Global Scientific JOURNALS

GSJ: Volume 7, Issue 3, March 2019, Online: ISSN 2320-9186
www.globalscientificjournal.com

WATER QUALITY INDEX AND ASSESSMENT OF HEAVY METALS IN TWO GROUNDWATER WELLS IN DAKAHLIA GOVERNORATE, EGYPT.

Ahmed E. Hagras[1], Sayed A. El-Tantawy[2], Ahmed M. El- Naggar[3], Engy A. Abo El-Makarm

1. Professor of Ecology, Department of Zoology, Faculty of Science, Mansoura University, Egypt.
2. Professor of Invertebrates and Parasitology, Department of Zoology, Faculty of Science, Mansoura University, Egypt.
3. Professor of Ecology, Department of Zoology, Faculty of Science, Mansoura University, Egypt.

Abstract

The growing population need tremendous amount of more freshwater for drinking, irrigation, and domestic affairs in arid countries like Egypt. In this study, 12 groundwater samples were taken for a one year (2016-2017) from Nawsa El-Gheit village in Aga city and Qlabsho area in Belqas city (Dakahlia governorate) to assess the quality of groundwater for drinking and irrigation purposes. A total of 23 water parameters were analyzed monthly for collected groundwater sample. Water quality index (WQI) is a mathematical model used to transform any water parameters into a single indicator value which represents the water quality level. Results of WQI showed that Nawsa El-Gheit groundwater fell in good water category and represented 48.785% while Qlabsho groundwater fell in poor category and represented 66.169%. For irrigation suitability, the study proved that Nawsa El-Gheit groundwater and Qalabsho groundwater were unsuitable. Atomic absorption spectroscopy documented high levels of the heavy metals cadmium, chromium, lead, manganese and nickel; however the levels of iron, copper and zinc were safe. This indicates the possible negative health impacts of this water type on human and animal.

Key words: WQI, groundwater, domestic wells, Dakahlia Governorate Egypt.

Introduction

Egypt is one of the arid zones in North Africa; the freshwater of the country is primarily extracted from the Nile River **(Ahmed and Ali, 2011)**.The Nile River provides the Egyptian community with approximately 55.5×10^9 m^3/yr **(Paisley and Henshaw, 2013)**. However, this vital water source is now shrinking and the losses of water will reach to 22% of the coming water to Egypt due to the construction of the Nahda Dam of Ethiopia, with a storage capacity of approximately 74×10^9 m^3**(Mulat and Moges, 2014)**. As a result, the government and experts in the water mining sector should be invited to adopt new strategies to meet the ever growing needs of the ever growing population density for this dramatically depleting blue gold. As reported in **(MWRI, 2014; Abukila, 2015)**, 1.3×10^9 m^3/yr is available perception on northern strip of delta, whereas 2×10^9 m^3/yr is nonrenewable groundwater in West Desert and Sinai. The actual annual water demands are 79.5×10^9 m^3/yr while the gap between requirements and actual amounts of water available are about 20×10^9 m^3/yr **(MWRI, 2014)**. Shallow groundwater in the Nile Delta aquifer is recharged by drains, irrigation canals, percolation losses from irrigation lands and seepage losses from the Nile River; therefore, it is the most important reservoir in the Nile River system with 7.5BCM/yr. Urban and industrial discharges, and emissions lead to a noticeable increase of the pollution level in drainage system that can cause serious public health problems (**Shaban *et al.*, 2010; Elsokkary and AbuKila, 2012)**. The Egyptian government succeeded to support human settlements in major urban sectors with advanced drain systems. In contrast, villages as well as rural areas are still suffering.

Heavy metals are naturally impregnated into the earth's crust and can play an important role in water and nutrient cycles via a composite of geochemical procedures **(Oyeko and Eludoyin, 2010; Laniyan *et al*., 2011)**. Chemical fertilizers, herbicides, pesticides, municipal and industrial effluents are additional sources of pollution in water and can cause serious health problems to human and animal. The groundwater blended with heavy metals acts as an environment ready for the growing of living organisms such as bacteria, virus, protozoa, and metazoa **(Duan and Kofi, 1993)**.

Water quality index (WQI) measures the quality of water for drinking and household purposes. This index transforms several water parameters into only a single number to assess the overall water quality at spatiotemporal scales **(Akter *et al.*, 2016; Boateng *et al.*, 2016)**. There are many indices used to assess the quality of water for irrigation; these are Sodium Adsorption Ratio (SAR), Sodium Percentage

(Na %), Permeability Index (PI), Magnesium Hazards (MH) and Chloro Alkaline Indices (CAI) **(El-Tahlawi *et al.*, 2014)**.

Materials and Methods

1. Study groundwater wells:

A total of 24 groundwater samples affected by agricultural and household activities were collected from a local well in Nawsa El-Gheit village, Aga, 13 Km south Mansoura city and another one in Qlabsho area, Belqas, Dakahlia, Egypt. Nawsa El-Gheit well attains a depth of approximately 35m and was constructed 30years ago, while Qalabsho well attains a depth of 150-200 m and was dug 10-15 years ago. Water samples were collected throughout one year, from August 2016 to July 2017(12 sample/ well). On monthly basis, water was collected in clean and dry polythene bottles.

1.1. Physicochemical parameters:

Sodium (Na^{+}) and potassium (K^{+}) were determined by flame photometer (Jenway PFP7). Biological Oxygen Demand (BOD_5) as well as Dissolved Oxygen (DO) were determined by DO meter. Sulfate (SO_4^{2-}) and total dissolved solids (TDS) were estimated according to the method adopted by **APHA (2005)**. Calcium (Ca^{2+}), magnesium (Mg^{2+}) and chloride (Cl^{-}) were analyzed by volumetric methods given by **(Richards *et al.*, 1954)**. Hydrogen ion concentration (pH) and Electrical conductivity (EC) were measured according to **(Richards *et al.*, 1954)**. Bicarbonate (HCO_3^{-}) and carbonate (CO_3^{2-}) were determined following the methods described by **(Dye, 1958)**. Amounts of Nitrate (NO_3^{-}) and Nitrite (NO_2^{2-}) levels were estimated according to **Singh (1988)**. Total hardness (TH) was calculated by the equation (TH= 2.5 Ca^{2+}+ 4.1 Mg^{2+}) given by **(Ragunath, 1987)**.

1.2. Heavy metals analysis:

Freshly collected water samples were transferred into Amber colored glass bottles with Nitric acid to be analyzed for iron (Fe), Zinc (Zn), Lead (Pb), Cadmium (Cd), Nickel (Ni), Copper (Cu), Chromium (Cr) and Manganese (Mn) using a Buck Scientific (Accusys 211) Atomic Absorption Spectro-photometer **(Allen *et al.*, 1974)**.

2. Weighted Arithmetic Water Quality Index Method (Horton, 1965, developed by **Brown *et al.*, 1972):**

Water quality index was calculated for studied groundwater source to assess the variation of the overall quality of the water sample. The water quality index model was done by using the mean of 23 important physicochemical and heavy metals parameters.

2.1. Parameter Weightage Determination:

The Weightage of each the parameters identified by using the equation:

$$W_n = 1/S_n$$

Where;

W_n = Unit weight of the different parameters tested.

S_n = Standard values of selected parameters (WHO Standard Limit).

2.2. Quality Rating or Sub Index of Selected Parameters:

If quality rating $Q_n = 0$ means complete absence of pollutants, while $0 < Q_n < 100$ implies that, the pollutants are within the prescribed standard and when Qn >100 implies that, the pollutants are above the standards **(Gungoa, 2016)**.The quality rating scale (Q_n) for each parameter was calculated by using the following equation:

$$Q_n = 100(V_n - V_i)/ S_n - V_i$$

Where:

Q_n = Quality rating or sub index

V_n = Laboratory test result for each parameter tested.

S_n = Standard value of each parameter tested (WHO standard criteria for drinking water)

V_i = ideal value of selected parameters tested (in pure water $V_i = 0$ for all parameters tested except pH and dissolved oxygen which is 7.0 and 14.6 respectively.

2.3. Water Quality Index Calculation:

1. The weightage unit (W_n) for all parameters tested was determined and summed up to obtain: ΣW_n
2. The quality rating or sub-index for all parameters tested was determined and summed up to obtain: ΣQ_n
3. The index $W_n \times q_n$ was calculated for each parameter tested and summed up to obtain: $\Sigma W_n \times Q_n$

4. Finally, Water Quality Index (WQI) was computed using the mass balance equation of the form: $(\Sigma W_n \times Q_n / \Sigma W_n) \times 100$

Brown *et al* (1972) classified the water quality based on weighted arithmetic WQI method into 5 categories namely: excellent (0-25), good (26-50), poor (51-75), very good (76-100) and unsuitable (above 100).

3. Water quality for irrigation purposes

The amount of mineral components in water affects the quality of soil and plants and the suitability of groundwater for irrigation purposes. Water quality for irrigation can be tested using Sodium Adsorption Ratio (SAR) **(Karanth (1987)**, Eq. (1); Sodium Percentage (Na%) **(Wilcox (1955)**, Eq. (2); Permeability Index (PI) **(Doneen, 1964)**, Eq. (3), Magnesium Hazard (MH) **(Szabolcs and Darab, 1964)**, Eq. (4) and Chloro alkaline Indices (CAI) **(Schoeller, 1967)**, Eq. (5) with concentrations expressed in meq /L in the following three formulas:

$$SAR = Na^{+} / (Ca^{2+} + Mg^{2+})^{1/2} \quad (1)$$

$$Na\% = [(Na^{+} + K^{+}) / (Na^{+} + Ca^{2+} + K^{+} + Mg^{2+})] \times 100 \quad (2)$$

$$PI = \{[Na^{+} + (HCO_3^{-})^{1/2}] / [Na^{+} + Ca^{2+} + Mg^{2+})]\} \times 100 \quad (3)$$

$$MH = [Mg^{2+} / (Ca^{2+} + Mg^{2+})] \times 100 \quad (4)$$

$$CAI = [(Cl^{-} - (Na^{+} + K^{+})] / Cl^{-} \quad (5)$$

The Wilcox for Na% and United States salinity Laboratory (USSL) diagram for SAR represent at 25°C for both in addition to the piper plot were subjected on Diagrammes software (**Simler, 2009)** Version 6.58.

Results and Discussion

Na^{+} level ranged from 121.20 to 200.93 mg/L, with only one sample above the WHO permissible limits in Nawsa El-Gheit groundwater and from 764.28 to 1141.76 mg/L, with all samples above the WHO permissible limits in Qlabsho groundwater. Cl^{-} concentration varied from 96.77 to 156.84 mg/L, indicating that all samples in Nawsa El-Gheit were within WHO permissible limits. However, in Qlabsho groundwater, Cl^{-} levels varied from 1001.10 to 1635.13 mg/L and all samples above the WHO limits. High concentration of sodium may be attributed to ion exchange between Na^{+} and Ca^{2+} that ends by winning Na^{+} and leaching process of sodium salts such as halite as a main source of increasing both Na^{+} and Cl^{-} during the movement of groundwater through sediments **(Abdel-Hafiz, 2017; Rabeiy, 2017)**. Also, the lack of sewage system can increase the amount of Na^{+} and Cl^{-} in the groundwater within old cultivated lands **(Rabeiy, 2017)**. The high Na^+ levels make water unsafe for the human consumption **(Azizullah *et al.*, 2011)** and may cause muscular twitching and rigidity as well as cerebral and pulmonary edema **(Elton *et al.*, 1963; DNHW, 1992)**. Drinking water with high Cl^- content has a salty taste and a laxative effect **(Bhardwaj and Singh, 2011)**. Groundwater with high levels of Cl^- which is used in irrigation may cause the toxicity for plants **(Hussain *et al.*, 2010)**. High amounts of chlorides recognized near the Mediterranean Sea in Qlabsho may be due to either saltwater intrusion or contamination from domestic waste which find its way to the groundwater through seepage **(Armanuos *et al.*, 2016)**.

Na/Cl ratio is smaller than 0.86 indicates that the groundwater has been contaminated by seawater; however, Na/Cl ratio >1 indicates that the groundwater is blended with an anthropogenic source (**El Moujabber *et al.*, 2006; Klassen *et al.*, 2014)**. In the present study, the Na/Cl ratio is 1.15 and 0.78 in Nawsa El-Gheit and Qlabsho groundwaters respectively.

TH level varied from 56.14 to 110.15 mg/L in Nawsa El-Gheit groundwater and 160.84 to 348.09 mg/L in Qlabsho groundwater; these data indicate that all samples were within the WHO permissible limits. Mg^{2+} level varied from 2.72 to 5.27 mg/L, whereas Ca^{2+} level varied from 17.60 to 39.60 mg/L in Nawsa El-Gheit groundwater. In contrast of Mg^{2+} levels in Qlabsho groundwater varied from 12.40 to 29.76 mg/L, whereas Ca^{2+} levels varied from 39.60 to 96.80 mg/L. Mg^{2+}values of both groundwater are within WHO permissible limits. However, Ca^{2+} values of both wells are within WHO permissible limits, expect 3 in Qlabsho groundwater. The erosion process dissolves the Calcite ($CaCO_3$) and Dolomite [$CaMg(CO_3)_2$] incorporated into the rocks, thus increasing the concentration of Ca and Mg in the groundwater. Agricultural activities may also influence the dissolution of minerals in the groundwater **(Böhlke, 2002)**. Hardness is the property of water which prevents the lather formation with soap and increases the boiling point of water **(Al-Ghamdi *et al.*, 2014)**.

HCO_3^- level varied from 153.42 to 189.59 mg/L in Nawsa El-Gheit groundwater and 121.88 to 292.72 mg/L in Qlabsho groundwater indicating that all samples were above WHO permissible limits. The relatively broad range for HCO_3^- concentrations reflects the diversity in geological formations in the area **(Al-Suhaimi**

***et al.*, 2017)**. SO_4^{2-} concentration varied from 21.86 to 91.97 mg/L in Nawsa El-Gheit groundwater showing that all samples did not exceed the permissible limits, but from 807.07 to 1241.66 mg/L in Qlabsho groundwater showing that all samples were above the WHO limits. Higher values of SO_4^{2-} in the groundwater may be contributed to the dissolution of gypsum ($CaSO_4 \cdot 2H_2O$) and potassium sulfates (K_2SO_4) added to the soil as fertilizers **(Rabeiy, 2017)**. The high intake of SO_4^{2-} may result in gastrointestinal irritation and respiratory disorders in human **(Subramani *et al.*, 2010; Hussain and Prasad Rao 2013)**.

NO_2^{2-} levels varied from 0.21 to 0.95 mg/L in Nawsa El-Gheit groundwater and 0.30 to 0.91 mg/L in Qlabsho groundwater. NO_3^- levels varied from 11.84 to 29.27 mg/L in Nawsa El-Gheit groundwater and 12.82 to 28.86 mg/L in Qlabsho groundwater. All samples were within the permissible WHO limits. Most analyses combine NO_3^- and NO_2^- and investigators report this as NO_3^- because NO_2^- occurs in substantially smaller concentrations in groundwater than NO_3^- **(Burkartaus and Stoner, 2008)**. Leaching of sewage and other waste discharges rich in nitrates is regarded as the main source for groundwater contamination with NO_3^- **(Patil and Patil, 2010)**. The high nitrate level in the drinking water is toxic and can cause blue baby syndrome (methemoglobinemia) in children and gastric carcinomas **(Hussain and Prasad Rao, 2013)**.

K^+ levels varied from 4.50 to 9.00 mg/L in Nawsa El-Gheit groundwater and 3.91to 7.50 mg/L in Qlabsho groundwater. All samples were within WHO permissible limits, expect one in Qlabsho. Because K is a common element in many rocks, the solubility of these rocks leads to an increase of this mineral level in the groundwater. Additionally, fertilizers and industrial reminants are also important sources for K in the groundwater **(Al-Suhaimi *et al.*, 2017)**.

TDS values varied from 310.40 to 652.80 mg/L in Nawsa El-Gheit groundwater, with 3 samples above the WHO permissible limits. On the other hand, TDS values varied from 2323.20 to 3507.20 mg/L in Qlabsho groundwater and all samples were above the WHO permissible limits. The salinity behavior of groundwater is indicated by TDS; their value depends on the climate, host rock, and residence time of the groundwater in the geological matrix. It is also enhanced in agricultural arid areas due to cyclic salting process **(Lloyd and Heathcote, 1985)**.

High concentration of TDS is observed near the shoreline of the Mediterranean Sea in Qlabsho as a result of interaction between freshwater in the aquifer and saltwater from the sea, and domestic and agricultural wastes. EC level varied from 490 to 1020 µs/cm in Nawsa El-Gheit groundwater and was within the WHO permissible limits, but from 3630 to 5480 µs/cm in Qlabsho groundwater and was above the WHO limits. High EC values were affected by temperature and also indicated the presence of high amount of dissolved inorganic substances in ionized form **(Patil and Patil, 2010)**. Water with high levels of chloride, sulfates and sodium or other ions will be more electrically conductive and may promote corrosion **(WUCEQ, 2002)**. High electrical conductivity affected the germination of crops and may result in much reduced yield **(Srinivas *et al.*, 2000)**.

The pH levels varied from 7.02 to 8.63 in Nawsa El-Gheit groundwater, with 2 samples exceeded the maximum permissible limits of WHO. This parameter varied from 7.32 to 8.51 in Qlabsho groundwater, with only one sample above WHO limits. Most of the waters are slightly alkaline due to presence of carbonates and bicarbonates **(Patil and Patil, 2010)**. High value of pH may results from waste discharge and microbial decomposition of organic matter in water **(Patil *et al.*, 2012)**.

DO is an important parameter in the water quality assessment and reflects the physical and biological processes prevailing in water. in the present analysis, DO varied from 2.80 to 5.20 mg/L in Nawsa El-Gheit groundwater and all samples were within the WHO limits. On the other hand, DO varied from 2.40 to 8.80 mg/L in Qlabsho groundwater with 7 samples exceeded the WHO limits. BOD is a measure of oxygen employed by microorganisms to decompose waste. BOD levels varied from 2.63 to 4.79 mg/L in Nawsa El-Gheit groundwater, and 2.42 to 4.95 mg/L in Qlabsho groundwater. All values were an agreement with the WHO limits. If there is a large quantity of organic waste in water, there will also be a lot of bacteria working to decompose this waste. Accordingly, the demand for oxygen will be high and so the BOD level. As the waste is consumed or dispersed through water, BOD levels will begin to decline **(Al-Wasify *et al.*, 2013)**. Organic matter such as plants, animals or bacteria existing in water may create sewage odor **(WSDH, 2018)**.

Cd levels varied from 0.00 to 0.66 mg/L in Nawsa El-Gheit groundwater, with 10 samples exceeded the WHO limits. This heavy metal varied from 0.00 to 0.56

mg/L in Qlabsho groundwater, with 11 samples above the WHO limits. Cd may occur in groundwater naturally or as a contaminant from sewage sludge, use of phosphatic fertilizer, mining and industrial effluents **(Tadiboyna and Rao, 2016)**. Cd has long biological half-life **(Orisakwe *et al*., 2006)**, leading to chronic effects as a result of accumulation in the liver and renal cortex **(Hammer and Hammer Jr., 2004)**.

Fe levels varied from 0.00 to 0.19 mg/L in Nawsa El-Gheit groundwater and no samples were above the WHO permissible limits. On the other hand, this metal varied from 0.04 to 0.69 mg/L in Qlabsho groundwater, with one sample exceeded the WHO limits. Fe is used in coatings pipes transporting water yielding; over time, these coatings can begin deteriorating and municipal landfill, introducing excess iron into the water supply **(Mandour, 2012)**. Liver cirrhosis was related to drinking water contaminated mainly with iron **(Mandour, 2012)**. Excess amount of Fe can result in dark green foliage, stunted growth of tops and roots, dark brown to purple leaves in some plants **(Afolayan, 2018)**.

Cr occurs naturally as chromite **(Oliveira, 2012)**. In the present study, Cr levels varied from 0.00 to 0.74 mg/L in Nawsa El-Gheit groundwater with 7 samples above the WHO limits. In Qlabsho groundwater, this heavy metal varied from 0.01 to 0.84 mg/L, with 7 samples exceeded the WHO limits. Cr compounds are highly toxic to plants and are detrimental to their growth and development; this toxicity can alter photosynthesis in terms of CO_2 fixation, electron transport, photophosphorylation, enzyme activities and induce the metabolic modification in plants **(Nagajyoti, 2010)**. Lung cancer, kidney and liver damage that can lead to death are diseases caused by high levels of copper **(Awasthi and Li, 2017)**.

Cu levels varied from 0.01 to 1.07 mg/L in Nawsa El-Gheit groundwater, and from 0.04 to 0.65 mg/L in Qlabsho groundwater. All samples for both wells were within the permissible WHO limits. The groundwater with high concentration of copper may be ascribed to the corrosion of piping system in hand pumps **(Tadiboyna and Rao, 2016)**. The alkaline pH of the medium can also be the cause of low level of copper; heavy metals are precipitated as their salts at high pH and are deposited as sediments **(Rao *et al.*, 2000)**. High dose of copper may damage liver as well as kidney and even lead to death **(Mahurpawar, 2015)**.

The contamination of groundwater by Pb may be the result of entry from old plumbing, household sewages, agricultural run-off containing phosphatic fertilizers, human and animal excreta **(Jameel *et al.*, 2012)**. Pb levels varied from 0.00 to 0.37 mg/L in Nawsa El-Gheit groundwater with 8 samples exceeded the permissible limits set by WHO. This heavy metal varied from 0.01 to 1.09 mg/L in Qlabsho groundwater, with only one sample within the WHO limits. This metal can cause several adverse effects, such as rise in blood pressure, kidney and brain damage; lead can also impair fertility of human through sperm damage and diminished learning abilities of children **(Awasthi and Li, 2017)**. Exposure to lead may also cause development of autoimmunity, in which the immune system attacks the body cells **(Al-Qutob *et al.*, 2013)**. A high lead level in soil inhibits seed germination and induces abnormal morphology in many plant species which inhibited root, stem elongation and leaf expansion **(Orji, 2018)**.

Mn levels varied from 0.04 to 0.81 mg/L in Nawsa El-Gheit groundwater, with 7 samples were above the WHO limits. Comparatively, Mn levels varied from 0.12 to 1.66 mg/L in Qlabsho groundwater, which all samples above the WHO limits. The groundwater contaminated by Mn may be the result of the influence of domestic waste, natural geological rocks and industrial effluent **(Jameel *et al.*, 2012)**. If the groundwater is oxygen poor, manganese will dissolve more readily, particularly if the pH is acidic **(Ibrahem *et al.*, 2017)**. Groundwater contaminated by Mn may acquire a metallic taste **(Ibrahem *et al.*, 2017)**.

Ni levels varied from 0.00 to 1.28 mg/L in Nawsa El-Gheit groundwater, with 10 samples were above the standard limits. On the other hand, Ni varied from 0.08 to 1.34 mg/L in Qlabsho groundwater, with all samples exceeded the WHO limits. Leaching from metals in contact with drinking water such as pipes and fittings is an important source of Ni contamination **(Mishra *et al.*, 2018)**. **El-Sanafawy (2002)** mentioned that the undesired practices such as uses of great amounts of phosphate fertilizers in agriculture, fuel oil used in brick kilns and so many types of pesticides may also lead to the storage of plentiful amounts of Cd and Ni in water. Toxicity of nickel is enhanced in presence of some other metals (Co, Cu, Fe and Zn) in drinking water **(Azab *et al.*, 2010)**. **Kaaber *et al.* (1979)** reported worsening of eczema for human exposed to high level of nickel. Plants grown in Ni -rich soil underwent impairment of nutrient balance and disorder of cell membrane functions **(Orji, 2018)**.

Diverse toxicity symptoms such as chalorosis and necrosis in different plant species may be developed **(Rahman *et al.*, 2005)**. The decrease in water uptake is used as an indicator of the progression of Ni toxicity in plants **(Gajewska *et al.*, 2006)**.

Zn levels varied from 0.01 to 0.22 mg/L in Nawsa El-Gheit groundwater, and from 0.00 to 0.15 mg/L in Qlabsho groundwater. All samples did not exceed the WHO limits. Levels of Zn are high under natural conditions, and are also affected by human activities such as waste water from foundry and instrument manufacturers **(Hu *et al.*, 2015)**. **Plum *et al.*, 2010** illustrated that whereas intoxication by excessive exposure is rare, it can cause the lethargy, metal fume fever due to inhalation it, vomiting, diarrhea and elevated risk of prostate cancer in addition to associated with Cu deficiency and can also altered lymphocytes function. Zn deficiency is widespread and in severe cases its consequences are lethal, The definicy of Zn can cause thymic atrophy, decreased wound healing, infertility, retarded genital development, hypogonadism in addition to associated with growth retardation and immune infection (**Plum *et al.*, 2010)**. The phytotoxicity of Zn is indicated by decrease in growth and development, metabolism and an induction of oxidative damage in various plant species **(Nagajyoti *et al.*, 2010)**. Another typical effect of Zn toxicity is the appearance of a purplish-red color in leaves, which is ascribed to phosphorus (P) deficiency **(Nagajyoti *et al.*, 2010)**. Excess Zn can also give rise to Mn and Cu deficiencies in plant shoots **(Orji *et al.*, 2018)**.

According to field investigations as well as soil column studies, Zn, Cu, Cr and Cd had rapid leaching levels **(Sukkariyah *et al.*, 2005; Ning *et al.*, 2011);** In addition, municipal waste contains Cd, Co, Cu, Fe, Hg, Mn, Pb, Ni, and Zn which end up in the soil due to its ability to be leached out from the dumping sites **(Fatoki, 2000; Orji, 2018)**.

Calculation of Water Quality Index (WQI) for groundwater samples:

The Weighted Arithmetic Water Quality Index Method classifies the water quality depending on the degree of purity by using the most commonly measured water quality variables **(Brown *et a.l*, 1972)** into 5 categories namely: excellent (0-25), good (26-50), poor (51-75), very good (76-100) and unsuitable (above 100); Nawsa El-Gheit groundwater fell in the good water category and represented 48.785% while Qlabsho groundwater fell in the poor water category and represented 66.169% (Table 2).

It can be noticed from table (2) that Q_n of DO, HCO_3^-, Cd, Cr, Ni and Pb were above 100 which have negative impact on Nawsa El-Gheit groundwater quality while Q_n of TDS,EC, SO_4^{2-}, K^+,.HCO_3^-, Cd, Cr, Mn, Ni and Pb which have negative impact on Qlabsho groundwater quality

2. Calculation of SAR, Na, PI, MH and CAI for studied groundwater wells:

Sodium Adsorption Ratio (SAR) represented (7.43 meq /L) in Nawsa El-Gheit groundwater and is classified as excellent, while it represented (26.96 meq /L) and is classified as poor in Qlabsho groundwater. According to **Todd (1980),** alkali hazards are classified according to SAR into 4 classes namely: excellent (up to 10), good (10-18), fair (18-26) and poor (>26). From USSL diagram (Fig. 1), most Nawsa El-Gheit groundwater samples fell in the category of high salinity and medium sodium (C3-S2), except 5 samples: 1 fell in (C3-S1) and 4 fell in (C2-S2). This water type can be used in soil of medium texture and high permeability. All Qlabsho groundwater samples belonged to the very high sodium and very high salinity (C4-S4) category and were considered harmful and unsuitable.

Sodium Percentage (Na%) represented 81.86% in Nawsa El-Gheit groundwater and 89.96% in Qlabsho groundwater; both were classified as unsuitable for irrigation depending on **Ragunath (1987)** who classified Na % into 5 classes namely: excellent (0-20), good (20-40), permissible (40-60), doubtful (60-80) and unsuitable (>80). From Wilcox diagram (Fig. 1), Nawsa El-Gheit groundwater fell in the permissible category, while Qlabsho groundwater fell in the poor category. This excess Na% can cause osmotic effect on the soil-plant system owing to the restriction of air and water circulation during wet conditions and eventually results in soil with poor internal draining **(Tiri and Boudoukha, 2010)**. Such soils are usually hard when they are dry **(Saleh *et al.*, 1999)**.

Permeability Index (PI) represented 103.22% in Nawsa El-Gheit groundwater and 93.66% in Qlabsho groundwater; both fell on class III corresponding to **(Doneen, 1964)** who classified PI into class I (>75%), class II (25‑75%) and class III (<25%); Class I and class II were categorized as good for irrigation with 75% or more of maximum permeability but Class III is unsuitable with 25% of maximum permeability. The soil permeability is affected by the long-term use of irrigation water as it effect on Na^+, Ca^{2+}, Mg^{2+} and HCO_3^- content of the soil.

Magnesium Hazard (MH) values represented 21.83 meq/L in Nawsa El-Gheit groundwater and 33.19 meq/L in Qlabsho groundwater. Both water types were not harmful according to (**Szabolcs and Darab, 1964)** who considered MH values >50 harmful and unsuitable for irrigation purposes. More Mg^{2+} in water can affect the soil quality converting it to alkaline and decreases crop yield **(Ramesh and Elnago, 2011)**.

Chloro alkaline Indices (CAI) values represented -0.81meq/L in Nawsa El-Gheit groundwater and -0.20meq/L in Qlabsho groundwater; the negative value indicates that the exchange is in indirect base (chloro-alkaline disequilibrium) and the positive value indicates that there is base-exchange reactions between sodium and potassium (Na^++K^+) in water with calcium and magnesium (Ca^{2+}+Mg^{2+}) in the rocks **(Schoeller, 1967)**.

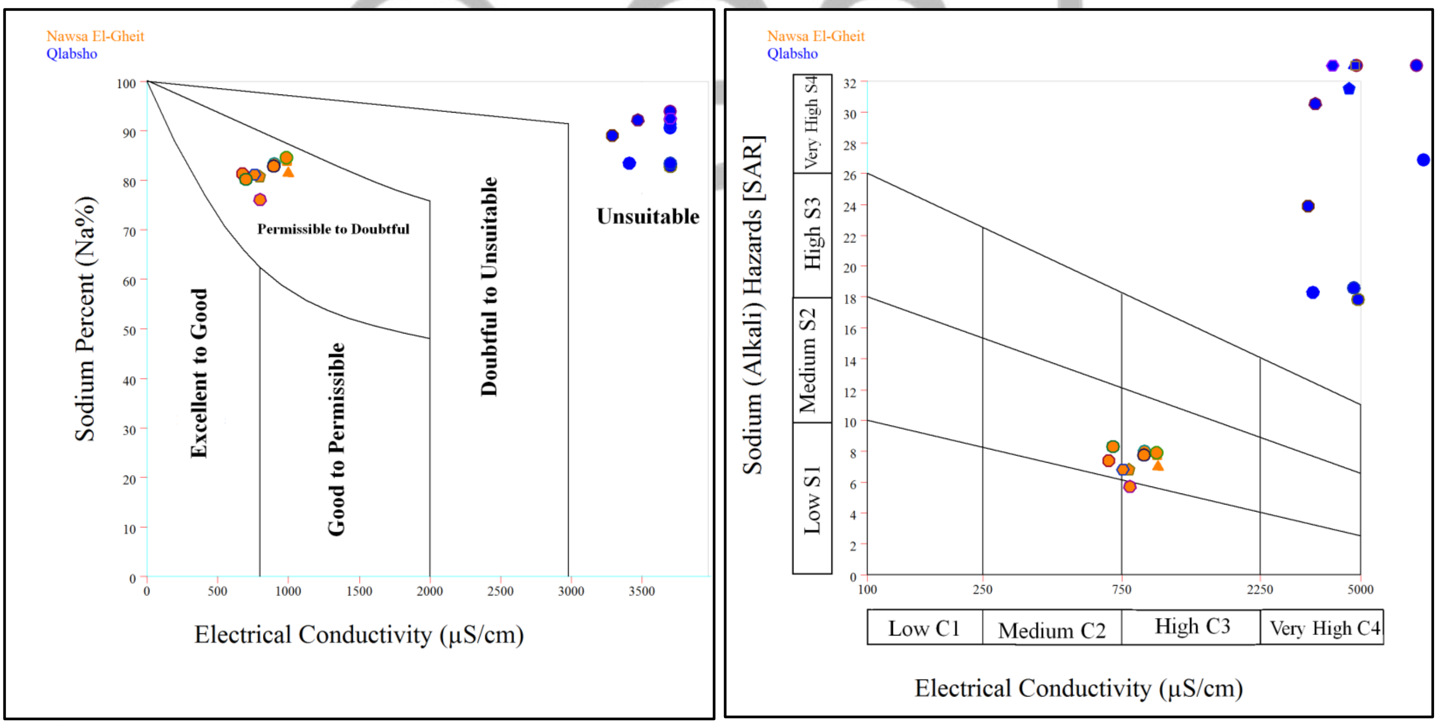

Fig.(1): Wilcox and USSL diagram at 25°C for monthly classification of the groundwater samples for irrigation purpose

GSJ: Volume 7, Issue 3, March 2019
ISSN 2320-9186

As shown from the plot in fig.(2), the two water types are classified as Na-Cl. This diagram clearly showed that the groundwater samples had a dominance of chloride and sulfate ions for anions, while sodium was the cation which marked the majority of samples and followed by the calcium.

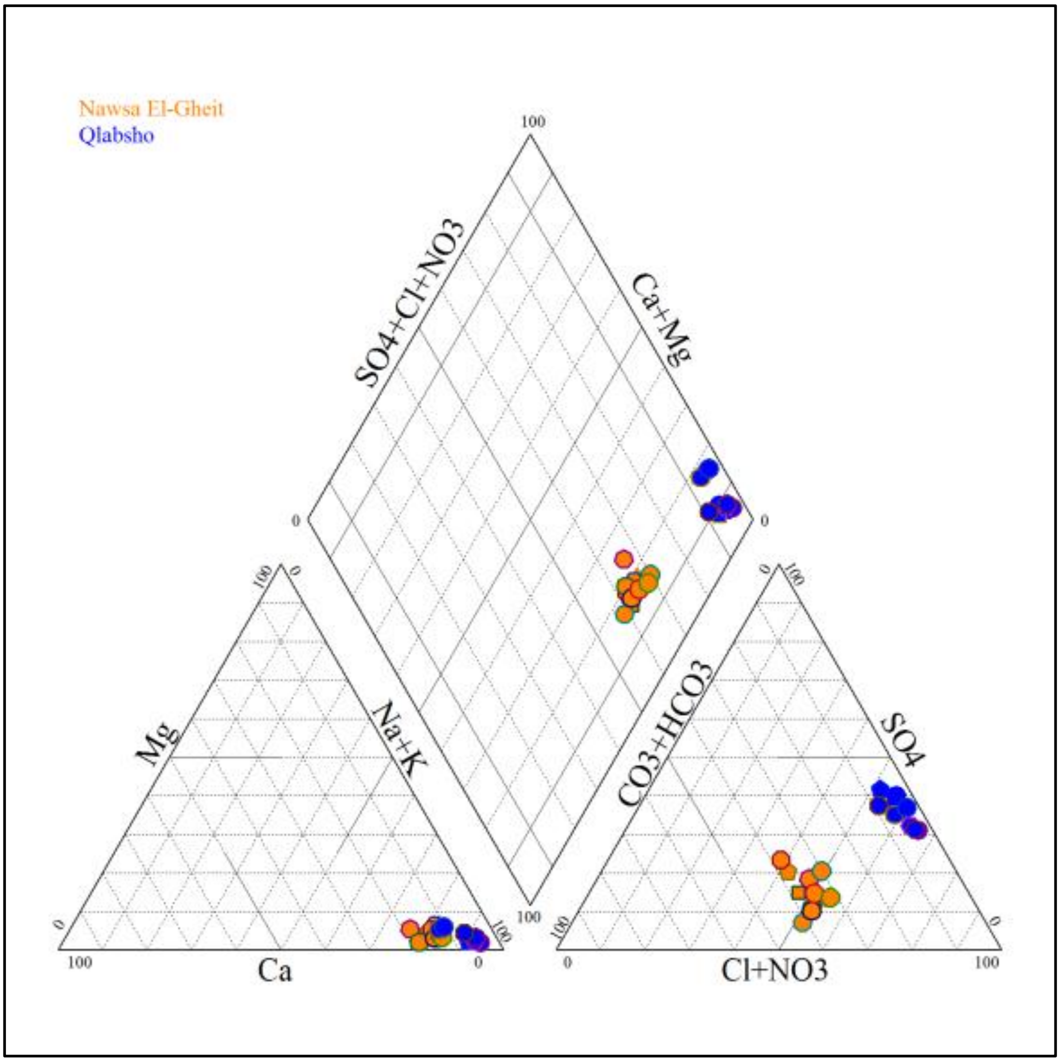

Fig.(2): Piper diagram for monthly classification of the groundwater for irrigation purpose.

GSJ: Volume 7, Issue 3, March 2019
ISSN 2320-9186

Table (1): Descriptive statistics of the physicochemical parameters in the present study compared with WHO standards.

	Nawsa El-Gheit			WHO (2017)	Qlabsho		
	Mean ± SD	Minimum	Maximum		Mean ± SD	Minimum	Maximum
Na^+ (mg/L)	143.90±20.24	121.20	200.93	200.00	944.60±139.60	764.28	1141.76
Cl^- (mg/L)	125.20±19.55	96.77	156.84	250.00	1212.00±201.20	1001.10	1635.13
HCO_3(mg/L)	169.70±12.12	153.42	189.59	120.00	185.30±53.38	121.88	292.72
TH (mg/L)	71.02±14.60	56.14	110.15	500.00	231.60±69.94	160.84	348.09
Mg^{2+} (mg/L)	3.80±1.02	2.72	5.27	30.00	18.72±6.11	12.40	29.76
Ca^{2+} (mg/L)	22.18±6.07	17.60	39.60	75.00	61.97±19.45	39.60	96.80
SO_4^{2-} (mg/L)	57.05±19.87	21.86	91.97	250	1009.00±122.80	807.07	1241.66
NO_2^{2-} (mg/L)	0.56±0.23	0.21	0.95	3.00	0.59±0.20	0.21	0.95
NO_3^- (mg/L)	20.30±5.59	11.84	29.27	50.00	21.07±4.88	12.82	28.86
K^+ (mg/L)	5.88±2.04	4.50	9.00	12.00	5.31±1.06	3.91	7.50
TDS (mg/L)	476.10±105.50	310.40	652.80	500	2972.00±360.00	2323.20	3507.20
EC (µs/cm)	164.20±745.00	490.00	1020.00	2000	4643.00±562.60	3630	5480
pH	7.94±0.51	7.02	8.63	8.5	7.92±0.35	7.32	8.51
DO (mg/L)	3.83±0.71	2.80	5.20	5.00	5.93±2.31	2.40	8.80
BOD_5 (mg/L)	3.67±0.74	2.63	4.79	10.00	3.81±0.80	2.42	4.95
Cd (mg/L)	0.17±0.21	0.00	0.66	0.003	0.23±0.15	0.00	0.56
Fe (mg/L)	0.08±0.06	0.00	0.19	0.3	0.15±0.17	0.04	0.69
Cr (mg/L)	0.13±0.21	0.00	0.74	0.05	0.21±0.28	0.01	0.84
Cu (mg/L)	0.37±0.37	0.01	1.07	2.00	0.27±0.18	0.04	0.65
Pb (mg/L)	0.09±0.13	0.00	0.37	0.01	0.17±0.30	0.01	1.09
Mn (mg/L)	0.25±0.23	0.04	0.81	0.10	0.50±0.43	0.12	1.66
Ni (mg/L)	0.44±0.41	0.00	1.28	0.07	0.53±0.49	0.08	1.34
Zn (mg/L)	0.09±0.07	0.01	0.22	5.00	0.07±0.04	0.00	0.15

Table (2): Values of water quality index (WQI) by Weighted Arithmetic for water extracted from studied groundwater wells in Dakahlia, Egypt.

parameter	WHO limit	W_n	Nawsa El-Gheit			Qlabsho		
			V_n	Q_n	$W_n \times Q_n$	V_n	Q_n	$W_n \times Q_n$
EC (µs/cm)	2000.00	0.0005	745	37.25	0.019	4643	232.15	0.116
pH (mg/L)	8.5	0.117	7.94	62.667	7.332	7.92	61.333	7.176
DO(mg/L)	5.00	0.200	3.83	112.188	22.438	5.93	90.313	18.063
TDS(mg/L)	500.00	0.002	476.10	95.22	0.190	2972	594.4	1.189
Ca^{2+}(mg/L)	75.00	0.013	22.18	29.573	0.384	61.97	82.627	1.074
SO_4^{2-}(mg/L)	250.00	0.004	57.05	22.82	0.091	1009	403.6	1.614
K^+(mg/L)	12.00	0.083	5.88	49.00	4.067	5.31	44.25	3.673
Mg^{2+}(mg/L)	30.00	0.033	3.80	12.667	0.042	18.72	62.4	2.059
Na^+(mg/L)	200.00	0.005	143.90	71.95	0.360	944.60	427.3	2.137
Cl^-(mg/L)	250.00	0.004	125.20	50.08	0.200	1212.00	484.8	1.939
TH(mg/L)	500.00	0.002	71.02	14.204	0.028	231.60	46.32	0.093
HCO_3(mg/L)	120.00	0.008	169.70	141.417	1.131	185.30	154.417	1.235
NO_2^{2-}(mg/L)	3.00	0.333	0.56	18.667	6.216	0.59	19.667	6.549
NO_3^- (mg/L)	50.00	0.020	20.30	40.60	0.812	21.07	42.14	0.843
Cd (mg/L)	0.003	333.333	0.17	5666.667	1888887	0.23	7666.667	2555553
Cr (mg/L)	0.05	20	0.13	260.00	5200.00	0.21	420	8400
Cu (mg/L)	2.00	0.500	0.37	18.50	9.25	0.27	13.5	6.75
Fe (mg/L)	0.30	3.333	0.08	36.667	88.88	0.15	50	166.65
Mn (mg/L)	0.10	10	0.25	250.00	2500.00	0.50	500	5000
Ni (mg/L)	0.07	14.286	0.44	628.571	8979.771	0.53	757.143	10816.543
Pb (mg/L)	0.01	10	0.09	900.00	9000.00	0.17	1700	17000
Zn (mg/L)	5.00	0.200	0.09	1.80	0.36	0.07	1.4	0.28
Sum		392.477			1914708.571			2596991.094
WOI%	48.785%					66.169%		

References

Abdel-Hafiz M. A., (2017). Hydrochemical and environmental assessment of waterlogging and soil for different purposes at El Obour city, East Cairo, Egypt. M.Sc. Thesis, Department of Geology, faculty of science, Al-Azhar University, Assiut. 272 p.

Abukila, A. F. (2015). Assessing the drain estuaries' water quality in response to pollution abatement. Water Science. 29(1): 1–18.

Afolayan, A.O. (2018). Accumulation of heavy metals from battery waste in topsoil, surface water, and garden grown maize at Omilende Area, Olodo, Nigeria. Global Challenges. 2(3): 1700090.

Ahmed, A.A.and Ali, M.H. (2011). Hydrochemical evolution and variation of groundwater and its environmental impact at Sohag. Egypt Arabian Journal of Geosciences 4:339–352.

Akter, T.; Jhohura, F.T.; Akter, F.; Chowdhury, T.R.; Sabuj Kanti Mistry, S.K.; Dey, D.; Barua, M.K.; Islam, M.A. and Rahman, M. (2016). Water quality index for measuring drinking water quality in rural Bangladesh: a cross-sectional study. Journal of Health, Population and Nutrition. 35: 4-4.

Al-Ghamdi, A.Y.; Saraya, M. E. I.; Al-Ghamdi, A. O. and Zabin, S. A. (2014). Study of physic-chemical properties of the surface and ground water. American Journal of Environmental Sciences 10(3): 219-235.

Allen, S.; Grimshaw, H.M.; Parkinson, J.A. and Quarmby, C. (1974). chemical analysis of ecological materials. Blackwell Scientific Publications, Oxford. 521p.

Al-Qutob, M.; Malassa, H.; Mahmoud Al-Khatib, M. and Al-Rimawi, F. (2013). Determination of Different Trace Heavy Metals in Ground Water of South West Bank/Palestine by ICP/MS. Journal of Environmental Protection**.** 4: 818-827.

Armanuos, A.M.; Negm, A. and Saavedra Valeriano, O.C. (2016). Groundwater quality investigation using multivariate analysis - case study: western Nile Delta aquifer, Egypt. International Journal of Environmental Science and Development, 7(1):1-9.

AlSuhaimi, A.O.; AlMohaimidi, K.M. and Momani, K.A. (2017). Preliminary assessment for physicochemical quality parameters of groundwater in Oqdus Area, Saudi Arabia. Journal of the Saudi Society of Agricultural Sciences, http://dx.doi.org/10.1016/j.jssas.

Al-Wasify, R.S.; Mostafa, A.H.; Sayed, A.M. and Bakry M. Haroun, B.M. (2013). Microbiological and physicochemical evaluation ofn groundwater in Egypt. International Journal of Environment and Sustainability. 2(2):1-10.

APHA (American Public Health Association) (2005). Standard methods for the examination of water and wastewaters. 21th edition, Washington, D.C.

Awasthi, A.K. and Jinhui Li, J. (2017). Management of electrical and electronic waste: A comparative evaluation of China and India. Renewable and Sustainable Energy Reviews 76: 434–447.

Mandour, R. A. (2012). Human health impacts of drinking water (surface and ground) pollution Dakahlyia Governorate. Applied Water Science journal. 2(3):157–163.

Azizullah, A.; Khan Khattak, M. N.; Richter, P. and Hader, D. (2011). Water pollution in Pakistan and its impact on public health-a review. Environment International. *37*(2): 479-497.

Bhardwaj, V.; Singh, D.S. (2011). Surface and ground water quality characterization of Deoria district, Ganga Plain, India. *Environmental Earth* Sciences Journal. 63: 383-395.

Boateng, T.K.; Opoku, F.; Acquaah, S.O.; Akoto, O. (2016). Groundwater quality assessment using statistical approach and water quality index in Ejisu-Juaben Municipality. Ghana Environmental Earth Sciences. 75: 1–14.

Böhlke, J.K. (2002). Groundwater recharge and agricultural contamination. Hydrogeology Journal. 10(1): 153–179.

Brown, R. M.; McClelland, N. I.; Deininger, R. A. and O'Connor M. F. (1972). Water Quality Index-Crashing, the Psychological Barrier, Proc. 6th Annual Conference, Advances in Water Pollution Research. 787-794.

Burkartaus D, M. R. and Stoner, J. D. (2008). Chapter 7, Nitrogen in Groundwater Associated with Agricultural Systems. Publications from USDA-ARS / UNL Faculty. 259p.

DNHW (Department of National Health and Welfare) (1992). Supporting documentation, Ottawa, Canada, doi: 10.1007/s13201-013-0109-y.

Doneen, L. D., (1964). Water quality for agriculture. Department of Irrigation, University of Calfornia. Davis. 48p.

Duan, A. and Kofi, D. (1993). Hazardous waste risk assessment, library of congress cataloging in publication, Data Lewis Publication. 8-9.

Dye, J.F. (1958). Correlation of the two principal methods of calculating the three kinds of alkalinity. American Water Works Association journal. 50(6): 800-820.

El Moujabber, M.; Bou Samra, B.; Darwish, T. and Atallah, T. (2006). Comparison of different indicators for groundwater contamination by seawater intrusion on the Lebanese coast Water Resour. Manag. 20(2): 161–80.

El.Tahlawi, M.R.; Mohamed, M. A.; Boghdadi, G. Y.; Rabeiy, R. E. and Saleem, H. A. (2014). Groundwater Quality assessment to estimate its suitability for different uses in Assiut governorate, Egypt. International Journal of Recent Technology and Engineering. 3(5): 53-61.

El-Sanafawy, H.M. (2002). Geochemical investigation of soil and water on polluted areas in mid-Nile Delta for environmental assessment. Ph.D. thesis, Faculty of Science, Mansoura University. 248p.

Elsokkary, I.H. and AbuKila, A.F.(2012). Prospective speculation for safe reuse of agricultural drainage water in irrigation. Alexandria Science Exchange Journal. 34:134–152.

Elton, N. W.; Elton, W. J. and Narzareno, J. P. (1963). Pathology of Acute Salt Poisoning in Infants. American Journal of Clinical Pathology. 39(1), 252-264.

Gajewska, E.; Sklodowska, M.; Slaba, M. and Mazur, J. (2006). Effect of nickel on antioxidative enzymes activities, proline and chlorophyll contents in wheat shoots. Biologia Plantarum. 50:653–659.

Gungoa, V. (2016). Use of water quality indices for water quality assessment in small island state: a case study in the northern aquifer of Mauritius. International Journal of Sciences: Basic and Applied Research. 30(2): 142-150.

Hammer, M. J. and Hammer, M. J. Jr. (2004). Water Quality. In: Water and Waste Water Technology. 5^{th} edition. New Jersey: Prentice-Hall. 139-159.

Hu, G.; Bi, S.; Xu, G.; Zhang, Y.; Mei, X. and Li, A. (2015). Distribution and assessment of heavy metals off the Changjiang River mouth and adjacent area during the past century and the relationship of the heavy metals with anthropogenic activity. Marine Pollution Bulletin. 96(1–2): 434–440.

Hussain, G.; Alquwaizany, A.; Al-Zarah, A. (2010). Guidelines for irrigation water quality and water management in the Kingdom of Saudi Arabia: an overview. *Journal of Applied* Sciences. 10(2): 79–96.

Hussain, M. and Prasad Rao, T. V. D. (2013). Assessment of the ground water quality and its suitability for drinking and irrigation purposes: A case study of Patancheru, Andhra Pradesh, India. Archives of Applied *Science* Research. 5(6): 232-238.

Ibrahem, I. A.; Abd El-aal1, R. M.; Hegazy, W. H. and Esmail1, M. A. (2017). Spectroscopic determination of some heavy metals and their effect on the quality of groundwater. International Journal of Advanced Research. 5(4), 1276-1289.

Jameel, A. A.; Sirajudeen, J. and vahith, R. A. (2012). Studies on heavy metal pollution of ground water sources between Tamilnadu and Pondicherry, India. Advances in Applied Science Research. 3(1):424-429.

Kaaber, K.; T. Menene; J. C. Tjell andN. Vein, (1979). Ant abuse treatment of nickel dermatitis. *Journal* of *Contact Dermatitis*. 5 : 221-228.

Karanth, K.R. (1987). Groundwater assessment, development and management. Tata McGraw Hill Publishing Company Limited, New Delhi. 576-638.

Klassen, J.; Allen, D. M. and Kirste, D. (2014). Chemical Indicators of Saltwater Intrusion for the Gulf Islands, British Columbia.

Laniyan, T.A.; Kehinde Phillips, O.O. and Elesha, L. (2011). Hazards of heavy metal contamination on the groundwater around a municipal dumpsite in Lagos, southwestern Nigeria. International Journal of Engineering & Technology. 11(1): 61-69.

Lloyd, J.W.; Heathcote, J.A. (1985). Natural Inorganic Hydrochemistry in Relation to Groundwater. Oxford University Press, New York. 294p.

Mahurpawar, M. (2015). Effects of heavy metals on human health. International Journal of Reseacrh-Granthaalayah. 2394-3629.

Mandour, R. A. and Azab, Y. A. (2011). Toxic levels of some heavy metals in drinking groundwater in Dakahlyia governorate, Egypt in the year 2010. International journal of Occupation and Environmental Medicine. 2(2): 112-117.

Mishra, S; Bhuyan, N. K.; Mohapatra, R. K. and Das, H. K. (2018). Seasonal assessment of groundwater quality in terms of heavy metal contamination in Sukinda mining region of Jajpur District, Odisha. International Journal of Development Research. 8(04): 19815-19820.

Mulat, A.G. and Moges, S.A. (2014). Assessment of the impact of the Grand Ethiopian Renaissance Dam on the performance of the High Aswan Dam. 6:583-598.

MWRI (Ministry of Water Resources and Irrigation, Egypt) (2014). Water Scarcity in Egypt: The Urgent Need for Regional Cooperation Among the Nile Basin Countries.

Nagajyoti, P.C.; Lee, K.D. and Sreekanth, T.V.M. (2010). Heavy metals, occurrence and toxicity for plants: a review. *Environmental Chemistry Letters*. 8(3):199–216.

Ning, L.; Liyuan, Y.; Jirui, D. and Xugui P. (2011). Heavy Metal Pollution in Surface Water of Linglong Gold Mining Area, China. Procedia Environmental Sciences, 10: 914 – 917.

Oliveira, H. (2012). Chromium as an environmental pollutant: insight on induced plant toxicity. *Journal* of *Botany*. 1-8.

Orisakwe, O. E.; Igwilo, I. O.; Afonne, O.J.; Maduabuchi, J. U.; Obi E. and Nduka, J.C. (2006). Heavy metal hazards of sachet water in Nigeria. Archives of Environmental & Occupational Health. 61(5): 209-213.

Orji, O. A.; Edosa, I. V. O.; Ogbemudia, I.; Omokaro, S. O. and Elenwo C. E. (2018). Assesement of Some Heavy Metals in Soils and Plants Growth in Dumpsites. Journal of Environmental Science, Toxicology and Food Technology. 12(3) Ver. III: 17-23.

Oyeku, O.T. and Eludoyin, A.O. (2010). Heavy metal contamination of groundwater resources in a Nigerian urban settlement. 4(4): 201-214.

Paisley, R.K. and Henshaw, T.W. (2013). Transboundary governance of the Nile River Basin: past, present and future. Environmental Development. 7: 59–71.

Patil, V.T. and Patil, P. R. (2010). Physicochemical analysis of selected groundwater samples of Amalner town in Jalgaon district, Maharashtra, India. E-Journal of Chemistry. 7(1), 111-116.

Patil S. G., Chonde S. G., Jadhav A. S., Raut P. D. (2012). Impact of Physico-Chemical Characteristics of Shivaji University lakes on Phytoplankton

Communities, Kolhapur, India, Research Journal of Recent Sciences. 1(2), 56-60.

Paul, M.J.; Walsh, B.; Oliver, J. and Thomas, D. (2017). Algal indicator in streams: a review of their application in water quality management of nutrient pollution. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, D.C. 2-44.

Plum, L. M.; Rink, L. and Haase, H. (2010). The essential toxin: impact of Zinc on human health- review. International Journal of Environmental Research and Public Health. *7*: 1342-1365.

Rabeiy, R.E. (2017). Assessment and modeling of groundwater quality using WQI and GIS in Upper Egypt area. Environmental Science and Pollution Research. 25(31): 30808-30817.

Ragunath, H. M. (1987). Groundwater. Wiley Eastern Ltd, New Delhi, 563p.

Rahman, H., Sabreen, S., Alam, S., Kawai, S. (2005). Effects of nickel on growth and composition of metal micronutrients in barley plants grown in nutrient solution. Journal of Plant Nutrition. 28(3): 393–404.

Ramesh, K., Elango, L., (2011). Groundwater Quality and its Suitability for Domestic and Agricultural Use in Tondiar River Basin, Tamil Nadu, India.

Rao, L.M.; Manjula Sree Patnaik, R. (2000). Heavy meal accumulation the catfish Mystlis vittatlis (bloch) from Mehadrigedda stream of Visakhapatnam, India. Pollution Research Paper. 19 (3): 325-329.

Rao, N.S. (2006). Seasonal Variation of Groundwater Quality in a Part of Guntur District, Andhra Pradesh, India. Environmental Geology. 49, 413-429.

Richards, L. A.; Allison, L. E.; Brown, J. W. and Hayward, H. E. (1954). Diagnosis and Improvement of saline and alkali soils. Agriculture Handbook No. 60.

Saleh, A.; Al-Ruwaih, F. and Shehata, M. (1999). Hydrogeochemical Processes Operating within the Main Aquifers of Kuwait. Journal of Arid Environments. 42: 195-209.

Schoeller, H., (1967). Geochemistry of Ground Water. An International Guide for Research and Practice, UNESCO.15: 1-18.

Shaban, M.; Urban, B., El Saadi, A. and Faisal, M. (2010). Detection and mapping of water pollution variation in the Nile Delta using multivariate clustering and GIS techniques. Journal of Environmental Management**.** 91(8): 1785–1793.

Simler, R. (2009). Diagrammes Software. http://www.lha.univ-avignon.fr/LHA-Logiciels.htm.

Singh, J. P. (1988). A rapid method for fertermination of nitrate in soil and plant extracts. Plant and Soil Journal. 110(1): 137-139.

Srinivas, C. H.; Ravi Shankar, P.; Venkatesan, R.; Sathya Narayan Rao M. S. and Ravinder Reddy, R. (2000). Studies on ground water quality of Hyderabad. Pollution Research. 19(2): 285-289.

Subramani, T., Rajmohan, N., Elango, L., (2010). Groundwater geochemistry and identification of hydrogeochemical processes in a hard rock region, Southern India. Environmental Monitoring and Assessment., 162(1&4):123-137.

Szabolcs, I. and Darab, C. (1964). The influence of irrigation water of high sodium carbonate content on soils, In I. Szabolics (Ed.), Proc 8th International Congress Soil Science Sodics Soils, **Schoeller, H. (1967)**. Geochemistry of ground water. An International Guide for Research and Practice, UNESCO. 15: 1-18.

Tadiboyna, R. and Rao, P. (2016). Trace analysis of heavy metals in ground water of Vijaywada, industrial area, Journal Environmental and Science Education, 11(10): 3215-3229.

Tiri, A,; Boudoukha, A. (2010). Hydrochemical analysis and assessment of surface water quality in koudiat medouar reservoir, Algeria. European Journal of Scientific Research Journal. 41(2): 273-285

Todd, D. K. (1980). Groundwater hydrology.2nd edition. John Wiley & Sons, New York. 535p.

Wilkes University Center of Environmental Quality (WUCEQ), Geoenvironmental Science and Engineering Department 2002 Corrosion, saturation index, balanced water in drinking water systems – Source and cause of corrosion.

Wilcox, L. V. (1955). Classification and use of irrigation waters, US Department of Agriculture, Washington Dc. 19p.

WSDH (Washington State Department of Health) (2018). Color, taste and odor problems in drinking water. Fact Sheet. 331-286.