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Groundwater Evaluation for Drinking and Domestic Uses in Diruot District, Assiut City, Egypt

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Abstract: The present study is an attempt to evaluate the groundwater for drinking and domestic uses in Diruot district through chemical and biological analysis of water samples using a Geographic Information System (GIS) technique. The study area is bounded by latitudes 27° 25 ' and 27° 40' N and longitudes 30° 45' and 30 ° 55 ' E. The goal of the study was verified by the acquisition of the available surface and subsurface geological data, collection of groundwater samples of about 27 wells distributed all over the area in different depths and carrying out the appropriate chemical and bacteriological analysis of these samples. The chemical results for well samples at depth less than 60 m were found principally acceptable for drinking use according to the Egyptian standards. According to those standards, statistically, some well samples at depths less than 60 m were not considered potable water. Also The shallow wells (less than 50 m depth) are affected by bacteriological pollution from sewage water wells and the pollution degree are most increased near to the river Nile and Al-Ibrahimiyyah canal because there is a direct contact with these wells.

Keywords: Ground water, Hydrocehmical analysis, Bacteriological analysis.

1 Introduction

River Nile and the groundwater are the main sources of water supply in Egypt. It is important to evaluate and assess these resources to rationalize the consumption and meet the increase in demand of water.

Different countries put great efforts to reduce and / or eliminate pollution and contamination of the drinking water, which affect not only people's life but also the life of animals and plants. The pollution is responsible for many human illnesses than any other environmental factors. Approximately one fourth of the human population does not have access to safe drinking water [1].

Recharge to the aquifer is mainly from the River Nile, the associated network of irrigation and drainage canals system, and return flow [1]. Regionally, groundwater flow is toward the north along the valley and laterally away from the River Nile. Some downward flow penetrates the semi confining Holocene clay as recharge to the aquifer and carries pollutants to the aquifer [2]. The uncontrolled construction, the inadequate capacity of the sewage network, and the high rate of vertical leakage increase the amount of deteriorated water that infiltrates downward to affect the aquifer [2].

2 Location of the study area

Diruot district is located north of Assiut city and represent a part of reclaimed land in Assiut Governorate, it is bounded by latitudes 27° 29 ' and 27°37' N and longitudes 30°42' and 30 °52 ' E (Fig 1.1).Assiut Governorate constitutes an interesting hydrographic part in the Nile Valley in Upper Egypt particularly in Diruotdistrict, which is one of the biggest districts in Assiut. It is located on the west bank of the River Nile occupies a region including both the floodplain and the desert fringes.

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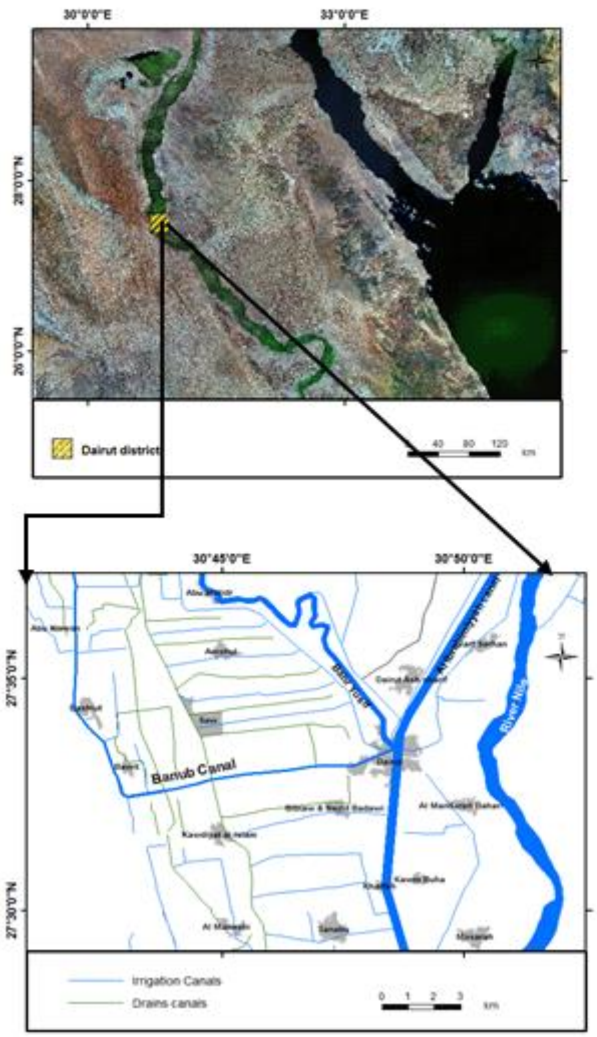

Fig. (1. 1): location of the study area, the upper image is a satellite image of Mr SID format (NASA 2000).

3 Geomorphological and Geologic Setting

The study area is a part of the Nile flood plain, which bounded by the Eocene limestone plateau in the West and the recent Nile deposits from the East. The plain is covered by different Quaternary deposits (e.g. gravels, sand, silt, and clay). The elevation of limestone plateau ranges from 80 to 180 m where the elevation of the floor of the study area varies from 35 to 90 m above sea level. The general slope is from South to North and from West to East. This plain is dissected by several drainage and irrigation canal systems, which run generally in some localities parallel to the River Nile and perpendicular at some others. The old alluvial plain of the Nile extends from the western boundary of the young alluvial plain to the pediment of the calcareous structural plateau district [12].

The geology of Diruot area is very important, especially in different types of assessments in which the runoff water is very influenced by the type of rocks. The various rock units distributed in Diruot area are composed of sedimentary succession ranging in age from Lower Eocene to Recent. A simplified geological map of Diruot district was simplified from the geological map of Egypt of CONOCO 1987 as shown in figure (2.1).

Stratigraphically, the area has been studied by different authors on the exposures bordering the Nile Valley from the West and East. From these studies is that given by [12] in which the important lithostragraphic units in Diruot area arranged from top to the base as follow:

1- Post –Eocene rocks, 2- Eocene rocks

Little is known about the structural setting of the northwestern part of Assiut. However, short descriptions were given by [14, 15, 16, 17, 18, and 20].

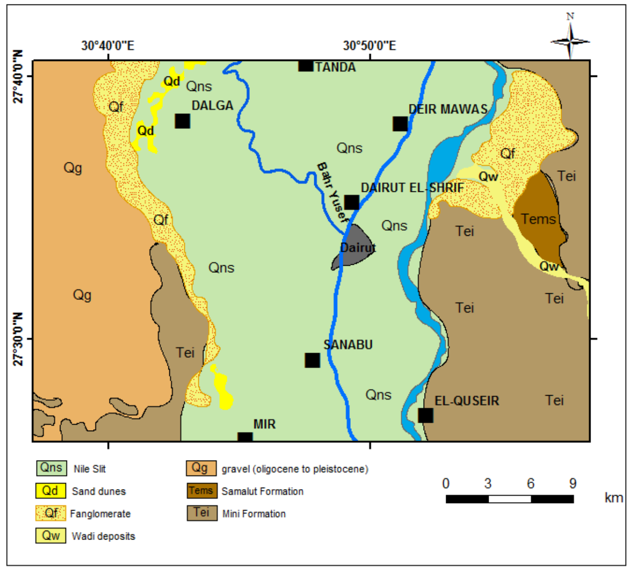

Fig. (2. 1): Geological map of the study area (Modified after CONOCO 1987).

Neither regional nor detailed geophysical survey has been done on the study area. Geoelectrical studies were carried out on the desert area west of El-Qussiya and Diruot district by [10].This study indicated that the possible presence of a major shallow wet zone (possibly water-bearing zones) at depth greater than 8 m and having true resistivity ranging from 15 to 200 m.

4 Hydrogeological and Hydrological Review

The study area is small portion of the major hydrological basin extended in the Nile Valley. The groundwater condition in the great hydrological basin is directly affected by the irrigation and drainage canal system within the Nile Valley itself.

The depth to groundwater as determined from different drilled water wells in the area of Diruot ranges from 3 to 13 m below the ground level surface. According to the hydrological & hydrogeological studies carried out by the

Deseret Research Institute (DRI) in 1983, it found that the boundary of the groundwater in the area Northwest of El-Qussiya from Northeast and South are of infinite condition, but that from the West is of finite condition. The recharge to the study area occurs mainly from the east and southeast directions, and the discharge occurs on the north and Northwest.

Diruot fed by Nile water through Banub Canal and Bahr Yusifthat branch from Al-Ibrahimiyyah Canal, which in turn takes from upstream Assiut Barrage (Fig.3.1).The irrigated area in Diruot is about 87 Fadden's.

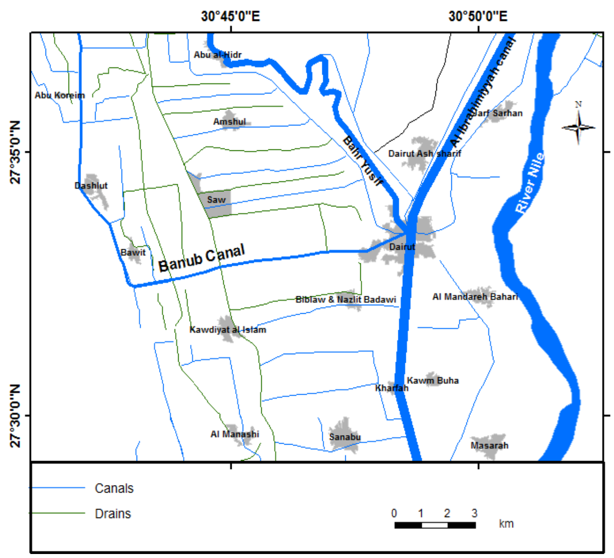

Fig (3. 1): Irrigation and drainage system in Diruot.

4.1 Drainage canal systems

Until the 1950 s, delivery of water to Diruot has not caused any severe problem to drainage canals system, where the amount of drainage water flowing to the Lake Qaroun was equal to evaporation from the lake. Introducing the perennial irrigation resulted in more drainage water discharged to the lake resulting in a rise of lake's water level.

This in turn caused salinity and water logging problems in adjacent low-lying areas and large areas had to be abandoned. The need for proper drainage facilities became more and more essential. In fact drainage activities started very early in Diruot. Later, when water delivery to Diruot increased to meet the increased irrigation requirements, which caused increase in drainage outflow that, exceeded the capacity of Lake Qaroun. Thus, a spill tunnel constructed to divert part of drainage water [3].

4.2 Cropping pattern

Ten major crops found to be grown in Diruot. These crops include Berseem and Vegetables.

Maize, Wheat, Cotton, Sorghum, and broad Beans, Cropping intensity defined as the total cropped area divided by the physical area. When the land is grown twice a year, then the crop intensity is said to be 200%. Cultivated area in Diruot is usually growing two crops a year; summer crops and winter crops. Small area grows perennial crops such as fruits and citrus. This makes the cropping intensity in Diruot of about 190%.

4.3 Water delivery and supply system

Bahr Yusif and Banubcanals constitute are the sole source of water to meet the whole water requirements in Diruot, the total water flow at Al-Ibrahimiyyah intake delivered through the branch canals and Mesqas through a well-established weir system. The breadth of the weir was designed to deliver water quantity that is proportional to the served area.

As water level goes higher, water allocated to the Mesqa will increase. One of the main features of this system is the existing of continuous flow that runs by gravity. Consequently, water diversion from to fields made over the 24-hour period in order to minimize canal water spills to drains. Therefore, a well-established rotational table among farmers, that determines the water quota for each user, is very essential to improving water use efficiency. This table is currently existing for each Mesqa and implemented by Mesqa leader. Water quota or water right defined on time-basis where measurements are not made. This means that each user has a certain time and period to irrigate his land [3].

4.4 Subsurface lithology in Diruot area

The subsurface lithology in the study area is deduced from preparing four subsurface lithologic sections. The location of the wells used in preparing the four subsurface lithologic sections is showed in figure (3.2). The lithology of the studied groundwater wells were used in construction of these sections. Three of these sections are extending from West to East and the fourth is extended from the South to North. The sections which extended from West to East (Fig.3.4, 3.5, and 3.6) show that the subsurface lithology started by 8 to 15 m of clay followed by interaction between fine, medium and Course sand. The thickness of the fine –medium-course sand layer changed laterally from West to East, it reaches to maximum thickness (98 m) in the middle parts of the area, and the thickness decreases to the West and Eastward. The fine \ coarse sand layers are underlain by a course to gravel layer. The later has thickness around 65 m in the middle parts of the area and decrease to the west and eastward to reach 20 m.

A long the S-N section (Fig.3.3), the clay, fine to medium sand and the gravel layer exhibit no great variation from South to North. This is due to that the section is located in the middle part of the area, which is representing the main channel of the Nile Valley.

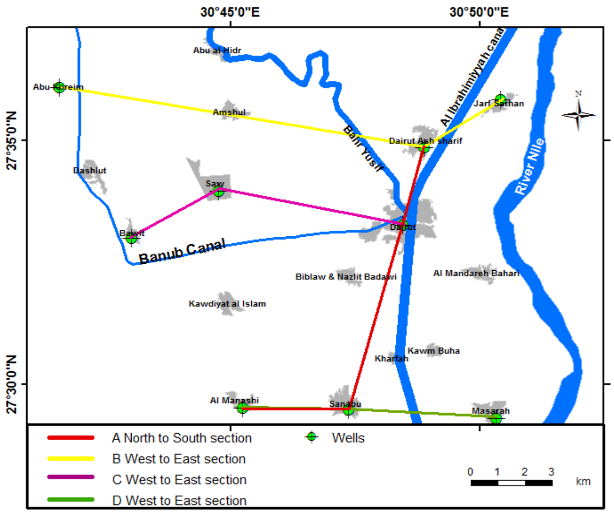

Fig. (3. 2): Locations of wells that used preparing the four subsurface lithelogic sections in Diruot district.

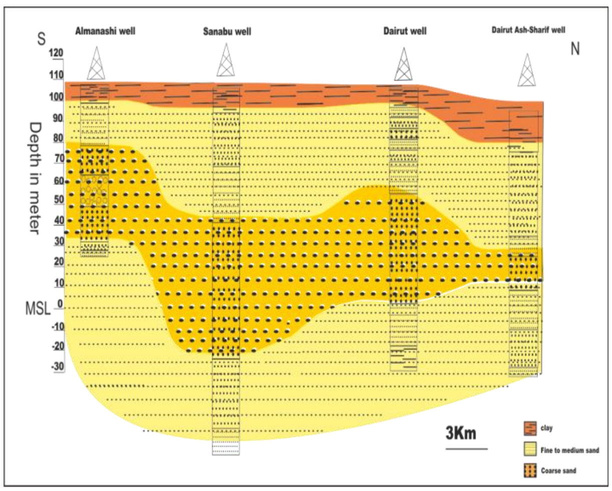

Fig. (3. 3): Subsurface lithelogic sequence in Diruot district from North to South.

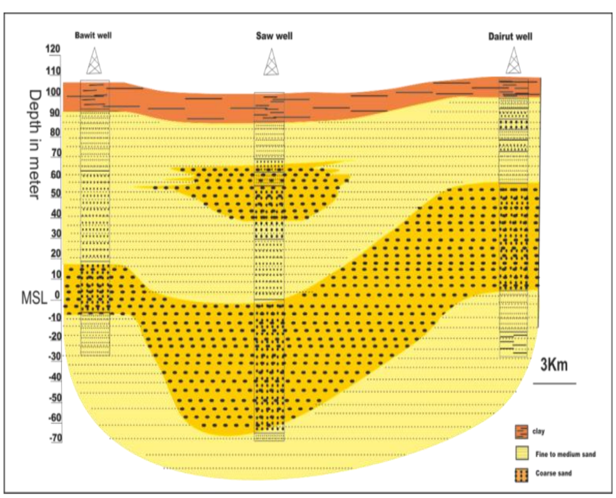

Fig. (3. 4): Subsurface lithelogic sequences in top part of Diruot district from West to East.

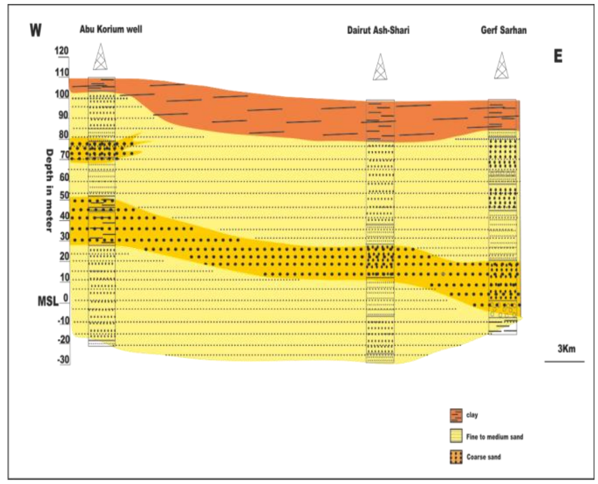

Fig. (3. 5): Subsurface lithelogic sequences in middle part of Diruot district from West to East.

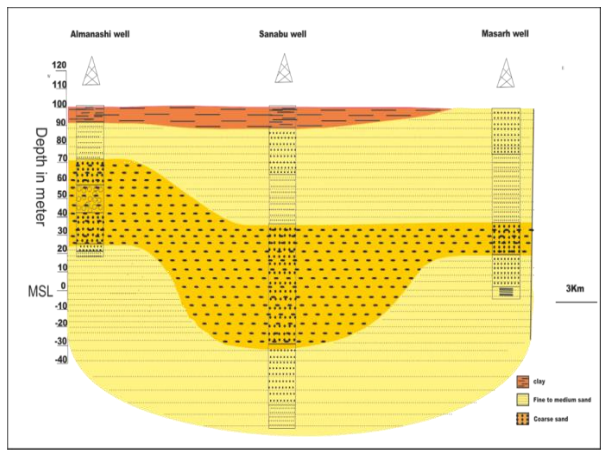

Fig. (3. 6): Subsurface lithelogic sequences in bottom part of Diruot district from West to East.

5 Materials and methods

Data collection was carried out in two phases: Phase I, primary data collection and Phase II, secondary data collection. Phase I include collection of the available maps and internal reports covering the study area. However, Phase II included field sampling of the groundwater from the studied drinking water stations.

The studied wells were classified based on depth into three groups: Group A includes the wells, which have depth less than 60 m, Group B include the wells of depth ranging from more than 60 m and less than 100 m. However, Group C includes the wells of depth more than 100 m.

The chemical drinking water samples are taking from a point where water enters the distribution system or connected plumbing.

The physical analysis of the collected groundwater samples includes measuring of pH, Turbidity and TDS. The pH was measured by pH meter model 2000 VWR consisting of potentiometer, glass electrode, and a temperature-compensating device.

The turbidity was measured in the field by using Turbidimeter (HANNA instruments) (The turbidity is an expression of the amount of light scattered and absorbed by the particles in a sample that is measured as Nephelometric Turbidity Units (NTU).

Electric Conductivity is a measure of the ionic strength of a solution. It used to evaluate the variation in concentrations of dissolved minerals in a water source to estimate the concentration of Total Dissolve Solids (TDS). In the present study, the electric conductivity was measured by conductivity meter model ORION.

The chemical analysis of the collected groundwater samples was carried out through two main methods. Colorimetric method, which includes measuring and estimating of ammonia NH_3, ferrous ions Fe^{+2} and manganese ions Mn^{+2}. Volumetric analysis from which Ca^{+2}, Mg^{+2}, Cl^{-1} and total alkalinity CO_3^{-2}& HCO^{-3} were estimated.

The biological drinking water samples are taken from any tap in the distribution or plumbing system – preferably from a cold-water tap used by the public for drinking purposes.

To give the most accurate results; the testing for bacteria must begin within 24 hours of collecting the drinking water sample. Clear instructions from the laboratory regarding sample submission drop-off time should be taken.

For coliform analysis, the cold water should run for about three to five minutes before sampling. One hundred milliliters (about 4 ounces) Collected in a bottle that certified as sterile and comes from a laboratory that certified for analyzing bacteria in drinking water.

The collected samples were analyzed in the holding company for drinking and wastewater laboratory in Assiut.

One of the most common and frequent tests performed is the Coliform test. This is the bacteriological analysis of water, Coliform is an indicator for the presence of fecal matter and the potential presences of harmful disease causing pathogens. A Coliform level of zero in drinking water is required or the water source is closed. The Most Probable Number (MPN) technique used for the microbiological testing.

5.1 GIS analysis of the obtained results

GIS is a computer-based information system that enables the capture, storage, manipulation, retrieval, analysis and display of Spatial Data [21].

GIS analysis was employed in the present study to concern the spatial analysis of different data in the current study area. This tool has the capability of using all the data to represent an area in which variability of specific parameters can be integrated.

In GIS analysis project, identifying the objectives of the project, create a project database containing the data needed. Using GIS functions to create an analytical tool, and present the results of the analysis [6].

Step 1: Identify the objectives

Step 2: Create a project database

Step 3: Analyze the data

Step 4: Present the results

The results of GIS analysis can be best shows on maps, printed separately and embedded in documents.

6 Results and discussion

6.1 Hydrochemistry of groundwater

The pH is a measure of the acidity of groundwater: the lower the pH, the more acidic is the water. At the typical temperature of groundwater, a pH of 7 is considered neutral. Therefore, a pH less than 7 is acidic and a pH greater than 7 means that the water is alkaline. The pH is actually a measure of the hydrogen ion (H+) availability (activity) [13].

The pH value along the whole time in Diruot district is ranging from 7.2 to 7.9. This range lies within the accepted limits according to Egyptian standard for drinking water under law No. 458 of 2007(6.5-8.5).

The Turbidity caused by suspended matter or impurities that interfere with the clarity of the water. These impurities may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisms [7].

The Total Dissolved Solids is the total value of the major cations and anions includes all solid material dissolved in the solution (Ali 2005). The increase in the TDS value in the shallow wells is recorded at the extreme western parts and at some local parts (i.e. Kharfah 1 and Dashlut 1) (Fig 4.1). The TDS value range from 420 to 867mg/l and suitable for drinking uses based on the Egyptian standard.

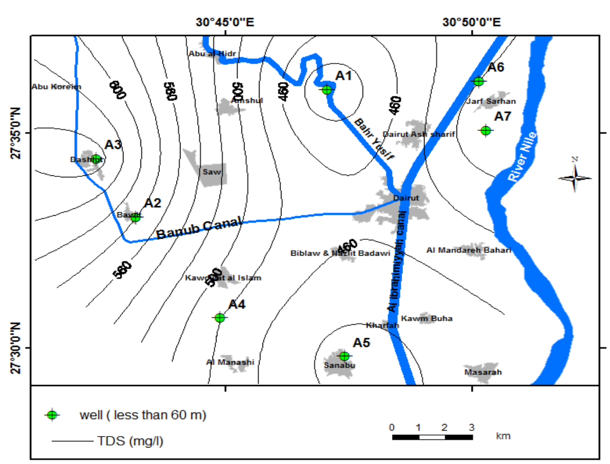

Fig. (4.1): Distribution of TDSin Diruot district through the time period from January to March 2010.

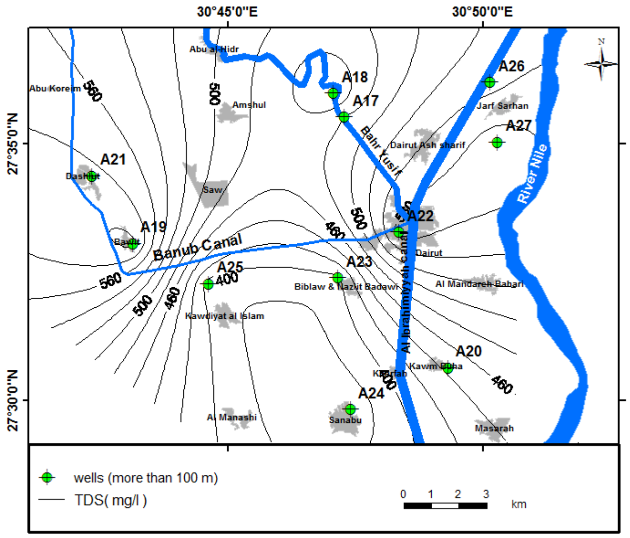

Fig. (4.2): Distribution of TDSin Diruot district through the time period from January to March 2010.

Carbonate rocks are principle source for calcium [11].Ca+2 & Mg+2 concentrations increase at the western parts of the study area could be related to that these parts are close to the limestone rocks. However, the decrease of the concentration in the area close to the River Nile may relate to the high recharge seasons (Fig 4.3, 4.4, 4.5, 4.6). The groundwater in the study area has Ca+2 and Mg+2concentrations ranges from 130 to 240 mg/l. All values of the samples lies within the limits according to the Egyptian standard for drinking water, which is 350 mg/l.

The Ca+2 and Mg+2 concentrations present in the groundwater for deep wells in the study area generally lies within the limits of the Egyptian standard for drinking water.

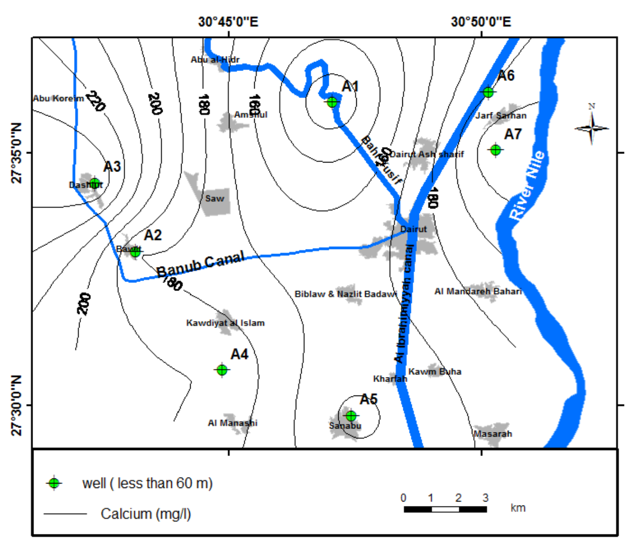

Fig. (4.3): Distribution of Ca^{+2} in Diruot district through the time period from January to March 2010.

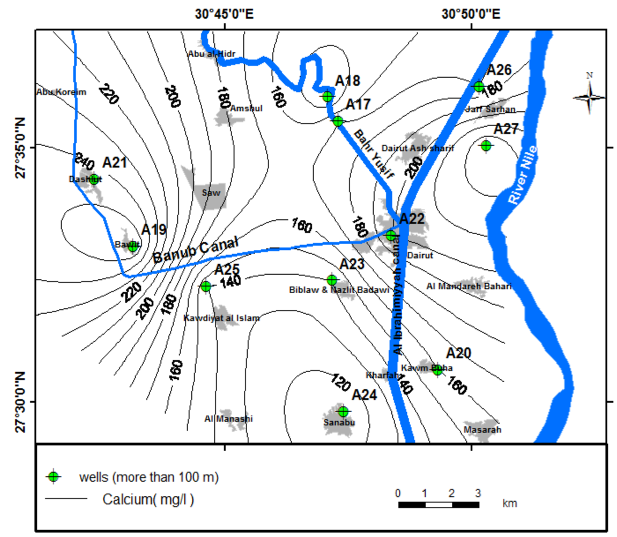

Fig. (4.4): Distribution of Ca^{+2} in Diruot district through the time period from January to March 2010.

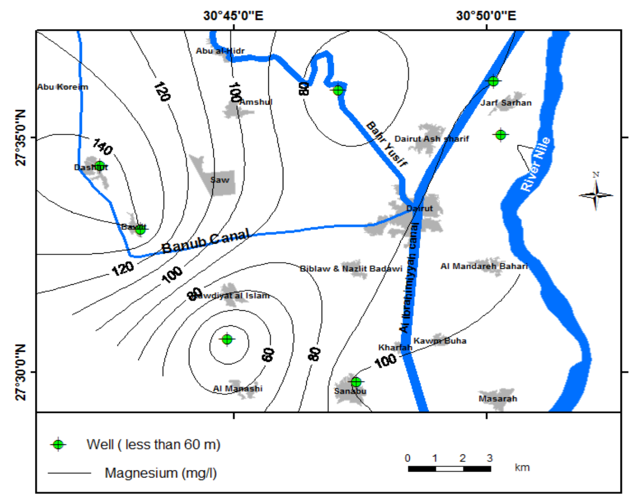

Fig. (4.5): Distribution of Mg^{+2} in Diruot district through the time period from January to March 2010.

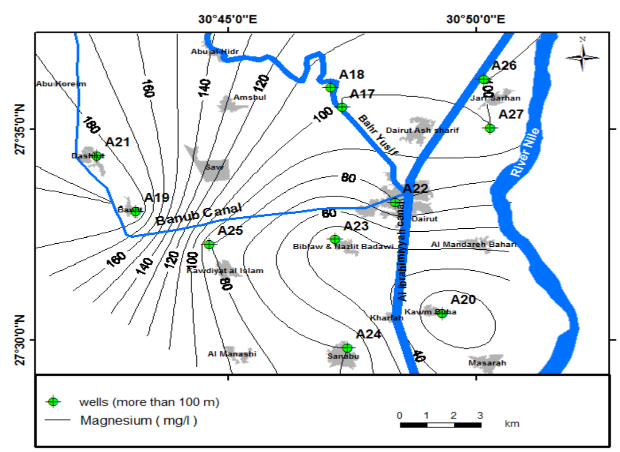

Fig. (4.6): Distribution of Mg^{+2} in Diruot district through the time period from January to March 2010.

Generally, the Chloride ions occur if the groundwater contacts highly soluble chloride minerals such as halite (NaCl) or (KCl). In the deep sedimentary basin, the chloride minerals can occur as salt originally deposits during the evaporation of the closed or restricted marine basin many millions of years ago .The solubility of other chloride minerals of sedimentary origin are very high.

Chloride in groundwater may also originate from marine water entrapped in sediments, and anthropogenic sources. Anthropogenic processes can locally affect chloride concentrations in groundwater. Some anthropogenic factors commonly cited as influences on chloride levels in water include road salting during the winter, improper disposal of oil-field brines, contamination from sewage, and contamination from various types of industrial wastes [8, 9]. The Cl^{-1} ions increased in the western part of the study area and decrease eastward in the main channel of the flood plain area (Fig.4.7 &4.8).

The Chlorides concentrations measured in the groundwater wells at these depths in Diruot district ranging from 23 to 90 mg/l, which is suitable for drinking uses according to the Egyptian standards for drinking water (250 mg/l).

The alkalinity content in the groundwater normally derived from dissolution of carbonate minerals as calcite ($CaCO_3$) and dolomite (Ca, Mg (CO_3) [22].The water passes through a soil developed from limestone, it becomes charged with CO_2 at a high partial pressure, and then infiltrates to the water table zone. During infiltration, saturation with respect to calcite attained as represented by this equation:

$$CaCO_3 + H_2CO_3 \rightarrow 2HCO_3^- + Ca^{+2}$$

The reaction of this equation proceeds to the right to achieve the equilibrium depends on the pressure and temperature. The practical pressure of CO_2 (generated in the soil zone) and the solubility of calcite and domilite are normally the limiting constraints on the level of the total dissolved solids attained (Ali 2005). Figures(4.9 &4.10) shows the distribution of the total alkalinity concentration of the groundwater in Diruot district and illustrate the increase of thetotal alkalinityin the western part of the study area and decrease eastward in the flood plain area. The reason for the increase of total alkalinity concentration in the desert fringe is the leaching process of the mineral constitutes.

Generally, the groundwater in the study area has Alkalinity concentrations range between 155 to 400 mg/l and lies within the limits according to Egyptian standard for drinking water (500 mg/l). The groundwater in deep wells (more than 100 m) have alkalinity concentrations suitable for the drinking uses according to Egyptian standard for drinking water.

Iron (Fe^{++}) and Manganese (Mn^{++}) are metals that occur naturally in soils, rocks, and minerals, in the aquifer, the groundwater contact with these solid materials dissolving them, releasing their constituents, including Fe^{++} and Mn^{++}.

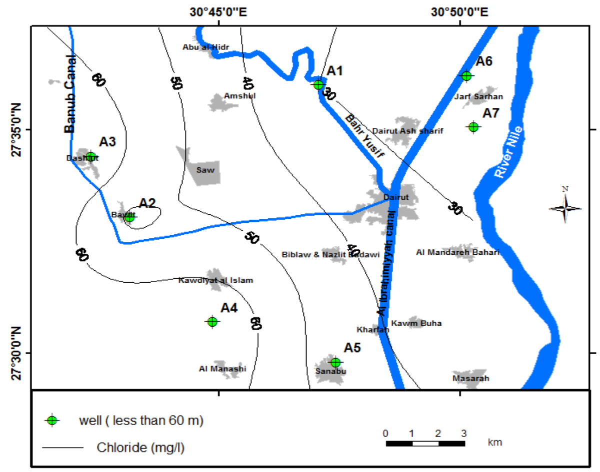

Fig. (4.7): Distribution of Cl^{-1} in Diruot district through the time period from January to March 2010.

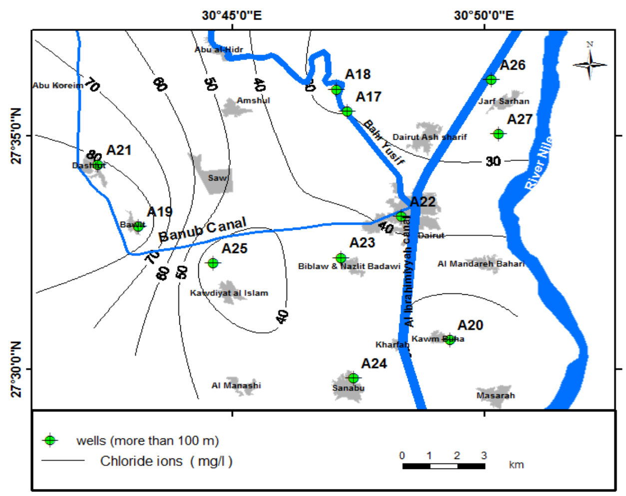

Fig. (4.8): Distribution of Cl^{-1} in Diruot district through the time period from January to March 2010.

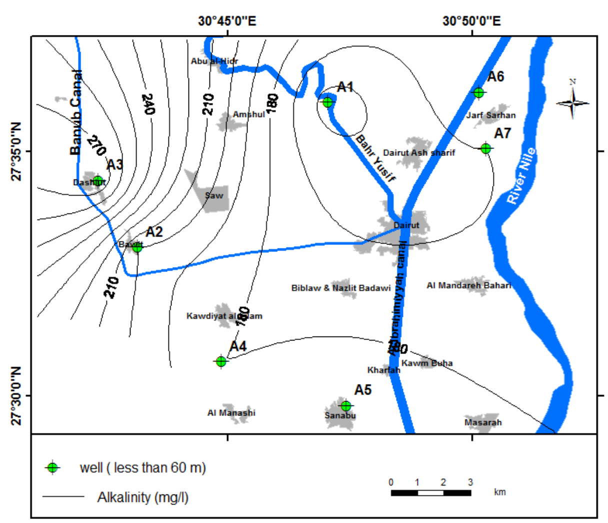

Fig. (4.9): Distribution of alkalinity in Diruot district through the time period from January to March 2010.

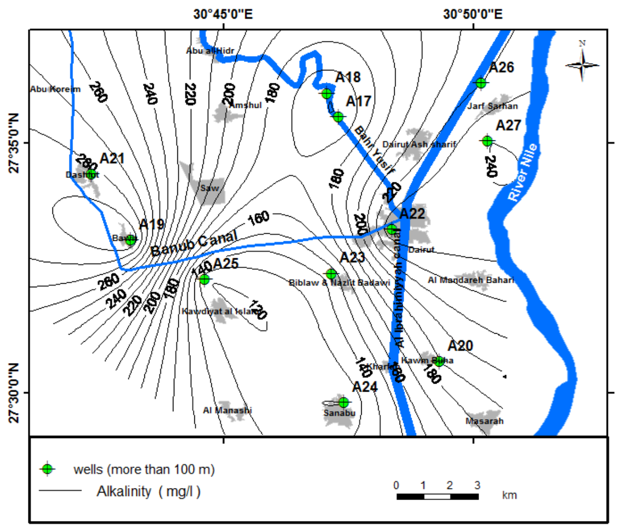

Fig. (4.10): Distribution of Alkalinity in Diruot district during period from January to March 2010.

The natural sources for iron in the groundwater is ferric sulfide or iron pyrite (FeS_2), magnetite (Fe_3O_4) and sandstone rocks such as oxides, carbonates and sulfides or iron clay minerals. For the manmade sources such as well casing, piping, pump parts and other objects of cast iron and steel that may be in contact with the water [13].

Generally, the extent to which Fe^{++} and Mn^{++} dissolve in groundwater depends on the amount of oxygen in the water and, to a lesser extent, upon its pH. Iron, for example, can occur in two forms: as Fe^{2+} and Fe^{3+}. When levels of dissolved oxygen in groundwater are greater, iron occurs as Fe^{3+}, while at lower dissolved oxygen levels, the iron occurs as Fe^{2+}. Although Fe^{2+} is very soluble, Fe^{3+} will not dissolve appreciably [13].

Iron in groundwater may originate from a variety of mineral sources; and several sources of iron may be present in a single aquifer system. Oxidation-reduction potentials, organic matter content, and the metabolic activity of bacteria can influence the concentration of iron in groundwater. Because iron-bearing rocks were eroded, transported, and deposited by glaciers, including igneous and metamorphic rocks from as far north, they have been incorporated into and are abundant in many unconsolidated deposits. Pyrite (FeS_2) oxidation may also contribute iron to unconsolidated aquifer systems. Iron is also present in organic wastes and in plant debris in soils. Low concentrations in some of the bedrock systems may be explained by precipitation of iron minerals from activity of reducing bacteria or by the loss of iron from cation-exchange processes occurring in confining clay, until or shale overlies the bedrock [8].

From the Fe^{+2}& Mn^{+2} distribution maps (Fig 4.11, 4.12, 4.13&4.14) the lowest values of Fe^{+2}& Mn^{+2}concentration (from 0.1 to 0.3 mg/l) are recorded at the western parts of the study area, where, the highest values (from 0.5 to 0.8) are observed at the eastern parts. The increase of the Fe^{+2}& Mn^{+2} concentration eastward and decrease westward may be related to the waste sources and the excessive application of fertilizers and manure in agriculture activities.

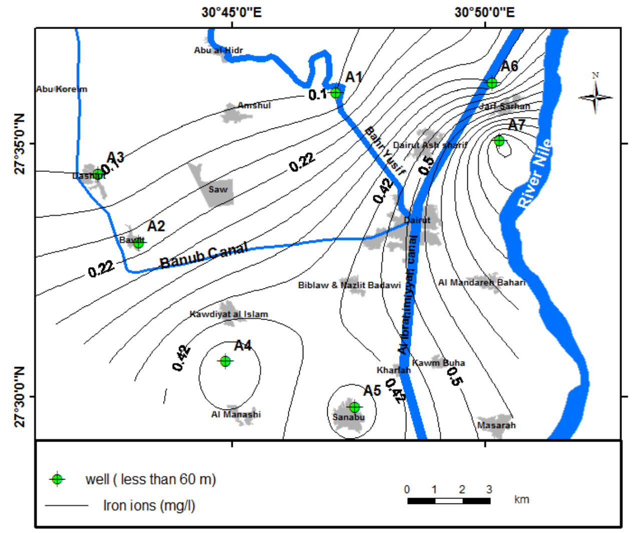

Fig. (4.11): Distribution of Fe^{+2} in Diruot district through the time period from January to March 2010.

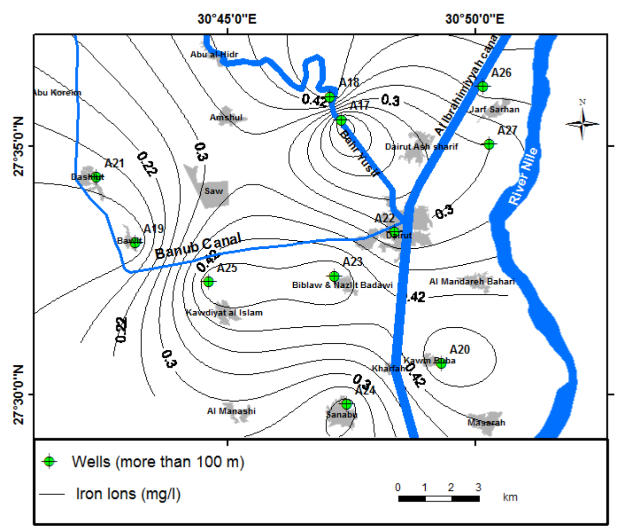

Fig. (4.12): Distribution of Fe^{+2} in Diruot district through the time period from January to March 2010.

The groundwater in the study area has Fe^{+2}& Mn^{+2} concentration lies in acceptance limits according to the Egyptian standard for drinking water (0.3 - 0.4 mg/l) respectively except for Elaoamer 1 and Kharfah 1 for Iron and JarfSarhan 1 and Biblaw 2 for manganese.

If the groundwater is oxygen poor, iron (and manganese) will dissolve more readily, particularly if the aquifer contains organic matter, Decomposition of the organic matter depletes the oxygen in the water, and the iron dissolves as Fe^{2+}, under these conditions, the dissolved iron is often accompanied by dissolved manganese.

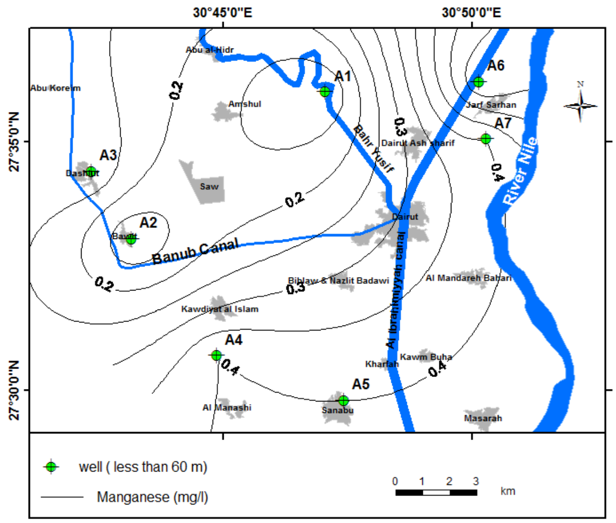

Fig. (4.13): Distribution of Mn^{+2} in Diruot district through the time period from January to March 2010.

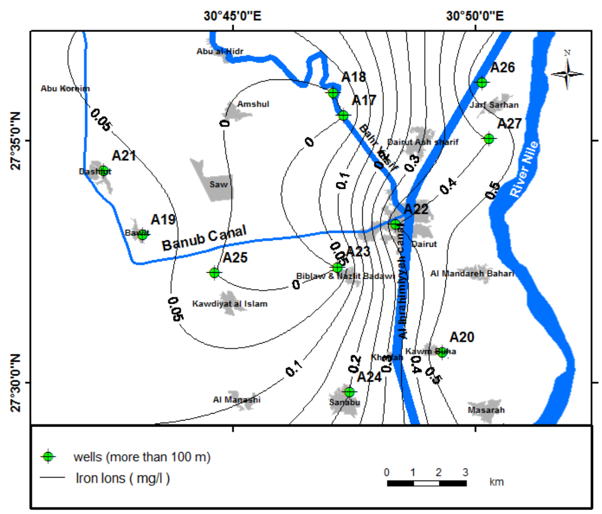

Fig. (4.14): Distribution of Mn^{+2} in Diruot district through the time period from January to March 2010.

Ammonia can exist as ammonium NH^{+4}, or as ammonia, NH_3, depending only on pH. The pH of most soils and groundwater dictates that ammonium is the dominant species. However, frequently these two species are used interchangeably with the generic title of "ammonia." For this study, the term "ammonia" refers to the sum of both the ammonium and ammonia species. The drinking water standard is set based on the correlation between high ammonia concentrations and microbial contamination due to human and animal waste sources, Ammonia contamination in groundwater related to depth. Ammonia in the presence of oxygen quickly nitrified to nitrites and nitrates. Thus, the presence of ammonia in a drinking water source generally indicates that a source of ammonia is in close proximity to the water intake.The anthropogenic sources of ammonia that could be near a water intake are generally some sort of animal or human waste product [5].

Ammonia concentration at the study area is varying from place to another between 0.1 to 0.6 mg/l. Figure (4.15 &4.16) shows the distribution of ammonia concentration. The concentration is high (0.6 and 0.45 mg/l) at the western and northern part of the study area at wells JarfSarhan 1 and Dashlut 1, however the lower value (around 0.1 mg/l) of the other parts of the studied area at wells Sanabu 4 and Elaoamer 1. The increase of ammonia may be related to the excessive application of fertilizers and manure in agriculture and microbial contamination due to human and animal waste sources are occurring.

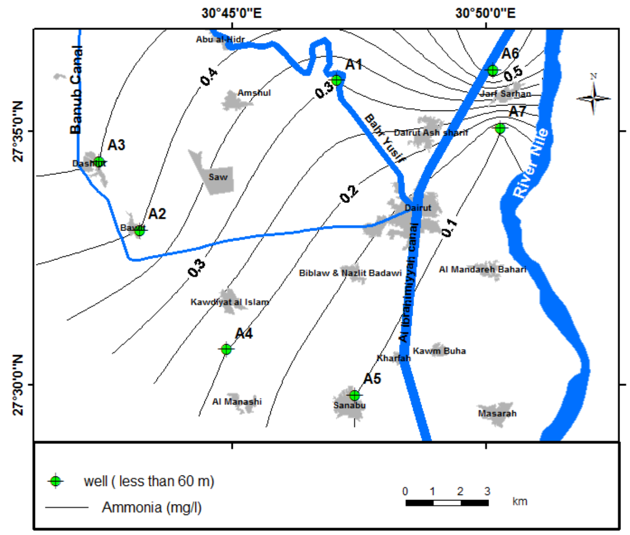

Fig. (4.15): Distribution of ammonia in Diruot district through the time period from January to March 2010.

The ammonia concentrations exist in few wells due to the geologic depositions of peat and lignite and anaerobic conditions deep below the surface.

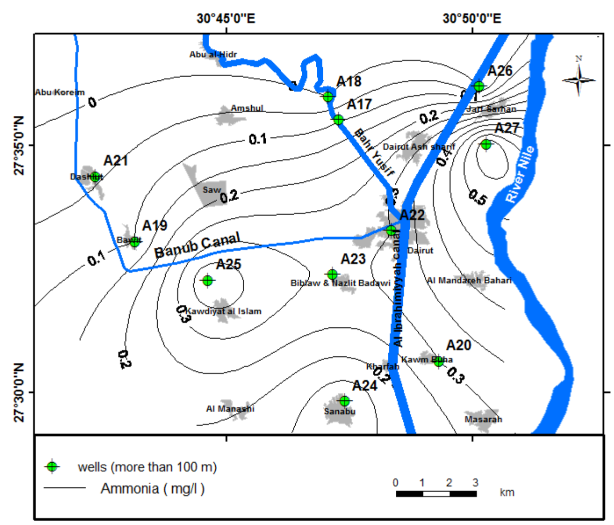

Fig. (4.16): Distribution of Ammonia in Diruot district through the time period from January to March 2010.

The GIS distribution maps of chemical analysis for ammonia, Fe^{+2}, and Mn^{+2} concentration in the study area show that the increase of their concentration at the western and northern part of the study area. The increase for ammonia, Fe^{+2}, and Mn^{+2} concentration was related to the natural geologic deposits, the excessive application of fertilizers and manure in agriculture and microbial contamination through human and animal waste sources [25].

The chemical results for well samples at depth less than 60 m were found principally acceptable for drinking use according to the Egyptian standards. According to those standards, statistically, some well samples at depths less than 60 m were not considered potable water because of its high concentrations such as 37.5 % from the total analyzed samples because of Fe^{+2} ions , 25% because of Mn^{+2} and 12.5 % because of ammonia .

Only 11% of wells samples at depth between (60-100 m) were not found acceptable for drinking use because of Ca^{+2} , Mg^{+2} And Cl^{-1} concentrations. Due to the high concentrations of Fe^{+2}, Mn^{+2} ammonia, the percentage of the samples that was found non potable was about 55.5 %, 33.3%, and 44.4 %, respectively. At higher depth wells (more than 100 m), the percentage of unacceptable samples due to high concentrations of Fe^{+2} is 90%, about 45% of Mn^{+2} concentrations and 36.4 % of Ammonia concentrations.

For groundwater conditions deeper than 100 meter, seasonal changes are generally less and temperature variations do not play a significant role in groundwater composition like in shallow groundwater except for some wells close the irrigation canals. From comparison of the chemical analysis results of groundwater from the aquifer at different depths, it can be concluded that the horizontal movement of the groundwater is much higher than vertical movement. This can be related to the natural hydrological condition of the aquifer that prevails confined to semi confined conditions.

7 Biological analysis

Biological contamination of water is usually caused by the presence of living organisms, such as algae, bacteria, protozoan, or viruses. Each of these can cause distinctive problems in the water.

Bacteria are microscopic one-celled organisms that multiple by simple division. Bacteria are universally distributed. Many of them are essential, they aid in the decomposition of dead organic material. However, there is numerous diseases - producing bacteria that the water industry needs to guard against. These may cause typhoid fever, dysentery, cholera, and gastroenteritis. Some bacteria, although are not harmful, may cause taste and odor problems. Examples of such bacteria are sulfur bacteria, which may produce hydrogen sulfide, or crenothrix iron bacteria, which can produce disagreeable taste, odors, and stains [24].

The wells drilled inside the settlements and communities that don't have wastewater drainage network exhibited high percentage of bacteriological contamination. However, the wells that located outside the communities are more or less free from bacteriological contamination. The shallow wells (less than 50 m depth) are affected by bacteriological pollution from sewage water wells and the pollution degree are most increased near to the river Nile and Al-Ibrahimiyyah canal because there is a direct contact with these wells.

8 Conclusion and Recommendations

Man's use and reuse of water for domestic, industrial, and agricultural purposes in the overpopulated regions result in the discharge of liquid or solid wastes with different kinds of contaminants into the geologic environment. As a result, groundwater quality is seriously under stress. The degradation of groundwater depends on the pollution load and the behavior of pollutants as well as the geological and hydrogeological factors that control the flow and dispersion. From the study of the periodical chemical, physical and biological analysis of groundwater samples which collected from wells at different depths in Diruot distinct it was concluded that:

- From comparison of the chemical analysis results of groundwater from the aquifer at different depths, it can be concluded that the horizontal movement of the groundwater is much higher than vertical movement. This can be related to the natural hydrological condition of the aquifer that prevails confined to semiconfined conditions.
- The causes of lateral and vertical variation in the physical, chemical, and biological characterization are mainly related to the irrigation and drainage networks in middle parts of the study area, however, in the other parts the variation is mainly to the aquifer characteristics.
- As the study area lacks of scientific regime in well drilling and testing which lead to scarcity hydrogeological information, a concrete system for drilling must be established.
- The pollution are returned in some wells after each disinfection, these wells must be closed or protected by chlorine stoke injection (WHO 1993).
- Protection of the wells from bacteriological pollution by closing all the holes around the wells by concrete except the hole that used in disinfection, this hole must be above ground surface about 30 cm at least and covered by rubber (WHO 1984).
- Protection of the wells from high reservoir water that may be polluted by using good valves which prevent water to return into well.
- Protection of the drinking water wells by disinfection and washing the wells monthly through valves.

- Distance between wells should be controlled, and pumping, should be managed to permit the aquifer equilibrium.
- The wells that show high concentrations (above the limits) must be treated immediately.

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