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# Study of groundwater quality in Wadi Almawaheb and Qa' Asawad in Dhamar City (Yemen) its validity for agricultural use

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**ABSTRACT**

Physical and chemical properties for water in Wadi Almawaheb and Qa' Asawad were studied for the purpose of classification of this water for irrigation use, where it was adopted on cations ions (Calcium ($Ca^{2+}$), Magnesium ($Mg^{2+}$), sodium ($Na^{+}$), Potassium ($K^{+}$), anions ions (bicarbonate ($HCO_3^{-}$), Chloride ($Cl^{-}$), Sulfate ($SO_4^{2-}$), pH value, Electrical Conductivity (EC),and Sodium Adsorption Ratio (SAR), the results showed that, 50% water samples fall within the water class (C3-S1) and 50% water samples fall within the water class (C2-S1) according to USSL system. Whereas, in FAO system, the samples fell within the class (increase in salinity hazard) for the salinity hazard, In addition, pH values were within natural limits.

**KEY WORDS:** Groundwater samples, Physico-chemical parameters.

## 1. INTRODUCTION

Water is one of the necessities for existence of mankind, whether it is in use of running water in our homes, rearing cattle and growing crops in our farms, or the increased uses in industry, remain immeasurable. It is important therefore, to not that depletion of this commodity either through contamination, or careless use results in serious consequences (Owa, 2014).

It should be noted that the problem of water quantity and quality necessary for the population and its economic development for many countries, particularly those receiving very little Such as the Sahel countries. Yemen, for example, because of its climate change, is a water-deficient country. Indeed, the low rainfall, the importance of evaporation and the geological features of the country mean that Yemen is water resources. Resources are therefore limited while Needs increase (Abddayem, 1997).

Based on the UNICEF, there are more than 3,000 children were die every day worldwide due to the contaminated of drinking water and pollution which considered as the biggest killers in the world, affecting over 100 million people (WHO, 2009). The assessment of the validity of water has become very important for the preservation of human life.

The assessment of the validity of water has become very important for the preservation of human life. The assessment of the pollution Water can be measured using different means viz. physical, chemical and biological. In physical testing properties such as temperature, solid concentrations and turbidity are measured. Usually, analytical chemistry principles are used to analyze and study the water samples chemical. These include: pH, Biochemical oxygen demand, chemical oxygen demand measurements. On the other hand, several techniques were used to evaluate the Biological effect and the environmental population (Chapman, 1992; Kannel Raj, 2007).

The study area is considered as one of the areas that suffer from the degradation of natural resources, particularly soil and water in both surface and groundwater sides as well as plant or vegetation cover. Poor farmers who don't have water resources to irrigate forage crops to feed their livestock, especially during winter season, still suffer from big problems healthily and environmentally as a result of using sewage water, as well as health damages on livestock drinking stagnant water or being fed with forage which has been irrigated using this water.

The aim of this study is to classify the irrigation water taken from some wells of Wadi Al Mawaheb and Qa'a Al-Sawad according to the commonly used classification systems and to identify the components of this water from dissolved ions and try determination of the validity of the irrigation operations of different crops.

**Study area**: The study area is located north of the city of Dhamar, which is about three kilometers from the city center (Figure.1.), It is between 16090000 "to 16290000" north latitude and 434000 "to 438000" longitude, that it is and covers an area of 70 $km^2$ with a population of more than 30,000 (based on 2004 Census) (William, 1985; Van Buitenlandse, 2007).


**Figure.1. Locations Study Area**

Geology of study area alluvium is the most important parent material for soil formation. Or the various rock types two stand out above all others, the dark basalts and the pale lithered pyroclastic ash deposits. The geology in the survey area is essential to an understanding or the soils, their origin, parent. Material and distribution. Table-1 shows in brier landforms, their geological formation and lithology for the study area (Chiesa, 1985; Overstreet, 1985; Al-Kohlani, 2009; Minissale, 2013).

**Table.1. Shows in brier landforms, their geological formation and lithology for the study area**

| Landform | Formation | Lithology |
|---|---|---|
| Plateau and lava flow Valle | Tertiary Yemen Volcanic Quaternary alluvium | Basalte Alluvium Ash-tuff |

Yemen's climate is arid and semi-arid, in the study area there are two distinct rain seasons, separated by a distinct dry interval (mid-May-mid-July). The first rainy season begins in mid-March - early April, the second rainy period begins in mid-July - early August and stops abruptly at the end of August. The months of September to February are generally dry, although occasional thunderstorms can cause rain during these months (Bruggeman, 1997; Al-Poranl, 1999; El-Abbas, 1997). Average precipitation during 1999-2015 is about 431.1 mm / year. With regard to the wide depressions to the east and north-east room. The average annual rainfall over the drainage basin of the surface water of the Dhamar depression is bottom to be 200-400 mm. The monthly precipitation distribution shows that most precipitation amounts precipitated in the five months most of which occur in March, April and May and the other highest amount occurs in July and August. Dhamar area is affected by moderate weather conditions, the maximum average annual temperature is during 1999-2015 about 24°C, as much as the surface potential relay potential on average during the rainy season, and while most Of the rainwater evapotranspiration (about 90%), to the atmosphere. Only 10% of the total precipitation infiltrate into the groundwater recharge and forms the runoff part (NWRA, 2015). Groundwater is the source of rain for domestic water supply and irrigation. The study area is considered to have the sufficient source of groundwater to cover the needs of the inhabitants by irrigation water.

## 2. MATERIAL AND METHODS

Groundwater samples were taken in May 2008 from twelve of the groundwater. All samples represent in wadi almawaheb and Qa, Asawad. The samples were taken after pumping for 10 min for the underground swabs. Clean and dry polyethylene bottles were used for sample collection, following standard, properly labeled and refrigerated procedures prior to analysis for different quality parameters (Bernard, 2009; Aquaref, 2015). The electrical conductivity (EC, TDS and T) was measured in the field using a (Medium Conductivity Session CEL / 850 (HACH). After that, the samples were transported in a fresh box and stored at an appropriate temperature until analysis in the office laboratory of the Agriculture Research and Extension Authority in the city DHMAR - YEMEN. The physicochemical analyzes of the well water were all carried out according to the methods described according (Bernard, 2009). After the sampling temperature taken in the laboratory, the pH was evaluated by pH-422. The samples were measured for their chemical constituents such as $Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $k^{+}$, $Cl^{-}$, and $HCO_3^{-}$, using the standard method proposed for the World Health Organization. Concentrations of Ca and Mg were estimated using 0.02 N EDTA and the concentration of $HCO_3^{-}$ and $Cl^{-}$ by titration $H_2SO_4^{2-}$ and $AgNO_3$, respectively. $Na^{+}$ and $K^{+}$ concentrations were analyzed using a flame photometer (PFP 7).

## 3. RESULTS AND DISCUSSION

The results of the calculation of the statistical parameters representative of the 12 samples (observations) and the 11 variables are given in Table.1, it were compared with the Food and Agriculture Organization (FAO, 1985) to determine its suitability for irrigation.

**Table.2. Result Statistical analysis of water samples for area study**

| Parametres | Mean | S.D. | Min. | Max. | WHO, 1992 |
|---|---|---|---|---|---|
| EC | 517.267 | 320.717 | 185.6 | 1408 | 700-4000 |
| PH | 7.5667 | 0.4849 | 7.1 | 8.6 | 6,5-8,5 |
| $Ca^{2+}$ | 55.277 | 32.8009 | 6.012 | 130.26 | 70-207 |
| $Mg^{2+}$ | 21.6853 | 15.0172 | 3.648 | 55.936 | - |
| $Na^{+}$ | 62.2917 | 27.0804 | 39.1 | 124.2 | - |
| $K^{+}$ | 18.162 | 47.2685 | 0.1564 | 168.13 | - |
| $HCO^{3-}$ | 179.98 | 69.0494 | 18.303 | 262.343 | 142-355 |
| Cl | 100.47 | 53.3795 | 42.552 | 234.036 | - |
| $SO_4$ | 85.2533 | 87.0613 | 19.212 | 297.786 | 92-519 |
| SAR | 5.1708 | 5.0256 | 1.378 | 17.1429 | 9 |

Potential hydrogen is known as the negative logarithm of hydrogen ion concentration It is a measure of acidity or alkaline solutions (-Log H) under normal conditions of temperature and pressure the factors that affect the value of pH are the degree Heat, presence of bicarbonate, calcium and plants. ts value ranged in the area of research

between (7.1-8.6) (Table.1 & Figure.2). Which indicates that groundwater in the area has a few base bases and falls within permissible limits and proposed by the World Health Organization.

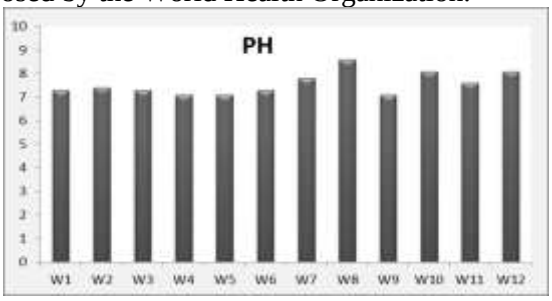


**Figure.2. Variation of pH of all samples**

Electrical conductivity (EC) range in the study area between where the values differ from your connection from the well to another according to his position where he has found a significant increase in the wells 11 and 12 (Figure.3) due to the proximity of the wastewater plant, it are located within allowed limits proposed by the Food and Agriculture Organization. (700-4000 µS/cm) in table.2. Which indicates that lower EC values (<1000 µS/cm) were found in entire Qa' Aswad. While, the higher EC values (>1000 µS/cm) were found in few parts of Wadi Al mawaheb, in case of wells that higher EC values (>1000 µS/cm) were found in surrounding area of station of treatment wastewater plant.

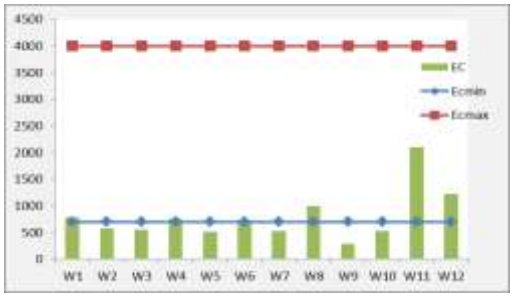


**Figure.3. Variation of electrical conductivity of all samples**

The results inTable-2and figure-4 indicated that a significant difference among the wells in respect to major the cations, $Ca^{2+}$, $Mg^{2+}$, $Na^{+}$and $K^{+}$ and the highest concentration of $Ca^{2+}$, $Mg^{2+}$ were 130.3, 55.9, respectively in well (w11) and, $Na^{+}$, $K^{+}$ $^{+}$ were 125.1,198.2 mg/l respectively in well (w12) and the lowest concentration for $Ca^{2+}$, $Mg^{2+}$ and K were 55.3, 21.7 and 18.2 mg/l respectively in well and the lowest concentration for $Na^{+}$ is 18.2 in well (w5). The concentrations of cations are located within allowed limits proposed by the Food and Agriculture Organization. (Ayers, 1985). All of these wells are located down of wastewater treatment plant (WWTP) and this difference of concentration may be due to migration of wastewater via soil towards near wells.

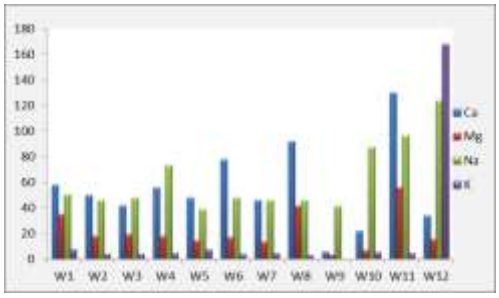


**Figure.4. Variation of Major actions of all samples**

The results in Table.2 and figure.5, indicated that a significant difference among the wells in respect to major the inions, $HCO_3^-$, $Cl^-$ and $HSO_4^{2-}$ and the highest concentration of $HCO_3^-$ is 262.3 mg/l in wells (w8 & w12), $Cl^-$ is 234.03 mg/l in well (w2 ) and $SO_4^{2-}$ is 297.8 mg/l in well (w11) and the lowest concentration for $HCO_3^-$ is 18.3, mg/l in well (w9) and the lowest concentration for $Cl^-$ is 42.6 mg/l in wells (w9 & w10) and the lowest concentration for $SO_4^{2-}$ is 19.2 in well (w5). The concentrations of anions are located within allowed limits proposed by the Food and Agriculture Organization (Ayers, 1985). All of these wells are located down of wastewater treatment plant (WWTP) and this difference of concentration may be due to migration of wastewater via soil towards near wells.

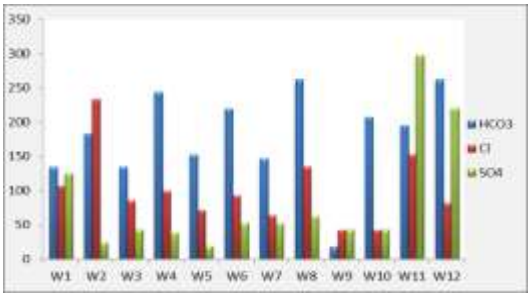


**Figure.5. Variation of Major anions of all samples**

For irrigation was evaluated by estimating of relations entre Electrical Conductivity (EC) and Sodium Absorption Ratio (SAR). The classification of SAR data (alkaline hazard) and EC (salinity) is plotted in a diagram USSL (1954) to determine the suitability of water for irrigation (Figure.6), (USSL, 1954).

50% of the wells enter the high salinity risk zone (C3) and 50% of wells entre the medium salinity zone (C2). On the other hand, all wells have SAR values below 9, which are of average quality for irrigation water. The percentage of sodium is not very high in groundwater in the aquifer.EC with SAR determines whether groundwater can be used for agricultural purposes. Water samples in categories (50%) C3-S1 and (50%) C2-S1, however C3-S1 is according to the US Salinity Laboratory This type of irrigation water is considered to be very low in water and this type of water cannot be used. In the irrigation of crops sensitive to saline, especially citrus.

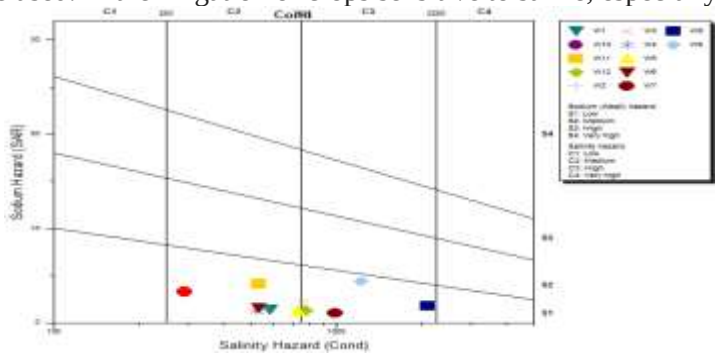


**Figure.6. Variation of EC&SAR**

**Piper Diagram:** The chemical composition of the water samples were illustrated by using Piper diagram tri linear diagram (Piper, 1944). Figure 7. Most of the ground waters cluster mixt between cations and anions. A one show $Na^+$ $Cl^-$ $SO_4^{2-}$ and $Na^+$ $Cl^-$ $HCO_3$. The dominance of ionic pattern for the groundwater samples were $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and $Cl^- HCO_3^- > SO_4^{2-}$.

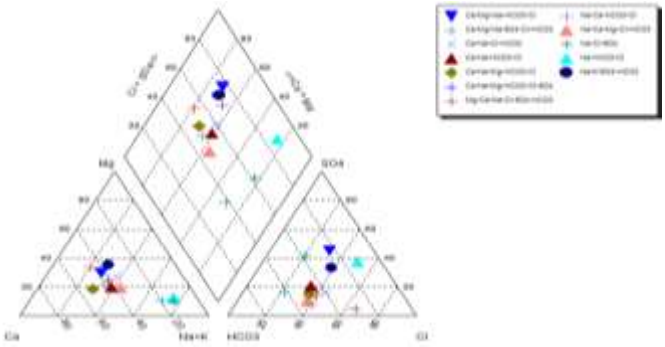

**Figure.7. Piper Diagram of all samples**

## 4. CONCLUSION

The results of the study showed high salinity in the wells near the wastewater treatment plant According to the classification of the American saline system, the amygdala is administered to two types. Water is medium salinity and low sodium (C2-S1), this type of irrigation water can be used in most crops and in most areas with the possibility of development of the problem of access to the soil soft textures when there is no lime. Water is medium salinity and medium sodium (C3-S1), this type of irrigation water can be used in most crops except for highly sensitive salts. His quality of water in most of the school wells was mixed with cations and ions. Determining the validity of water for irrigation and agriculture does not depend only on the laboratory conduct of water irrigation, but other factors affecting determining the validity of water for irrigation and agriculture should be studied including soil (determination of physical and chemical properties), type of cultivated crop and its salt tolerance, climate conditions include (temperature, rainfall, wind speed, evaporation speed etc.) and irrigation and drainage management in terms of the availability of appropriate and good irrigation networks and irrigation systems effective.

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