastics products	Plastic
Manufacture of textiles	Textile
Manufacture of tobacco products	Food
Manufacture of wearing apparel	Textile
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Wood
Other manufacturing	Metal
Other mining and quarrying	Mining
Other mining and quarrying & Manufacture of other non-metallic mineral products	Mining
Printing and reproduction of recorded media	Paper
Sewerage	Sewerage
Waste collection, treatment and disposal activities; materials recovery	Waste
Water collection, treatment and supply	Water
Original Source Category	**Water Category**
Crop and animal production, hunting and related service activities	Food
Manufacture of basic metals	Metal
Manufacture of basic pharmaceutical products and pharmaceutical preparations	Pharma
Manufacture of beverages	Food
Manufacture of chemicals and chemical products	Chemical
Manufacture of coke and refined petroleum products	Oil
Manufacture of fabricated metal products, except machinery and equipment	Metal
Manufacture of fabricated metal products, except machinery and equipment & Other manufacturing	Metal
Manufacture of food products	Food
Manufacture of food products and beverages	Food
Manufacture of furniture	Wood
Manufacture of leather and related products	Tannery
Manufacture of machinery and equipment	Metal
Manufacture of machinery and equipment n.e.c.	Metal

Table 3. shows the total estimated flow of wastewater from 74 facilities in Jenin area is about 3742 m^3/month. The liquid waste released from the facilities may also contribute to pollution of the environment, in addition to ground water contamination.

Table 3. Total wastewater flows in m^3/month, [ARIJ, 2015]

Governorate	Sanitary	Cooling Water	Process	Total Estimated Flow
Bethlehem	293	629	1771	2693
Hebron	4189	84	2201	6474
Jenin	857	623	2262	3742
Jericho & Al Aghwar	126	56	10256	10438
Jerusalem	217	0	308	525
Nablus	2662	23	310779	313464
Qalqiliya	417	0	64	481
Ramallah and Al Bireh	676	409	237708	238793
Salfit	188	0	108	296
Tubas	208	0	132	341
Tulkarm	463	15	11131	11609

A survey was conducted by the authors in the Eocene Aquifer study area to record some of the potential on ground source of pollution. About 24 potential on-ground sources with their coordinates were recorded. A spatial map was developed for about 24 point potential on-ground source of pollution is shown in Figure 5. Wadi Al Far'a dam Figure 6. , and Zahrat Al-Finjan landfill are situated very close to the Eocene Aquifer boarder , and considered as main on-ground source of pollution for groundwater. Al Far'a dam currently retains the domestic wastewater discharged for the neighboring villages.

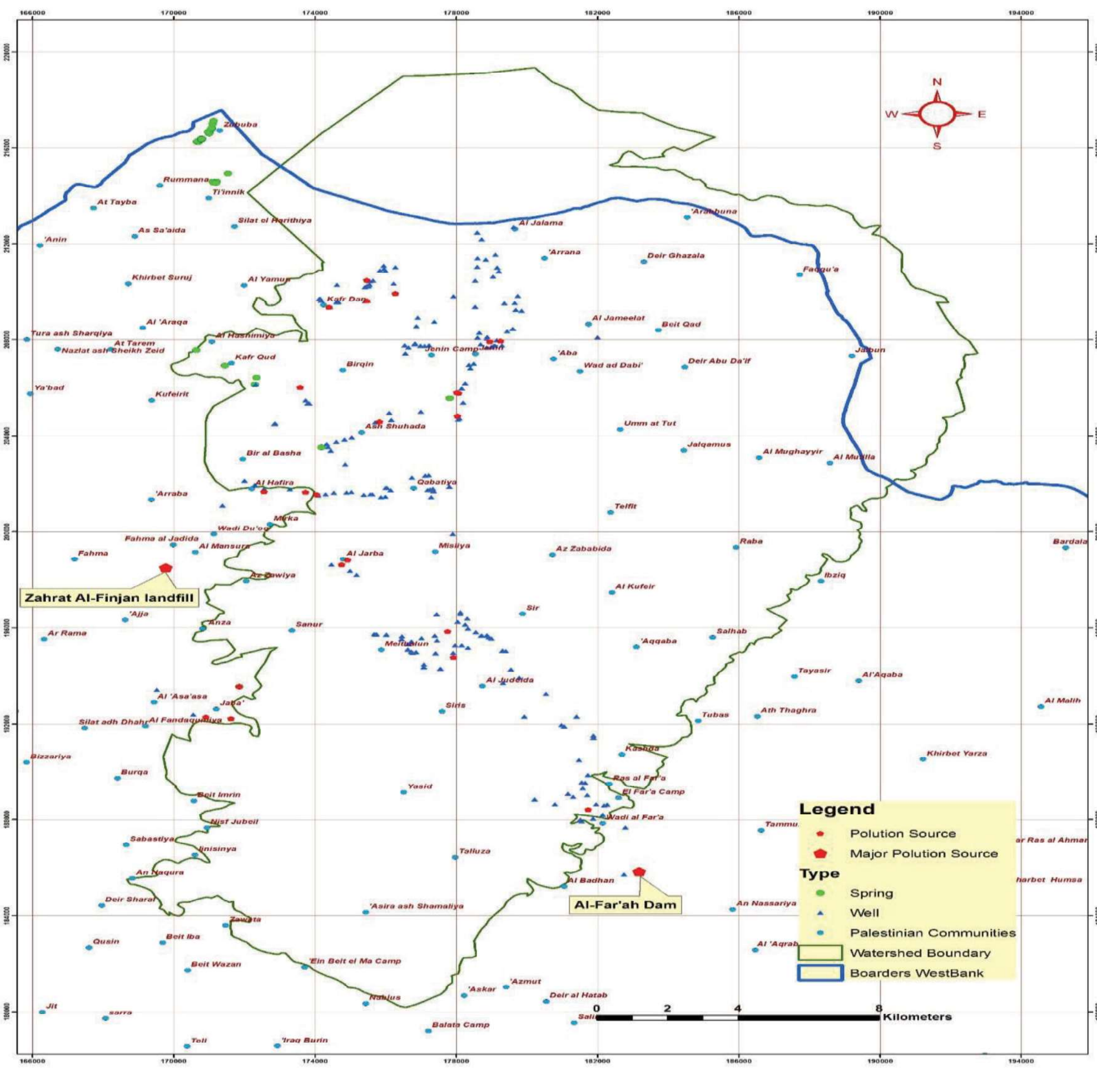

Figure 5. Spatial map of on-ground source of pollution in the Eocene Aquifer area.

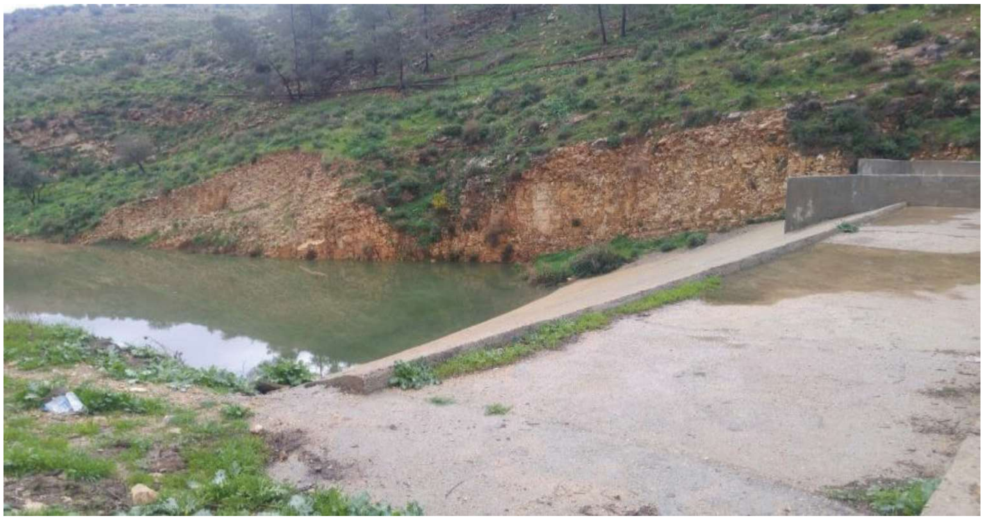

Figure 6. Wadi Al Far'a Dam - A major source of contamination for groundwater

8. Conclusion and Recommendations

1- A spatial map was developed for the ground water wells database , for about 312 wells
2- Land use and Land cover maps were developed for the Eocene Aquifer zone by digitization
3- A spatial map was developed for the potential on-ground source of contamination
4- A spatial map was developed for the suspended and closed wells in the study area
5- It is highly recommended to put the suspended and closed wells under constant control and monitoring, to avoid the misconduct of dumping the sewer and waste materials in the wells.

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