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Assessment of Treated Wastewater Quality And Impact Of Using It On The Soil In Wadi Al-Mawaheb-Dhamar, Republic Of Yemen

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ABSTRACT

This study aims to assess wastewater quality in Wadi Al-Mawaheb Dhamar city, and the extent to which it used for irrigation and its comparison with standards of the food and agriculture organization (FAO), and compare it with some old data, and also assessing its impact on the soils. The results of the study showed that the wastewater treatment plant for the city of Dhamar is unable to treat the required and that it is only a collection point for wastewater flowing from the city of Dhamar collecting wastewater and allowing it to flow to the Valley of Talents, and through the results of the analysis of wastewater inlet and outlet of The station, the analysis showed that there is no significant difference to the results of the analysis, which indicates that the wastewater plant is not working on the required treatment, due to weak capacity of the station, and also then compared it with results of the analysis of 2005, 2009 and 2012, it found that there is a big difference in the results of the analysis. As well as the US salinity diagram illustrates that of the treated wastewater sample fall in the field of C4-S2, indicating high salinity and low sodium water, which can be used for irrigation on almost all types of soil without danger of exchangeable sodium. As for the results of the analysis of the soil irrigated with wastewater used, its effect was low on soil and it does not appear only after some time.

INTRODUCTION

The world's population in urban societies is increasing extraordinarily, However, water consumption increases dramatically, making it necessary to collect, and treat wastewater flows to control the transmission of waterborne diseases (**Van, 2007; Council, 2012; Cosgrove and Loucks, 2015; Darwesh *et al*., 2019**). Concern for public health is the main justification for investing in water and sanitation improvement. In both settings, the selected technologies should be environmentally sustainable, appropriate to the local conditions, acceptable to the users, and affordable to those who have to pay for them. Simple solutions that are easily replicable, that allow further upgrading with subsequent development, and that can be operated and maintained by the local community, are often considered the most appropriate and cost-effective **(Scott, *et al*., 2000; Van, 2007; Abosoliman and Halim, 2012; Joshua *et al*., 2017**). Unpurified domestic wastewaters represent the main source of organic pollution of waters **(Hamilton *et al*., 1984; WHO, 2006; El Rhaouat *et al*., 2013**). Wastewater reuse is advantageous for many reasons such as scarcity of water in arid and semi-arid regions; the high energy cost of advanced wastewater treatment, and the pollution of surface waters as a result of direct discharge of wastewater effluents (**Hamilton *et al*., 1984)**. Yemen still faces an acute problem in the shortage of water resources where there are no water resources except for rainwater and groundwater stored for hundreds of years. Moreover, for the purposes of drinking, agriculture, and industry, there is a semi-entire reliance on groundwater 93% of water is consumed by the agriculture sector while 7% for other purposes. It reported that the per capita of water in Yemen is 150 m3/year whereas it found to be 1250 m3/year in the Middle East and North Africa and reaches up to 7500 m3/year globally. In addition, this indicates the apparent low per capita in our country compared to other countries in the world. In addition, it implies the increasing population growth in Yemen as the population growth rate is estimated at around 3.7% and thus, the population of Yemen will have reached 27 million in 2017 **(Glass, 2010; Hill *et al*., 2013; Almoayed, 2019**).The wastewater use for irrigation is advantageous for many reasons such as water conservation, ease of disposal, nutrient utilization and avoidance of surface water pollution. On the other hand, it must be bored in mind that although the soil is an excellent adsorbent for most soluble pollutants, domestic wastewater must be treated before they can be used for crop irrigation to prevent risk to both public and the environment (**Musa *et al*., 2011**). This study represents the identification of the physical and chemical properties of wastewater in Dhamar and its validity for agricultural use. And to know the extent of the impact of wastewater on the irrigated soils in the study area by three types of soils, one a field not irrigated with wastewater, a field irrigated with wastewater for 2-3years, and a field irrigated with wastewater for over ten years.

Study area

Study area represent Wady Almawahb, which, is located in Dhamar city and far about a hundred kilometers to the south of Sanaa (Fig. 1). It is located between longitudes 1628300 - 1628700E and altitudes 4944000 - 4944600 N **(Overstreet *et al*., 1985; Gibson and Wilkinson, 1995**). It had an average elevation of 2400 – 2450 masl. The main source of drinking is groundwater, where it is considered Dhamar the largest agricultural area in the central highlands of Yemen, it has a population of 175.159 people based on the 2004 Census (**Al Aizari *et al*., 2017**; **Al-Aizari H.S *et al*., 2018**).

Wastewater Treatment Plant (Natural Stabilization Ponds System) is located towards North -East of the city, which it was established in 1991, and it is treatment plant was designed to receive an average wastewater flow about 8,000 m'/day during winter and 12.000 m3/day during summer, which is not adequate for the current wastewater flows. It has the highest level of sanitation provision with about 75% of the population connected to sewer conveying sewage to treatment facilities.

The geology of the study area is very complex, it consists of the sediments and volcanic rocks of Tertiary (Paleocene and late Miocene), which, in addition to the sediments and volcanic rocks of Quaternary. The most recent rocks are the basaltic lava, which was formed, in the last stage of the volcanic activities of the Quaternary **(Chiesa, 1983; Kamra, 2006; Minissale *et al*., 2007; Al-Kohlani, 2009**).

The climate of the study area is arid to semi-arid annual, and the raining season occurs during the summer and the spring. Rainfall average is about 431.1 mm /year during 1999-2015, the monthly rainfall distribution shows that most of the rainfall amounts precipitate within five months of which most part occurs in March, April and May and the other higher amount occur in July and August. The study area is affected by moderate weather, the average maximum annual temperature is during 1999-2015 about 24°C, as much as the surface water potential relay by direct mean on the rainy season, and while most of the rainwater. As for Evapotranspiration (about 90%), to the atmosphere. only 10% of the total rainfall infiltrates into groundwater recharge and forms the runoff a portion **(Al-Aizari *et al.*, 2018a,b**).

This study represents the identification of the physical and chemical properties of wastewater in Dhamar and its validity for agricultural use. Moreover, to know the extent of the impact of wastewater on the irrigated soils in the study area and three types of soils one a field not irrigated with wastewater; a field irrigated with wastewater for 2-3years, and a field irrigated with wastewater for over ten years.

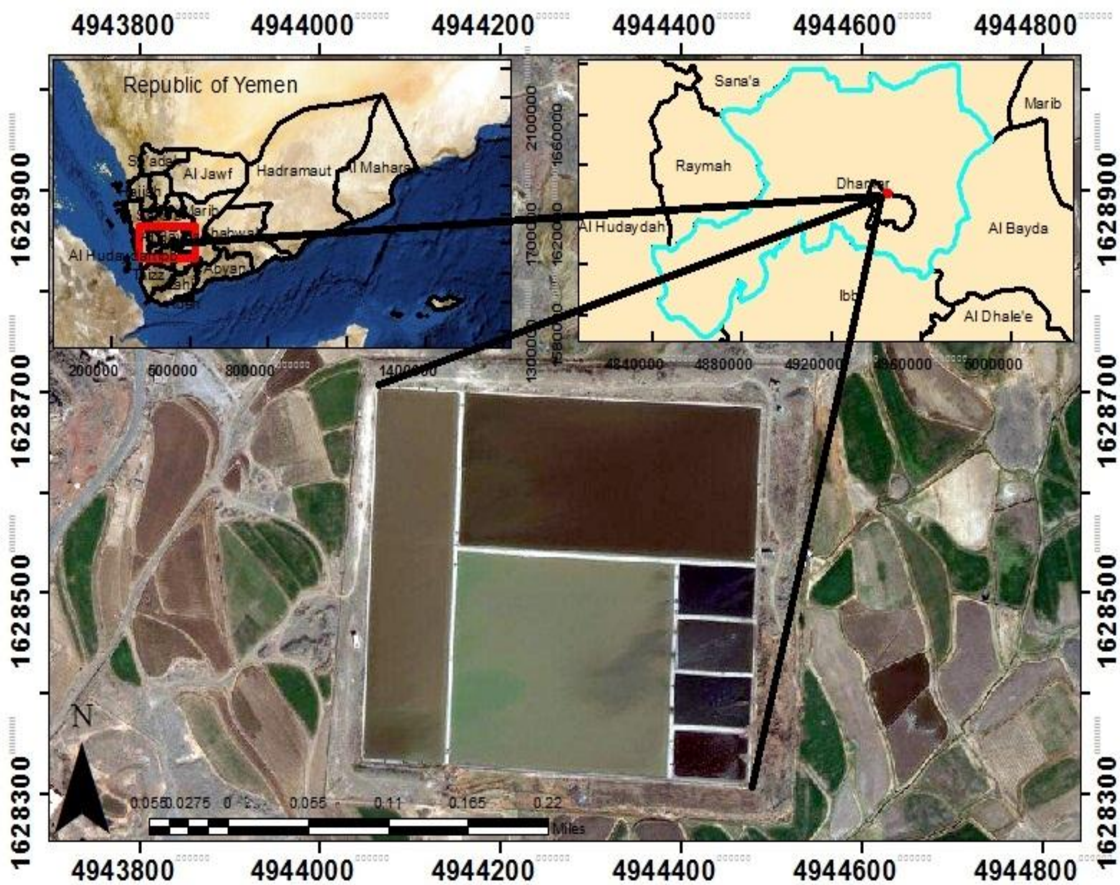

Fig 1: Study area Wady Almawahb

MATERIALS AND METHODS

The sample of wastewater is carried out in the years 2017, taken following standard methods APHA(**APHA/AWWA/WEF, 1998**). In the field of the samples, immediately after taking the sample, temperature, electric conductivity and total dissolved soled measured by (Conductivity Meter medal CEL/850 (HACH), the pH and electrical conductivity evaluated by pH-422. transferring the sample taken to the Laboratory of Renewable Natural Resources Research Center (RNRRC), Dhamar. Subsequently, the sample analyzed in the laboratory for their chemical constituents such as Ca^{2+}, Mg^{2+}, Na^{+}, k^{+}, Cl^{-}, HCO_3^{-}, and SO_4^{2-}, the concentrations of Ca^{2+} and Mg^{2+} were estimated titrimetric using 0.02 N EDTA and those of HCO_3 and Cl by H2SO4 and $AgNO_3$ titration, respectively. Concentrations of Na^{+} & K^{+} were measured using a Flame photometer (PFP 7), all samples were estimated by the standard methods of water and wastewater(**APHA, 1998; Rice *et al*., 2012**). Soil samples irrigated with wastewater and groundwater were selected to to compare the impact of water source on the soil from 3 sites (one a field not irrigated with wastewater, a field irrigated with wastewater for 2-

3years, and a field irrigated with wastewater for over ten years) all samples of soil were collected randomly from three farms , then were chosen all points at depth of 25 cm in all farm, And then analyzed for pH and for electrical conductivity (EC) in rate 1:5 soil water extract for phosphorus by 0.5 M NaHCO3 (**Blakemore, 1987**), for CaCO3 by acid neutralization method **(Lawrence and Scheske, 1997**), for the cation exchange capacity (CEC), phosphate and cations of soils was detriment according **(Polemio and Rhoades, 1977; Blakemore, 1987; Beretta *et al*., 2014**).

RESULT AND ANALYSIS

Physic-chemical data and statistical summary water resources are presented in raw form in Table 1.it were carried out using package for social sciences (Minitab Version17 and EquaChemi 2014.2 and Compared with the Food and Agriculture Organization of the United Nations (**FAO.; Ayers and Westcot, 1985)**, (Table 1) and compare it with data for the year 2005,2009, and 2012 for the same station data not published (Table 2).

Table 1. Physico- chemical parameters of wastewater samples.

Parameters	unit	Inlet 2017	Outlet 2017	FAO 1985
EC	µS/cm	3530	3100	3000
TDS	mg/l	2259.2	1984	2000
pH		6.9	7.7	6,0-8,5
Ca^{2+}	mg/l	212.424	158.316	100.2
Mg^{2+}	mg/l	116.736	99.712	486.4
Na^{+}	mg/l	340.4	333.5	920
K^{+}	mg/l	68.425	68.425	-
HCO_3^{-}	mg/l	1006.66	976.16	600.1
Cl^{-}	mg/l	400.698	283.68	1063.8
SO_4^{2-}	mg/l	360.225	336.21	960.6

Through the result of wastewater in 2017, table 1 and Fig 2, the electrical conductivity (CE) and the total soluble solids (TDS) of wastewater for inlet and outlet were 3,530 & 3,100 µS/cm and 2259.2 &1984 mg / l, respectively, it indicates the values are of no suitabile quality as per FAO for irrigation, which is showed that the station of wastewater to become unable to perform, this is because lower capacity for station. Comparing with the past years in Table 2 and Fig 2 (A), it is differences in the results of hydar study in 2005, al kadasi study in 2008 and Rajeh. et al in 2013 with results of present study of 2017, it indicates that the treatment is very bad in order to increase the water entering it. As for the pH value of wastewater was 6.9, and 7.7 respectively for inlet and outlet, where it indicates alkaline natural, which can indicate that nondecomposition of organic matter in wastewater Fig.2 (B) **(hydar, 2005; Al-Kadasi, 2009; Rajeh *et al*., 2012**).

Table 2. Comparing of physic- chemical parameters for wastewater samples in Dhamar station for differences years

Parameters	**2005**	**2009**	**2012**	**2017**
EC	1662	1700	1220	3530
TDS	1063.7	1088	735	2259.2
PH	7.5	7.5	8.5	6.9
Ca^{2+}	152	50.1	56	212.424
Mg^{2+}	17.03	207	21.6	116.736
Na^{+}	163.3	207	204.7	340.4
K^{+}	23	39.1	68.25	68.425
HCO_3^{-}	659	427.07	610	1006.665
Cl^{-}	106.4	177.3	195.75	400.698
SO_4^{2-}	91.8	240.15	33.6	360.225
SAR	3.2	1.8	7.8	2.9

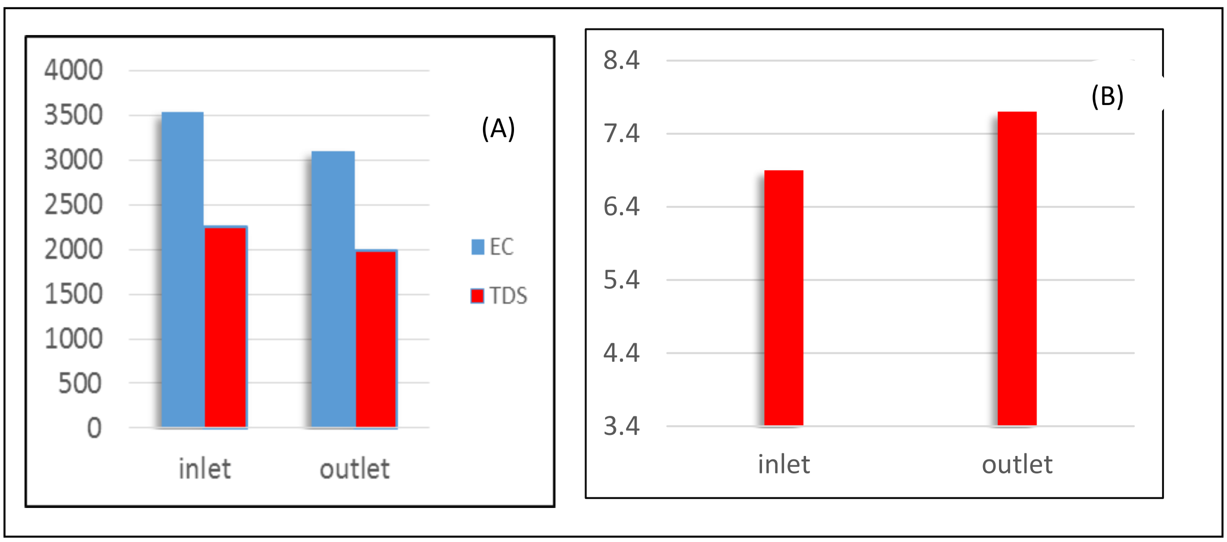

Fig. 2: EC and TDS of WWT(A)and pH of WWT(B).

The concentrations of cations (Ca^{2+}, Mg^{2+}, K^{+} & Na^{+}) and anions($HCO3^{-}$, Cl^{-} & $SO4^{2-}$) in wastewater in 2017 (Table 1,2,& Fig. 3) inlet and outlet were not much difference concentrations of wastewater entering and leaving the station. Comparing with FAO for irrigation, it observed that most concentrations of cations and anions are within the acceptable limits of agriculture except the concentration of bicarbonate.

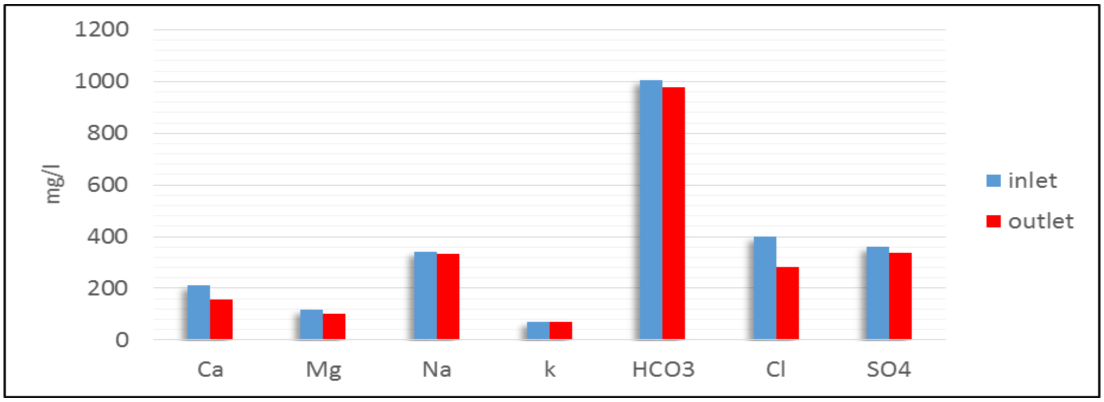

Fig. 3: Concentrations of cations and anions of WWT

Through Table 2 and Fig. 4, the results of the analysis of wastewater for the year 2017 comparing with the results of the analysis of 2005, 2009 and 2012, it was found that there is a big difference in the results of the analysis, indicating that the wastewater station does not work on the required treatment, due to the increase in the water entering it and the small size of the sedimentation basins.

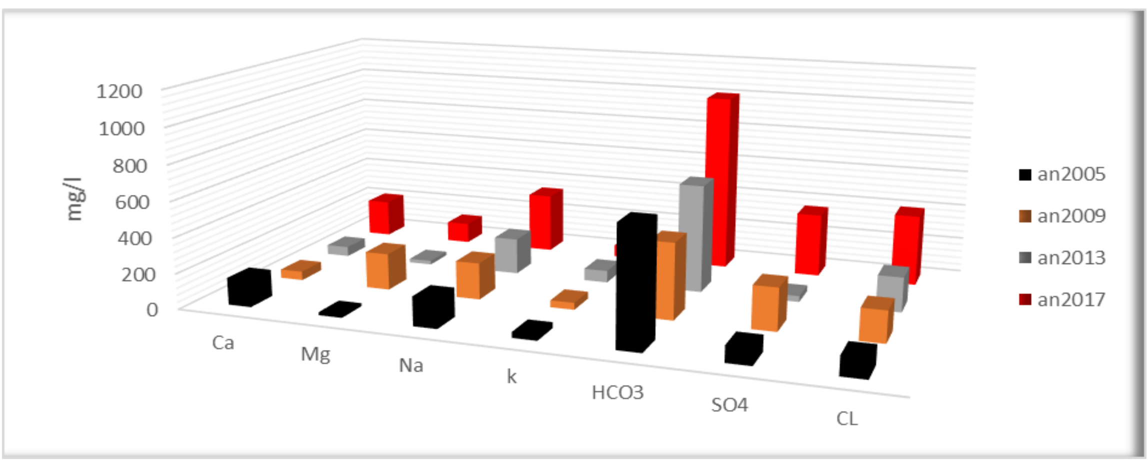

Fig. 4: Concentrations of cations and anions for differences years

Sodium adsorption ratio (SAR) is very impotent for irrigation, it is a measure for use in agricultural irrigation activities, its concentration can reduce the soil permeability and soil structure, which is a measure of alkali/sodium hazard to crops (**Richards, 1954)**. Where the value of SAR was (2,9 meq/l) (Table 2 & Fig. 5), according to the classifications for irrigation based on SAR was excellent for 2017 and also for the 2005,2009 and 2012.

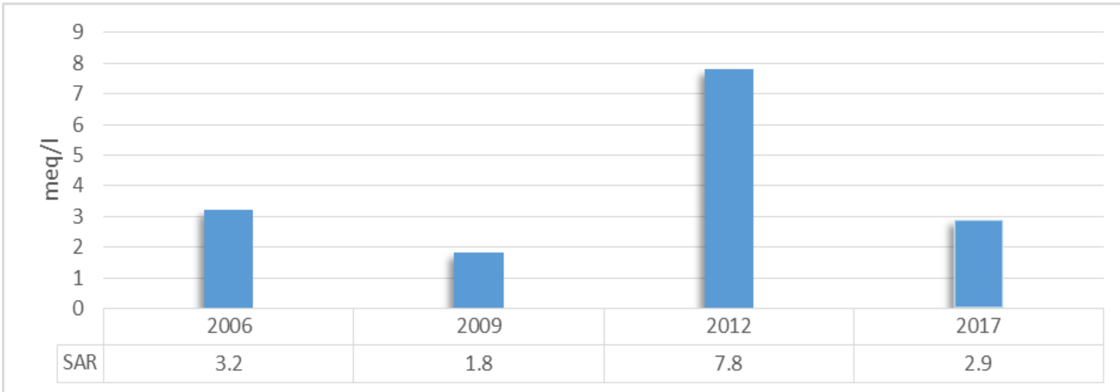

Fig. 5: Sodium adsorption ratio (SAR)

SAR (alkali hazard) and EC (salinity hazard) data are plotted in a USSL (1954) diagram to determine the suitability for irrigation (Fig. 6), where, the EC and SAR determine whether be able to use for agricultural purposes **(USSR, 1945)** . Through Fig. 7, the USSL diagram of the wastewater sample is located in C4-S2, according the US Salinity Laboratory, this type of irrigation water is considered to be high water - low sodium and this type of water cannot be used in irrigation of saline sensitive crops, particularly citrus, can be used for high tolerant salinity crops with a network effective sludge and in soils where there are no hard layers to prevent leaching **(Pescod, 1992**).

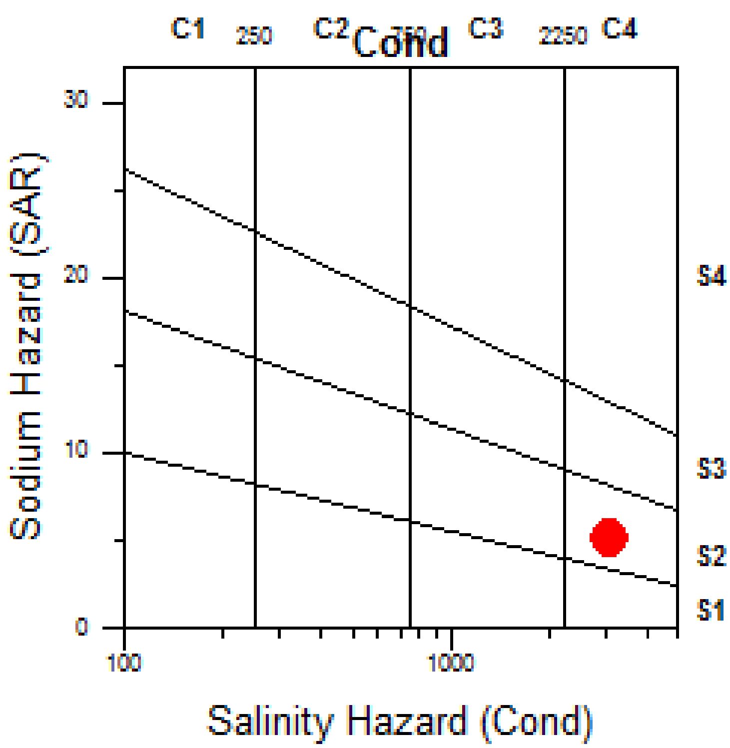

Fig. 6: Classification diagrams for irrigation purposes.

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Physic-chemical parameters of irrigated soil with three types of water

The samples of soil have been collected from three Farm fields that vary in the irrigation period with treated wastewater in Wady Almawaheb area of DHAMAR city (Table 3).

Table 3: Results of analysis of three soil samples

field no	Depth (cm)	pH	EC (µS/cm)	(%)CaCO3	P(mg/l)	CEC (Cmol/kg)	Na exchange	Exchange bases Cmol/kg	
								Na	K
*1	0-25	8.1	380	11	21	27	3.41	0.92	0.9
**2	0-25	7.9	430	4.75	4.9	37.5	4.27	1.6	1.2
***3	0-25	7.9	2250	4.25	7.7	28.5	9.83	2.8	0.6

1= a field not irrigated with wastewater; 2**= a field irrigated for 2-3years; 3***= a field irrigated for over ten years.*

The results of the analysis of soil samples taken from the study area are shown as follows (Table 3), the values of pH were 8.1, 7.9 & 7.9 respectively (*1, **2 & ***3) (Fig. 7 (C)), the pH of the soil samples taken from the study area indicates that the area falls within the middle alkaline range to the high where, it indicated that the time of irrigation had a slight impact on the value of this indicator, as it de decreased in the third field (irrigated for a long time) to 7.9. This may be due to the rule of acidic compounds among the results of treating wastewater, like sulfur compounds which turn into sulfuric acid and thus lead to decrease in pH values.

The electrical conductivity (EC) of soils were 380, 430 & 2250, respectively (*1, **2 & ***3),(Fig. 7 (D)), which is reflected of soil salinity degree, it varied gradually as it was 380 µS/cm/cm in soil sample not irrigated with wastewater. Then it increased to 430 µS /cm in soil sample irrigated for three years. In the last sample (***3) (irrigated for more than ten years), EC reached the highest level of 2250 µS/cm/cm. It was noticed that the accumulation level in the last field (***3) has increased significantly and this may be due to the heavy soil type, which hinders the washing process and the movement of the dissolved salt. due to irrigation using wastewater. As for calcium carbonate ($CacCO_3$), its value was generally and closely related, giving values of (11, 4.75 & 4.25) respectively (*1, **2 & ***3) (Fig. 7 (E)), where, it should be noted that calcium carbonate has a high rate in the first field compared to the second and third fields due to the large number of irrigation by wastewater. Cation exchange capacity (CEC) was 27, 37.5 & 28.5 Cmol /kg respectively in three field of soil (*1, **2, & ***3) (Fig. 7(F)). It was observed from the values of the cation exchange capacity (CEC), that there is no significant change in the irrigated soil with wastewater. Also, the values of phosphorus (P) were 21, 4.9 & 7.7 (mg/l) respectively (*1, **2 & ***3) (Fig. 7(G)), and it was observed that there is a discrepancy in the three fields irrigated with diferent types of water, and there is no significant effect on them. Also the quanti sodium exchange, that the values were 3.41, 4.27 & 9.83 respectively (*1, **2 & ***3),(Fig 7(H)), where this variation is because the high salinity in the third field (***3) has increased the proportion of sodium. Also it was no significant difference in the value of the Na^+ and K^+ exchange bases between the three types of soils (*1, **2 & ***3)(Table 3).

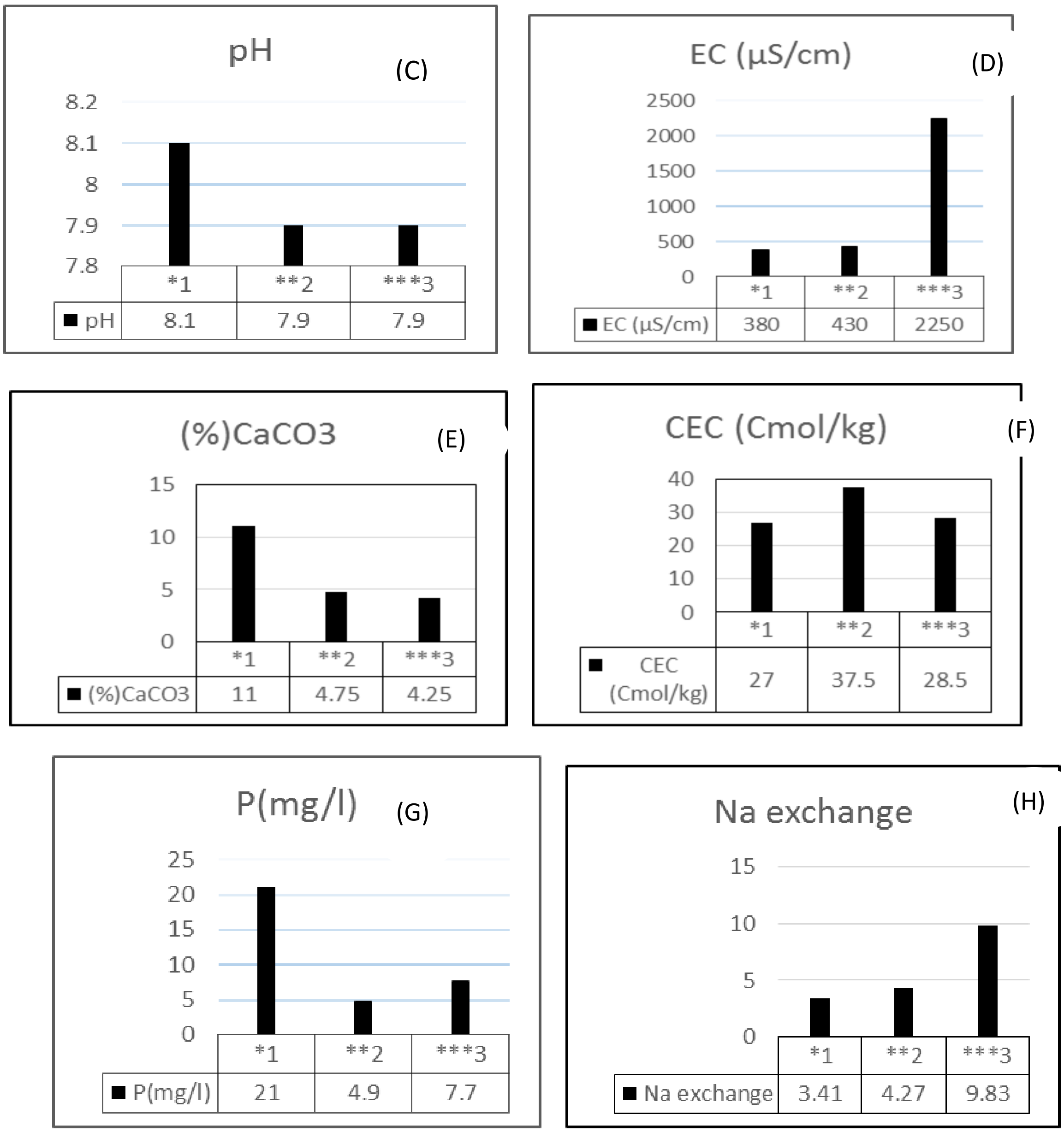

Fig.7: pH of soils (c), EC of soils (D) CaCO3 of soils(E) , CEC of Soils(F), avail of Potassium(G), and Exchange of Sodium (H).

CONCLUSION

The study area is located within a region affected by volcanoes, which makes it subject to many earthquakes, causing faults and cracks in the study area, which makes it vulnerable to sewage leakage through these cracks and contamination of ground and surface water in the area. The results of wastewater analysis in Dhamar station are showed that the treated wastewater was slightly alkaline, the conductivity electric (CE) and the total soluble solids (TDS) of wastewater for inlet and outlet were 3,530 & 3,100 µS/cm for (TDS) and 2259.2 &1984 mg / l for (CE), It indicates the values are of no suitability quality as per FAO for irrigation. As well as the concentrations of cations ($Ca2+$, $Mg2+$, $Na+$ & $K+$) and anions($HCO3-$, $Cl-$ & $SO42-$) in wastewater in 2016 were 158.316, 99.712,333.5, 68.425, 976.16, 283.68 and 336.21 respectively Comparing with FAO, while it indicted that most concentrations of the cations and anions are within the acceptable limits of agriculture except the concentration of $HCO3-$. Comparing it with results of the analysis of 2005, 2009 and 2012, it was found that there is a big difference in the results of the analysis, indicating that the wastewater station does not work on the required treatment, due to the increase in the water entering it and the small size of the sedimentation basins. As well as the value of SAR was excellent for 2016 and also for the 2005, 2009 and 2012. According of the US salinity diagram illustrates the wastewater sample fall in the field of C4-S2, indicating high salinity and low sodium water, which can be used for irrigation on almost all types of soil without danger of exchangeable sodium. As for the results of the analysis of the soil irrigated with different water, its effect was a low on soil and it does not appear only after some time.

REFERENCES

Abosoliman, M. S. and Halim, M. (2012). Status and New Developments on the Use of Brackish Water for Agricultural Production in the Near East. United Nations Food and Agriculture Organization (FAO)–Regional Office for the Near East (RNE), 522pp.

Al Aizari, H.; Lebkiri, A.; Fadli, M. and Albaseer, S.S.(2017). Quality assessment of ground water in Dhamar City. Yemen. Int. J. Environ., 6: 56–71.

Al-Aizari, H.; Achaouch, A.; Fadli, M. and Al-Kadasi, F. (2018a). Study of groundwater quality in Wadi Almawaheb and Qa' Asawad in Dhamar City (Yemen) its validity for agricultural use. J. Chem. Pharm. Sci., 11: 40–44.

Al-Aizari, H.; Achaouch, A.; Fadli, M. and Al-Mashreki, M.(2018b). Impact of Climate Change on Groundwater in Dhamar Basin (Yemen). J. Chem. Pharm. Sci., 11: 93–99.

Al-Aizari, H.S.; Chaouch, A. and Fadli, M.(2018). Assessment of hydrochemical quality of groundwater in Wadi Almawaheb and Qa,a asawad area, Dhamar city (Yemen). JournalofMaterials Environ., 9: 2884–2893.

Al-Kadasi, F. (2008). Effect of wastewater on the degradation of renewable natural resources in the valley ofAmawaheb Qa,a aswad. Dhamar. Theses (Unpublished).

Al-Kohlani, T.A.M. (2009). Geochemistry of thermal waters from Al-Lisi-Isbil geothermal field. Dhamar governorate. Yemen., 2:32-48.

Almoayed, K. A.; Break, A. B.; Al-Qassimi, M.; Assabri, A. and Khader, Y.(2019). The Acute Flaccid Paralysis (AFP) Surveillance System in Yemen. 2010-2015. Descriptive Study Based on Secondary Data Analysis. JMIR Public Health and Surveillance., 5(4): 144 - 153.

APHA, A. (1998). Standard methods for the examination of water and waste water. Inc Wash. DC. 265pp.

APHA/AWWA/WEF. (1998). Standard methods for the examination of water and waste water, 20th edition. American Public Health Association/American Water Works association, Water Environment Federation, Washington DC. USA., pp. 235-237.

Ayers, R.S. Westcot, D.W.(1985). Water quality for agriculture. FAO Irrigation and Drainage paper. Rome. FAO., 29(1):174pp.

Beretta, A.N.; Silbermann, A.V.; Paladino, L.; Torres, D.; Bassahun, D.; Musselli, R. and García-Lamohte, A.(2014). Soil texture analyses using a hydrometer. modification of the Bouyoucos method. Cienc. E Investig. Agrar., 41: 263–271.

Blakemore, L.C. (1987). Methods for chemicalanalysis of soils. NZ Soil Bur. Sci., 80 : 72–76.

Chiesa, S. (1983). Geology Of The Dhamar-Rada'volcanic Field, Yemen. Arab Republic., 235pp.

Cosgrove, W.J. and Loucks, D.P.; (2015). Water management: Current and future challenges and research directions. Water Resour. Res., 51 : 4823–4839.

Council, N.R. (2012). Water reuse: potential for expanding the nation's water supply through reuse of municipal wastewater. National Academies Press.,320pp

Darwesh, N.; Allam, M.; Meng, Q.; Helfdhallah, A. A.; Ramzy SM, N.; El Kharrim, K. and Belghyti, D. (2019). Using Piper trilinear diagrams and principal component analysis to determine variation in hydrochemical faces and understand the evolution of groundwater in Sidi Slimane Region. Morocco. Egypt. Aquat. Biol. Fish., 23(5):17-30.

El Rhaouat, O.; El Kherrati, I.; Chiguer, H.; Ezziani, K.; Ibeda, A.; Fareh, M.; Saidi, Y.; El Kharim, K. and Belghyti, D. (2013). Physic-chemical evaluation of urban wastewater of the town of Sidi Kacem. Comput. Wat. Energ. Env. Eng., 3: 30-36.

Gibson, M. and Wilkinson, T.J.(1995).Oriental Institute Investigations In Yemen., 301pp.

Glass, N.(2010). The water crisis in Yemen: causes, consequences and solutions. Glob. Major. E-J., 1: 17–30.

Hamilton, D.L.; Brockman, R.P. and Knipfel, J.E.(1984). The agricultural use of municipal sewage. Can. J. Physiol. Pharmacol., 62: 1049–1055.

Haydar, A. (2005). the environmental impact of wastewater use on agricultural irrigation. Abu Dhamar Sana'a. Raport (Unpublished).

Hill, G.; Salisbury, P.; Northedge, L.and Kinninmont, J. (2013). Yemen: corruption. capital flight and global drivers of conflict. Chatham House.

Joshua N, S.; John, O.; Odiyo and Olatunde, S. and Durowoju, n.d.(2017) Impact of Wastewater on Surface Water Quality in Developing Countries. A Case Study of South Africa.

Kamra, A.A. (2006). Yemen Geothermal Resources. GRC Trans., 30: 637-642.

Lawrence, R.W. and Scheske, M.(1997). A method to calculate the neutralization potential of mining wastes. Environ. Geol., 32: 100–106.

Minissale, A. ; Mattash, M.A.; Vaselli, O.; Tassi, F.; Al-Ganad, I.N.; Selmo, E.; Shawki, N.M. Tedesco, D., Poreda, R. and Ad-Dukhain, A.M.(2007). Thermal springs. fumaroles and gas vents of continental Yemen. their relation with active tectonics. regional hydrology and the country's geothermal potential. Appl. Geochem., 22: 799–820.

Musa, J.J.; Ode, O.G.; Anijofor, S.C. and Adewumi, J.K.(2011). Quality Evaluation of Household Wastewater for Irrigation. J. Appl. Sci. Environ. Manag., 15 : 431–437.

Overstreet, W.C.; Kiilsgaard, T.H.; Grolier, M.J.; Schmidt, D.L.; Domenico, J.A.; Donato, M.M.; Botinelly, T. and Harms, T.F.(1985). Contributions to the geochemistry, economic geology, and geochronology of the Yemen Arab Republic. US Geological Survey. DC., 350pp.

Pescod, M.B., (1992). Wastewater treatment and use in agriculture. DC., 550pp.

Polemio, M. and Rhoades, J. D.(1977). Determining Cation Exchange Capacity: A New Procedure for Calcareous and Gypsiferous Soils 1. Soil Sci. Soc. Am. J., 41 : 524–528.

Rajeh. A; Al-Ghulaybi, N.; Al-Asbahi, Q.; Al-Swaidi, N.; Hussein .J and Al-Husseini.(2013) .Environmental Impact Assessment Study of Treated Wastewater and its Use for Agricultural Irrigation (forage crops-livestock) Almawaheb area. Dhamar. Raport (Unpublished).

Rice, E.W.; Baird, R.B.; Eaton, A.D. and Clesceri, L.S.(2012). Standard methods for the examination of water and wastewater. American Public Health Association Washington. DC., 650pp.

Richards, L.A. (1954). Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook No. 60. ed. Agriculture Handbook No. 60.

Scott, C.A.; Zarazúa, J.A. and Levine, G.; (2000). Urban-wastewater reuse for crop production in the water-short Guanajuato river basin, Mexico. 41pp.

USSR. (1945). Diagnosis and Improvement of Saline and Alkali Soils. USDA. Handbook., 60: 147pp.

Van, M. (2007). Support to rural water supply and sanitation in Dhamar and Hodeidah Governorates. Republic of Yemen, DC., 250pp.

WHO. (2006). Guidelines for drinking-water quality [electronic resource]: incorporating first addendum. Recommendations., Vol(1):650pp.