Journal of Asian Scientific Research
ISSN(e): 2223-1331
ISSN(p): 2226-5724
DOI: 10.18488/journal.2.2017.79.379.388
Vol. 7, No. 9, 379-388

URL: www.aessweb.com

HYDRO-GEOCHEMICAL CHARACTERISTICS AND EVALUATION OF GROUNDWATER QUALITY ASSESSMENT FOR DRINKING AND DOMESTIC PURPOSES IN ASWAN, EGYPT

M. Sharkawy[1+]
M. Saber[2]
A. Sefelnasr[3]
G. El-Habaak[4]

[1]*Aswan Water and Wastewater Company, Aswan, Egypt*
[2,3,4]*Geology department, Faculty of Science, Assiut University, Assiut, Egypt*

(+ Corresponding author)

Article History
Received: 6 July 2017
Revised: 31 July 2017
Accepted: 8 August 2017
Published: 15 August 2017

Keywords
Groundwater
Aquifer
Pollution
Evaluation
Disinfectant
Drinking water.

ABSTRACT

In arid regions, people strive to have high drinking water quality resource. Limited water resources in arid regions present a critical factor that affects economic and societal development. The hydrogeological and hydrological conditions in such areas are extreme variable and affect largely the hydrochemical characteristics of the groundwater system. This study was carried out in Elhasya (Edfu, Aswan, Egypt) with an objective of understanding the suitability of local groundwater quality for domestic purposes in such arid climate region and to investigate the potential impact of untreated sewage discharges and irrigation canals on groundwater quality. In order to accomplish these targets, 250 water samples were collected from 4 groundwater wells and analyzed for physical, chemical and biological parameters in the period from Jan. 2007 to Dec. 2012. The hydrological characteristics of the region have been identified. Aquachem tool was used to define and characterize the hydrchemistry of the pumped water samples. Wells can be considered neutral to slightly alkaline, pH is around (6.5-8.5). Cations (Mg^{2+}, Na^{+} and Ca^{2+}) and anions (HCO^{3-}, Cl^{-}, and SO_4^{2-}) were measured using ion chromatography instrument and it was clear that they did not exceed the recommended limits of world health organization (WHO) nor the Egyptian standards. However, bacteriological and biological results refer to that the wells are contaminated and a dose of disinfectant should be injected for drinking use. Stiff and piper diagrams were used to evaluate the hydrochemistry of groundwater of the study area. According to the plotting results, we can say that the majority of groundwater samples was characterized by the abundance alkaline earth metals (Ca^{2+}, Mg^{2+}) over of the alkalis (Na^{+}, K^{+}). In conclusion, it is apparent that the pumped water in El-Hasya city needs to be injected with dose of disinfectant to promote the biological activity so as to be suitable for drinking uses.

1. INTRODUCTION

Water pollution is a major global problem which requires ongoing evaluation of water resource policy at all levels (international down to individual aquifers and wells). It has been suggested that water pollution is the leading worldwide cause of deaths and diseases [1] and that it accounts for the deaths of more than 14,000 people daily [2]

Discharging huge amount of treated waste and industrial waters to the surface water systems is the main reason related to the pollution of water systems and thus increasing the cost of treatment. In Egypt, 239 wastewater treatment plants discharge annually more than 4.5 billion m3 to surface water systems [3] that may affect the surface water and its adjacent groundwater quality.

In arid climate, the interaction between surface and groundwater systems is highly variable [4] thus may affect the groundwater quality. Furthermore, evaporation rate is high, that may concentrate the pollutants in the pumped water. Therefore, it is very important to monitor the change in groundwater quality and review its suitability for drinking water use. Many studies have been developed to characterize the hydrochemical aspects of the Nile aquifer Shamrukh [3]; Hamdan and Rady [5]; Shamrukh and Abdel-Wahab [6] and Mohamed, et al. [7]. However, hardly any researcher studied the hydrochemical characters of El-Haysa city where 4 wells produce 360 m^3/day drinking water for more than 100,000 habitants per day. This research aims to evaluate the groundwater quality in El-Hasya city (Aswan, Egypt), define its suitability of it for drinking water use and determine the hydrochemical aspects of the aquifer.

1.1. Study Area

The present Study (El-Hasya wells) is located in the western part of Aswan governorate (Egypt) at latitude (24.87°) and longitude (32.86°). It is surrounded from eastern north by Awlad Ali valley and western north by Abo Makah valley (Figure 1). The wells had been drilled and operated since 1960.

The Climatology of this area is generally characterized by hot summer and mild winter with low rainfall. Air temperature ranges between 36.5°C (summer) and 15.5°C (Winter), relative humidity ranges between 51% and 61% (Winter), 33% and 41% (Spring), and 35% and 42% (Summer) [8].

1.2. Hydrological Setting

The quaternary aquifer consists of unconsolidated materials of sands, gravels and clays .These sediments are underlain by a thick bed of clay which is considered to act as an impervious base for groundwater flow. The aquifer has a thickness that ranges between 80 and 120 meters (Figure 2). It is mainly recharge from River Nile, small irrigation canals and drains that penetrate the study area [9].

The regional groundwater flow is generally from southeast to northwest (Figure 3**)**, paralleling to the water flow of the Nile. It overlies a thick layer of alluvial deposits which consider the main groundwater aquifer in the Nile Valley (the Quaternary aquifer) stream aquifer system [9].

1.3. Geological Setting

The stratigraphic succession is very important to clarify the type of aquifers, its thickness and its extent in the study area. The subsurface studies of the geological sequence showed the geological cross sections and its characteristics (type of rocks, layer thickness and horizontal stretch). These studies showed that there is a sequence of sedimentary rocks in all regions. These sedimentary rocks are belonging to the modern eras and particularly the Quaternary. The sediments of the study area are considered as Quaternary sedimentary rocks, which represent the main water-bearing unit in the Nile Valley region. These deposits are belonging to the Protonile River system which is occupying the present Nile Basin, and made up of gravels and coarse sand, embedded in brown muddy matrix [9].

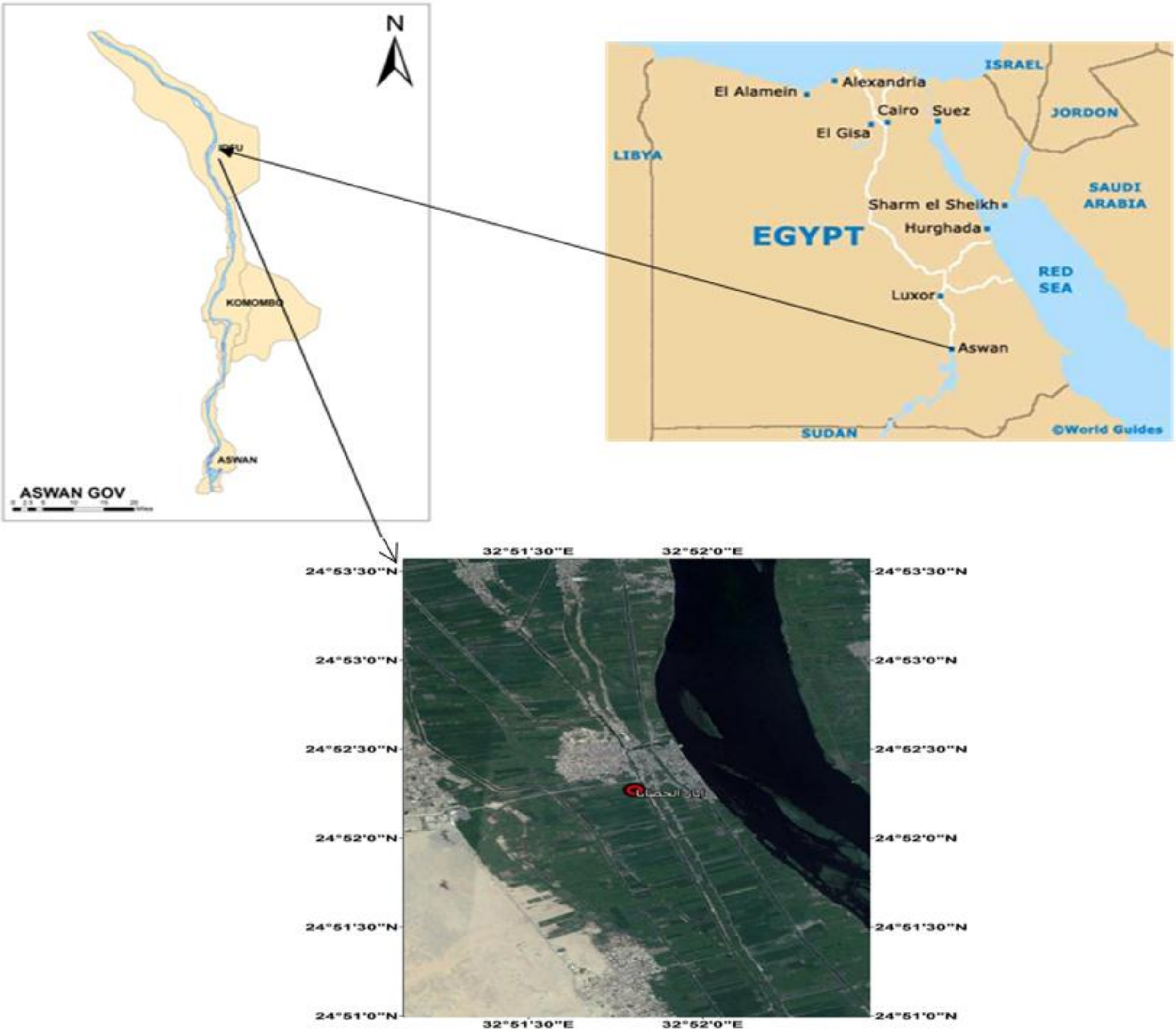

Figure-1. Map of the study area from google earth

Figure-2. Lithology of the study area [9]

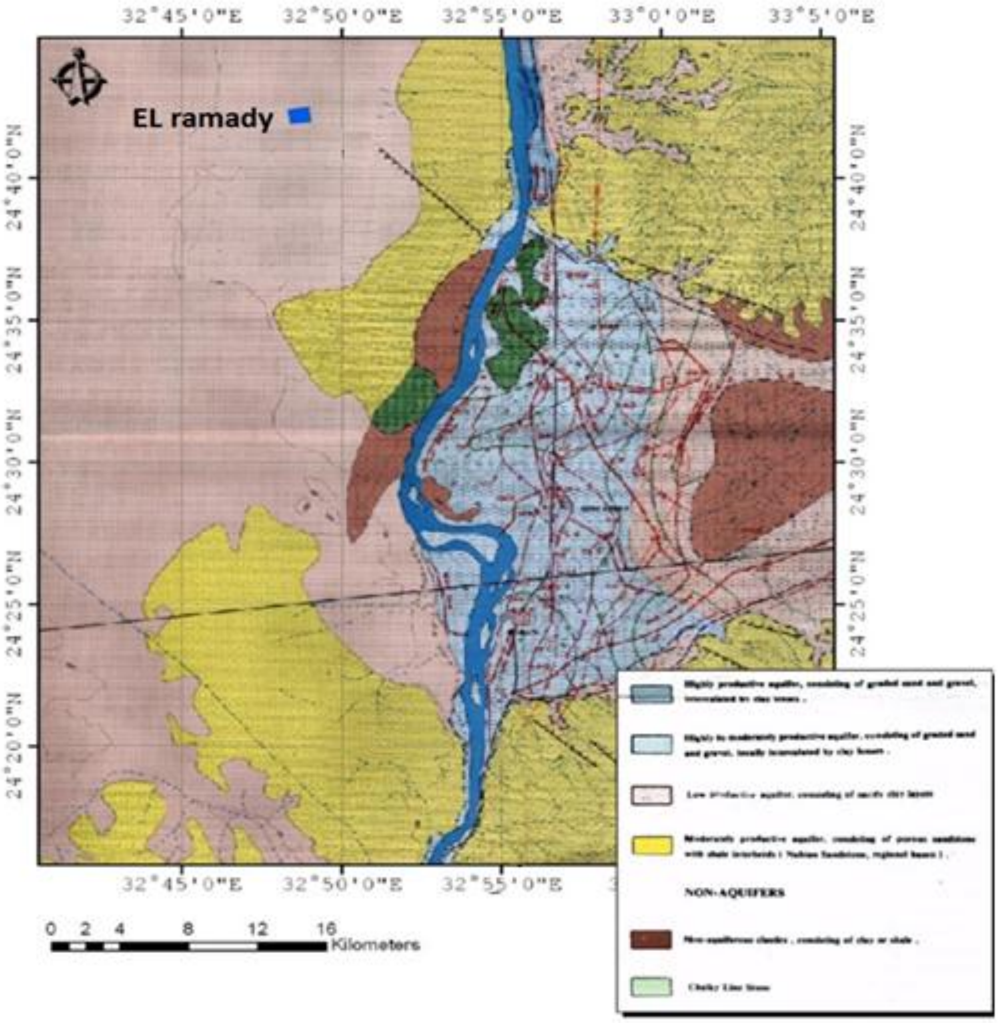

Figure-1. The movement of groundwater in the Quaternary aquifer [9]

2. MATERIAL AND METHODS

2.1. Sample Collection and Storage

Water samples collected from January 2007 to December 2012 from the drilled wells for chemical, bacteriological and physical analysis. Water samples were stored in a lightproof insulated box with cooling packs and transferred to the laboratory. The samples were kept in refrigerator container at 4 °C until the time of analysis. The techniques and methods followed for collection and preservation were in accordance with the 20th edition of the Standard Methods of APHA [10].

2.2. Analytical Methods

Cations (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, NH_3^{+}) and anions (NO_2^{-}, NO_3^{-}, $F^{-,}$ Cl^{-}) were measured using (Metrohm 881 Compact IC Pro ion chromatograph). ICP –OES Perkin Elmer Optima 7000 DV was used to determine the concentration of metals include: Fe^{+2}, Mn^{+2}, Cd^{+2}, Pb^{+3}, Zn^{+2}, Ni^{+} in the pumped water. Sulphate ions (SO_4^{-2}) had been measured using turbidimetric method. Physical properties such as PH (HACH Model 51910), conductivity (Crison EC meter +30) and turbidity (Hach model 2100N) were measured.

The chemical analyses for the ground water samples were carried out in Reference Laboratory for Drinking Water accordance with the 20th edition of the Standard Methods of APHA [10].

The biological analyses for the ground water samples were carried out in Aswan Laboratory for Drinking Water accordance with the 22^{th} edition of the Standard Methods of APHA [10] . R2A media was used to detect heterotrophic bacteria. Endo Agar media was used to detect the total coliform bacteria. MFC Agar was used to detect the fecal coliform bacteria in water samples.

AQUACHEM program was used to evaluate the hydrochemical characteristics of the pumped water and to define its suitability for drinking water use.

3. RESULTS AND DISCUSSION

3.1. Hydrochemical Characteristics

The present work had the objective of understanding the hydrochemical constituents of groundwater related to its suitability for drinking and domestic use. The chemical analytical results of groundwater samples are presented in Table1. A compassion between the analytical results and the Egyptian and WHO drinking water guidelines had been carried out to determine its suitability for drinking water and domestic purposes [11].

Wells can be considered neutral to slightly alkaline, pH is around (6.5-8.5). According to international standards set of drinking water [12] In the study area, the collected groundwater samples don't exceed the standard limit. Magnesium in the study area ranged from (8.9 – 32.6) mg/L. The standard limit of magnesium concentration based on WHO [11] is 150 mg/L. So that, all analyzed samples found below the standard limit. Calcium in the groundwater samples ranged from (42.8 to 63.9) mg/L which is lower the standard limit (200 mg/L) based on WHO [11].

Chloride in the study area ranged from (14.9 to 21.1) mg/L and the standard limit of chloride concentration is 250 mg/L based on WHO [11] and the Egyptian Standard limit, 2007.

Iron values ranged from 0.010 mg/l (min.) to 0.039 mg/l (max.) the standard limit of Iron in WHO [11] is 0.3 mg/l and Egyptian standards limits 2007 is 0.1 mg/l. Manganese (Mn^{2+}) concentration of groundwater ranged from 0.003 to 0.074 mg/l

Table-1. Egyptian standards and WHO guidelines for drinking water as well as the chemical results of our studied wells

Parameter	Egyptian standards limits 2007	WHO guidelines (2004)	Concentration range for Well 1, 2,3 and 4
pH	6.5 - 8.5	6.5–8.5	6.5 - 8.5
Turbidity (NTU)	<1	<5	0.13 - 0.44
EC µS/Cm	1500	750	581.2 - 411.6
TDS (mg/L)	1000	500	226.4 – 319.7
TH (mg/L)	500	500	152. 8 - 252.4
HCO_3^- (mg/L)	250	250	213.7 – 251.1
Cl^- (mg/L)	250	250	14.9 – 21.1
Mg^{+2} (mg/L)	150	150	8.9 – 32.6
Na^+ (mg/L)	200	200	13.6 - 21.3
Ca^{+2} (mg/L)	200	200	42.8 – 63.9
SO_4^{-2}(mg/L)	250	250	19 -58.9
Fe^{+2} (mg/l)	0.3 for surface water 0.1 for groundwater	0.3	0.010 - 0.039
Mn^{+2} (mg/l)	0.1 for surface water 0.5 for groundwater	0.4	0.003- 0.074

N.B: All the measured heavy metals include Cd^{+2}, Pb^{+3}, Zn^{+2}, Ni^+ were under the limit of detection

3.2. Total Dissolved Solids (TDS)

The Egyptian Standard Limits Low No. 458 (2007) for TDS is 1000 mg/l, according to this limit all samples suitable for drinking and WHO [11] limit (Figure 4). The groundwater salinity of the aquifer belongs to freshwater class based on the classification of Chebotarev [13]. The ground water salinity can be classified in all samples are excellent to good water.

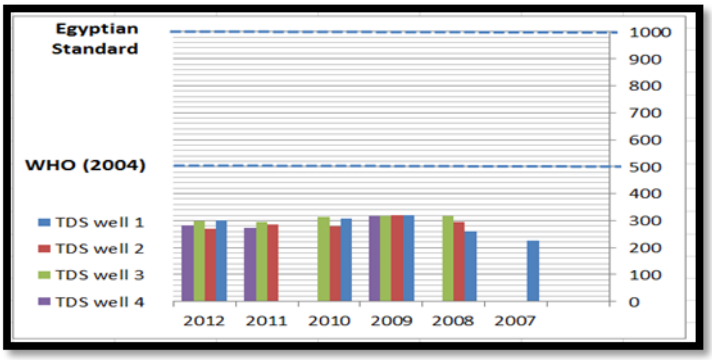

Figure-4. Total dissolved solids of results of our studied wells compared with Egyptian standard & WHO [11]

3.3. Total Hardness (TH)

It obvious that the value of total hardness ranges between (152. 8 -252.4) mg/l (Figure 5), Which can be classified as hard water to very hard water according to Hem [14]. The total hardness values ranged between (152.8-252.4) mg/L, so all wells are suitable for laundry uses according to Hem [14] the Egyptian Standard Limit.

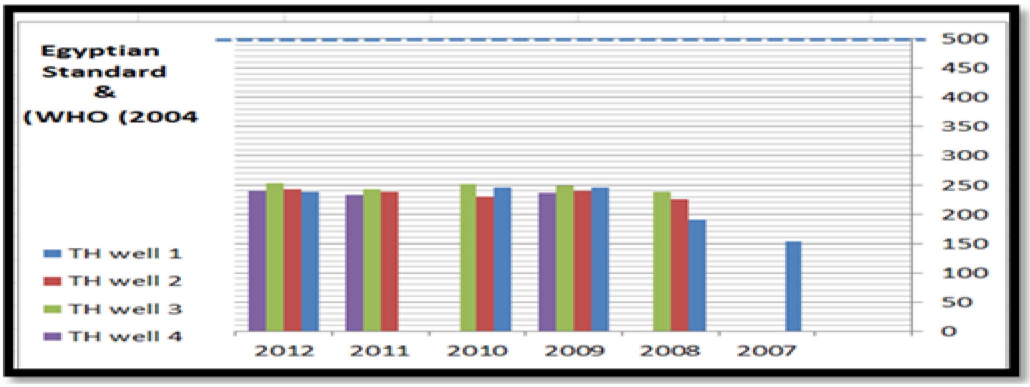

Figure- 5. Total hardness of results of our studied wells camper with Egyptian standard & WHO Sodium (Na+)

The low sodium concentration is recorded in all the locations in the studied area within safe limits of 200 mg/l (Figure 6). Sodium in the study area ranged from (13.6 - 21.3) mg/L. The standard limit of the sodium concentration is 200 mg/L based on the international standard limit [11]

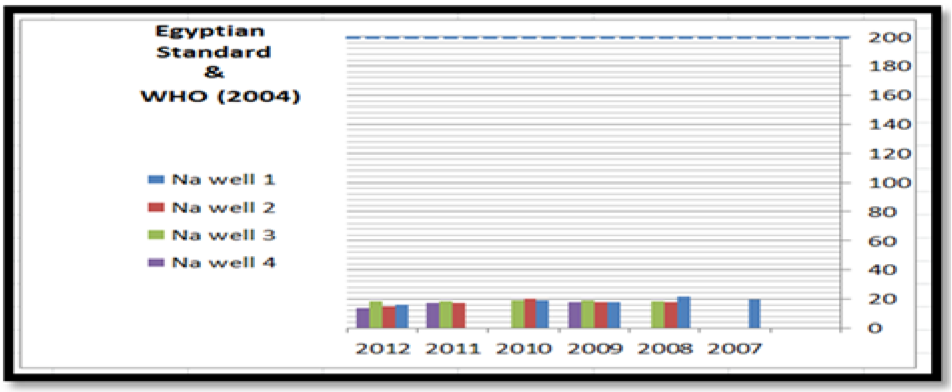

Figure-6. Sodium concentration **results of our studied wells** camper with Egyptian standard & WHO [11]

3.4. Calcium (Ca^{2+})

All samples were represented within limit prescribed by WHO [11] and Egyptian Standard Limits Low No. 458 (2007). If the concentration of calcium and magnesium in drinking water is more than the permissible limit, it causes unpleasant taste to the water (Figure 7).

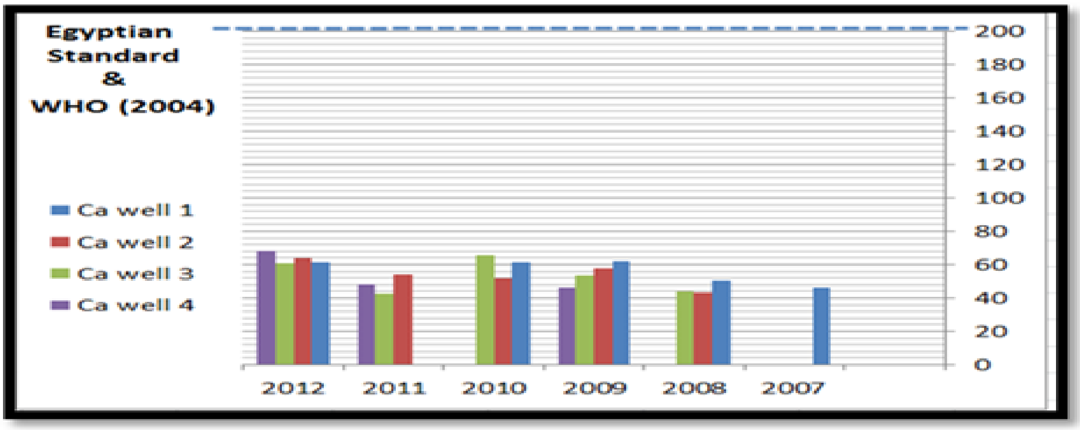

Figure-7. Calcium concentration of results of our studied wells camper with Egyptian standard & WHO [11]

3.5. Sulphate (SO_4^{2-})

The limit prescribed by WHO [11] and The Egyptian Standard Limits Low No. 458 (2007) for Sulphate is 250 mg/l, according to this limit all samples suitable for drinking (Figure 8) . Sulfate in the analyzed groundwater samples ranged from (19 to 58.9) mg/L.

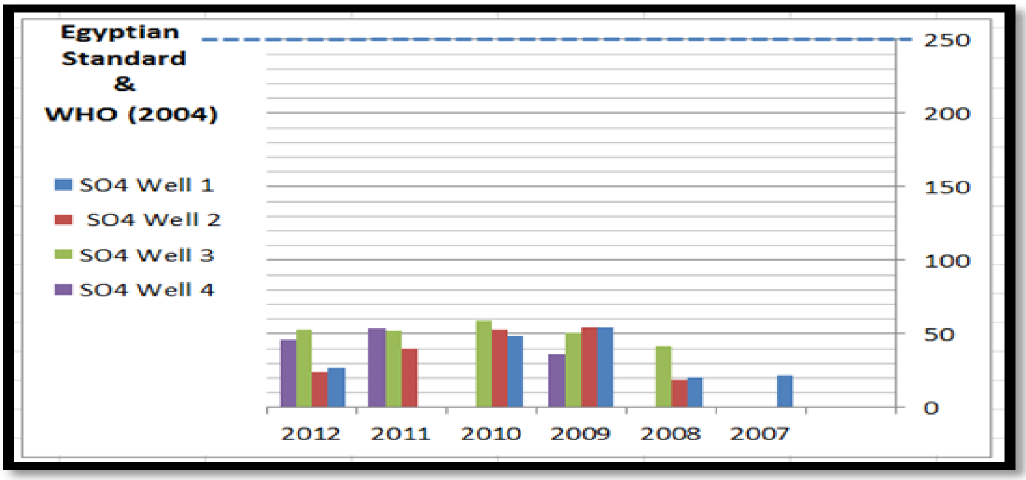

Figure-8. Sulphate concentration of results of our studied wells camper with Egyptian standard & WHO

3.6. Geochemical Characteristics

3.6.1. Stiff and Piper Diagrams

AQUACHEM program was used to draw stiff and piper diagrams. It was observed that, alkaline earths (Ca^{2+} and Mg^{2+}) significantly exceed the alkalis (Na^{+}, K^{+}) and strong acids ($Cl^{-}$and SO_4^{2-}) exceed the weak acids (CO_3^{2-}, HCO_3^{-}). So, the main compound of El-Hasya groundwater was (Ca^{2+} and HCO^{3-}), that means the initial EL-Hasya groundwater was coming from surface water (River Nile) (Figure 9&10).

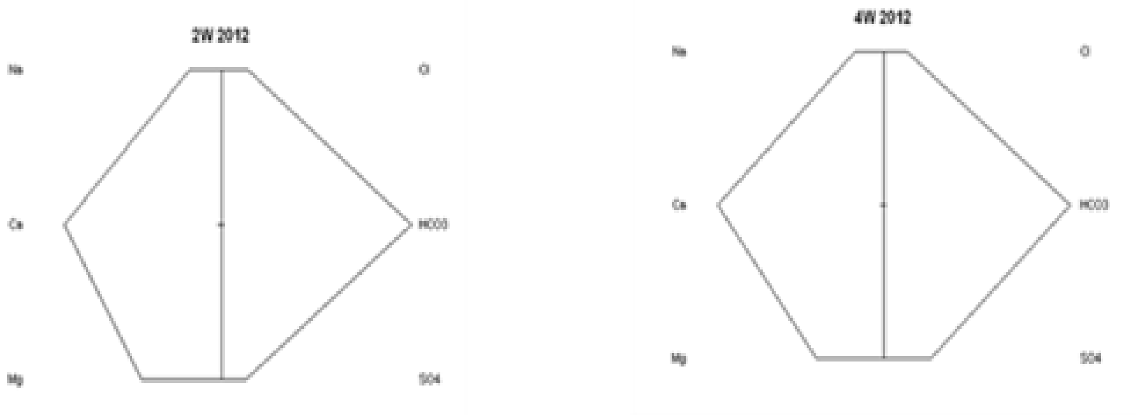

Figure-9. Stiff diagram of **results of our present studied wells**

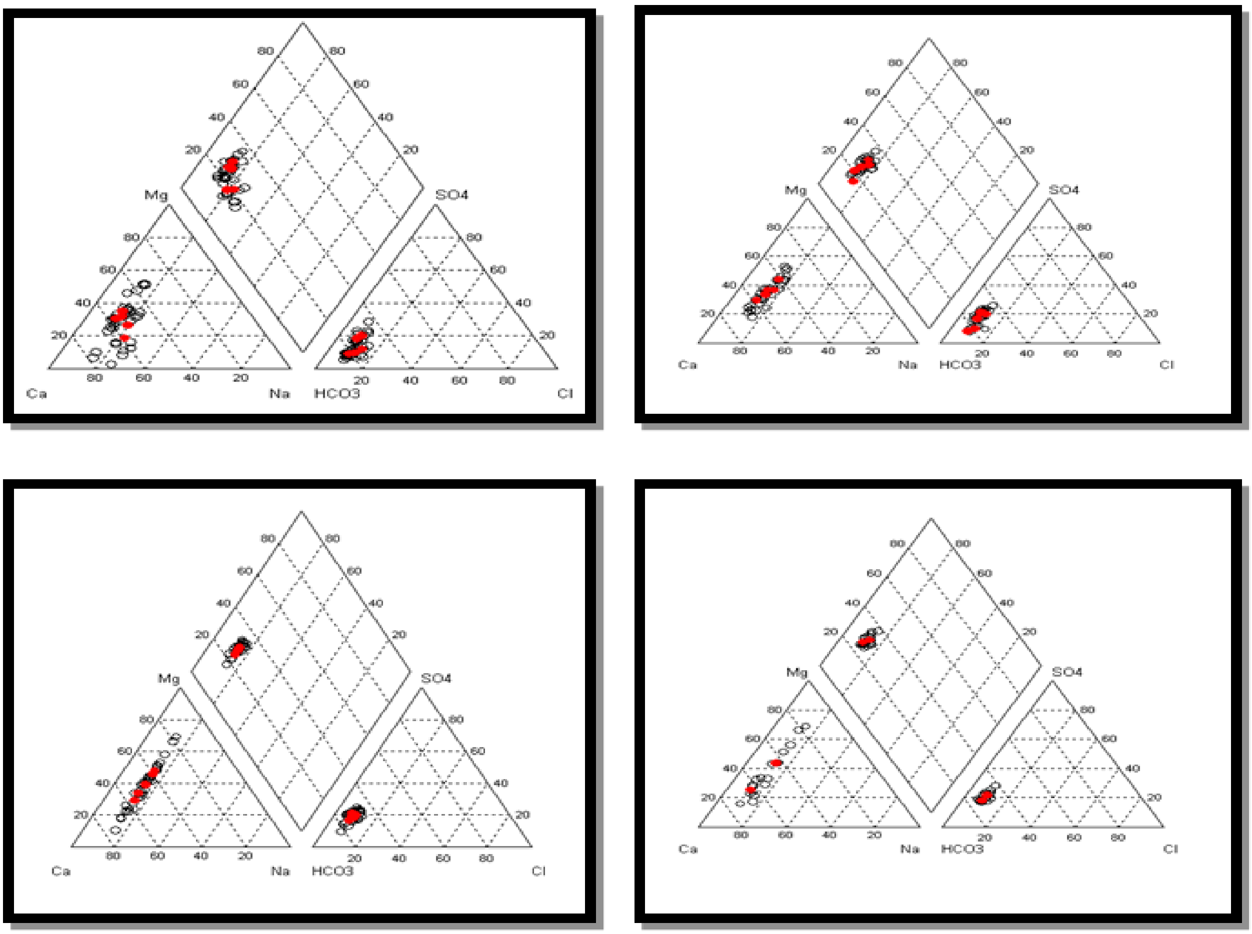

Figure-10. Piper diagram **of our present studied wells**

3.7. Bacteriological Characteristics of Groundwater

Bacteriological pollution found in all analyzed samples. Heterotrophic bacteria result between (990 – 1972) , Total coliform bacteria are between (124 – 215) and fecal coliform bacteria between (32 – 60)   Levels of microbial contamination of water in these areas were due to disposal of sewage, wastewater and irrigation water from nearby areas. Table 2

Table-2. Bacteriological results of our present studied wells

parameter	Egyptian standards limits 2007	WHO guidelines (2004)	Concentration range for Well 1, 2,3 and 4
Heterotrophic **Bacteria (CFU)**	50	50	(990 – 1972)
Total coliform bacteria **(CFU)**	2	3	(124 – 215)
Fecal coliform bacteria **(CFU)**	-ve	-ve	(32 – 60)

The bacteriological result all in WHO and as Egyptian Standard Limits of drinking water and that make EL-HASYA groundwater not safe drinking and domestic purposes but Aswan water company solve these problem by addition chlorine gas in the expulsion pipe . Chlorine has power to kill and destroy all present bacteria. After that the groundwater is safe for drinking and domestic purposes.

4. CONCLUSION

This study examines the suitability of groundwater as a drinking water source in arid climate (El-Hasya City, Edfu, Egypt). The hydro-chemical characteristics of water samples taken during the period (Jan.2007 to Dec. 2012) refers that the chemical parameters of the pumped water doesn't exceeds the WHO and Egyptian standards. However, discharging waste water to the surface systems and infiltrating to groundwater system increase the number of diseases bacteria and degrade the quality of water. A dose of disinfectant (like chlorine) is recommended to suppress the biological activity. A further research to investigate the pollution of this aquifer by pesticides from the surrounded agricultural is needed.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study.

REFERENCES

[1] D. H. Pink, "Investing in tomorrow's liquid gold world determination of some physicochemical parameters and some heavy metals in boreholes from Fagge L.G.A of Kano Metropholis Kano State- Nigeria," *Journal of Analytical Chemistry*, vol. 2, pp. 42–46, 2006.

[2] L. D. Geohring, P. M. Wright, T. S. Steenhuis, and M. F. Walter, *Fecal coliforms in tile drainage effluent*: CORNELL, 1999.

[3] M. Shamrukh, "Assessment of Riverbank Filtration for Potable water supplly in Upper Egypt," *Journal of Engineering Sciences*, vol. 34, pp. 1175–1184, 2006. View at Google Scholar

[4] A. Saleh, F. Al-Ruwaih, and M. Shehata, "Hydrogeochemical processes operating within the main aquifers of Kuwait," *Journal of Arid Environments*, vol. 42, pp. 195–209, 1999. View at Google Scholar | View at Publisher

[5] A. M. A. Hamdan and A. R. A. Rady, "Vulnerability of the groundwater in the quaternary aquifer at El Shalal-Kema area, Aswan, Egypt," *Arabian Journal of Geosciences*, vol. 6, pp. 337–358, 2013. View at Google Scholar

[6] M. Shamrukh and A. Abdel-Wahab, *Water pollution and riverbank filtration for water supply along River Nile, Egypt, in Riverbank Filtration for Water Security in Desert Countries, M. Shamrukh, Ed.* Dordrecht: Springer Netherlands, 2011.

[7] Z. A. Mohamed, E.-S. M. Hassan, and A. S. Wafaa, "Microcystin concentrations in the Nile River sediments and removal of microcystin-LR by sediments during batch experiments," *Archives of Environmental Contamination and Toxicology*, vol. 52, p. 489-495, 2007. View at Google Scholar | View at Publisher

[8] O. Ahmed, "Evaluation of the quality of groundwater at fares, Kom Ombo, Aswan, Egypt, Assiut," 2015.

[9] Ministry of Water Resources and Irrigation (MWRI), The Final Technical Report– The Results of the Groundwater Potential Study in the Desert Alternative Housing Project in Aswan – Urgent Plan – The new Fares, The New Elramady and The New Allaqi2007.

[10] APHA, *Standard methods for the examination of water and wastewater*, 22nd ed. Washington (U.S.A): American Water Works Assnb, 2005.

[11] WHO, *Guidelines for drinking-water quality recommendations*, 3rd ed. vol. 1. Geneva, Switzerland, 2004.

[12] S. N. Davis, *De Wiest, hydrogeology*, 6th ed. New York: John Wiley {&} Sons, 1966.

[13] I. I. Chebotarev, "Metamorphism of natural waters in the crust of weathering—1," *Geochimica et Cosmochimica Acta*, vol. 8, pp. 22–48, 1955. *View at Google Scholar* | *View at Publisher*

[14] J. Hem, *Study and interpretation of the chemical characteristics of natural water*: U. S. Geological Survey, 1989.