Ground Water Quality Assessment for Drinking and Irrigation Purposes of Tazerbo Well Field, Libya, Line 500

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Abstract: The suitability of ground water in the studied wells is evaluated for drinking water and public health purposes compared with WHO (2018) guideline values. All physicochemical analysis of the ground water samples are less than the safe limit except for the iron (Fe) which must be treated, high concentration level of Fe in drinking water due to is the presence of Fe in lateritic rocks. According to total dissolved solids (TDS) classification, the studied water samples were classified as fresh water and desirable for drinking In addition, the cross plot of total dissolved solids (TDS) vs. total hardness (TH) showing the hardenss of water, which suggest the ground water samples were soft fresh water, the irrigation parameters that used in the studied wells were suitable for irrigation uses.

Keywords: Water quality, Drinking water, Irrigation use, Tazerbo wells

1. Introduction:

The Man-Made River project (MMRP) has constructed a network of 4m diameter pre-stressed concrete pipes that transports the fresh water from the Nubian Sandstone Aquifer System to cities along the country's populous northern Mediterranean coast, such as Sirte and Benghazi. In 1983 the Man-Made River Authority, established important water supply well fields, which include: Phase I Sarir-Sirt/Tazerbo-Benghazi System (SS/TB), Phase II Hasouna-Jeffara System, Phase III Tobruq- Jagbob System, Phase IV,Ghadamis /Zwara System, Phase V Sirt/Assdada System. This study will be focused on the Phase I, Line 500. Hundreds of water wells were drilled at two fields, Sarir and Tazerbo, where water was pumped up from a depth of some 500 From Sarir water from both fields was pumped through a twin pipeline straight to the holding reservoir south of Ajdabiya since1989. From there the water was piped in two directions, west to the coastal city of Sirte and north to Benghazi. Phase 1 is capable of transporting 2 million cubic metres of water per day through some 1,600 km of double pipeline between the well fields in the south and the destination cities in the north (Lenghi et al.,2008). The specific aims of this study as follows: 1) To complete the pervious study (Shaltami et al,.2021) that focused on line100 wells,(101-109) .2) To increase knowledge and understand of hydrochemical systems of groundwater in Tazerbo region (Fig.1).Several recent studies were conducted to date addressing water quality criteria for drinking and irrigation uses such as (Al Faitouri, M., Sanford W.. 2015; Nawal Alfarrah et al., 2017; Mostafa F. et al. 2021)

2.Reasrch method and tools

The physicochemical analysis of ground water samples were done in the laboratory of the Man-Made River Authority (MRA). Nine water samples were taken from line 500, wells (501 – 509) in polyethylene bottles (Table 1). The pH, total dissolved solids (TDS) and electrical conductivity (EC) were measured at the sample site using handheld analyzing kits. Sodium (Na) and potassium (K) was measured by flame photometry. Sulphate (SO4) was measured by spectrophotometer turbidimetry. Calcium (Ca) and magnesium (Mg) were determined titrimetrically using standard EDTA. Chloride (Cl) was determined by standard AgNO3 titration.

3.Results and dissuasion

3.1.Power of hydrogen (pH)

The pH values in drinking water is an important parameter and may affect health of humans. The studied ground water samples display pH within a range of 6.05 to 6.46 with a mean 6.3, reflecting all the ground water samples were fitting for drinking water as recommend by WHO (2018). Generally, the pH influence by the geology of the area and water storage capacity.

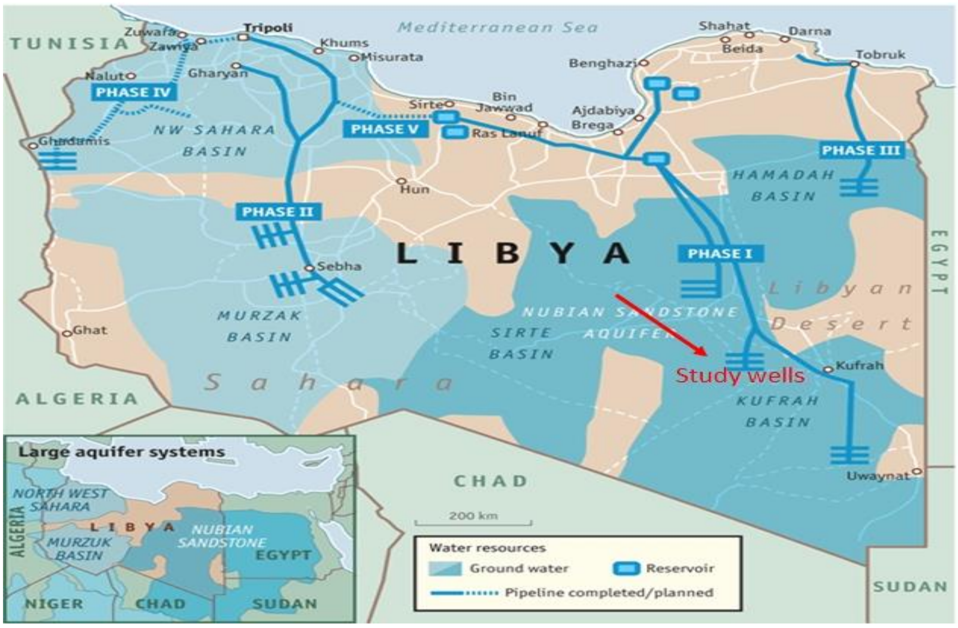

Fig.1: Libya’s water supply: The Great Man-Made River and location map of the studied wells (PERC, 2011).

Table.1: Physicochemical analysis of the studied ground water samples compared with WHO (2018)

	Wells No.									
Parameters	**501**	**502**	**503**	**504**	**505**	**506**	**507**	**508**	**509**	**WHO**
T	30.6	31.2	31	31.7	31.4	32.4	33.5	32.5	31	_
pH	6.21	6.46	6.3	6.45	6.28	6.29	6.46	6.25	6.05	8
EC	331	359	321	302	309	307	301	294	296	2500
TDS	215	233	209	196	200	201	196	191	192	500
Ca	10	10	10	9	8	9	10	9	9	200
TH	75	77	74	72	70	72	75	72	72	500
Na	17	19	14	16	18	18	21	19	21	200
Cl	22	24	21	20	20	20	22	21	20	250
K	31	30	29	26	26	27	25	25	24	150
Mg	12	13	12	12	12	12	12	12	12	150
Fe	1.59	1.61	1.74	1.86	2.04	2.49	2.62	2.97	3.31	0.3
T-Alk	117	119	105	108	105	93	94	93	93	_
SO_4	19	20	20	20	20	24	22	22	24	600
NO_3	0	0	0.1	0	0.1	0	0.4	0	0	50

3.2.Total Dissolved Salts (TDS)

The values of TDS in the studied wells range from 191 to 233 mg/l with a mean 204 mg/l, the WHO (2018) guideline of drinking water shall not be more than 500 ppm. All the ground water samples were below the permissible limit. According to TDS classification (Table 2), the studied water samples were classified as fresh water and desirable for drinking (Table 3). In addition, the cross plot of total dissolved solids (TDS) vs. total hardness (TH) showing the hardens of water (Fig.2), which suggest the water samples were soft fresh water. The hydrogeochemical data of water was classified using a Gibbs plot 1970; based on precipitation, rock and evaporation dominances. The main source of major ions originated from rock dominance (Fig.3).

Table.2: Classification of water based on Total Dissolved Solids (after Fetter,1994).

Class	TDS (mg/l)
Fresh	0 - 1000
Barkish	1000 - 10000
Saline	10000 - 100000
Brine	> 100000

Table.3: Classification of water based on Total Dissolved Solids (after Davis and De Wiest, 1966).

NO.	Suitablity of water	TDS (mg/l)
1	Desirable for drinking	< 50
2	Permissible for drinking	50 - 1000
3	Useful for irrigation	1000 - 3000
4	Unfit for drinking and irrigation	> 3000

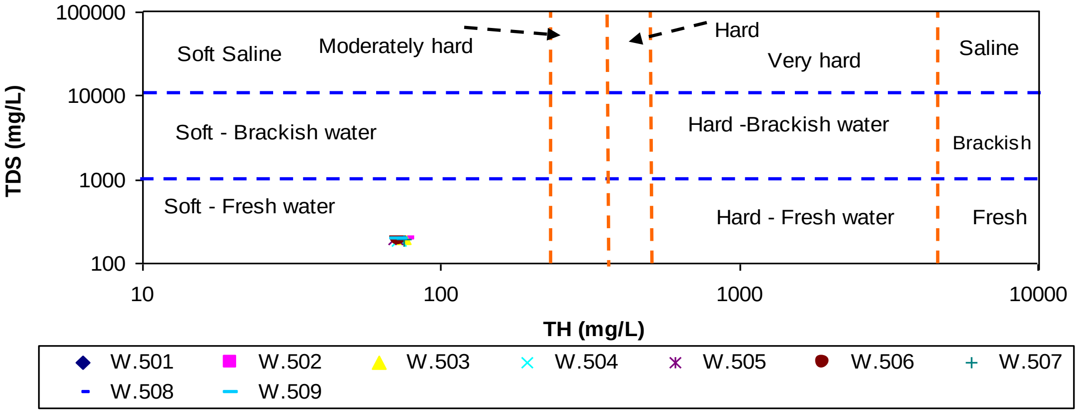

Fig.2 : Plot of total dissolved solids (TDS) versus total hardness (TH) of the water samples (fields after Todd D., 1989).

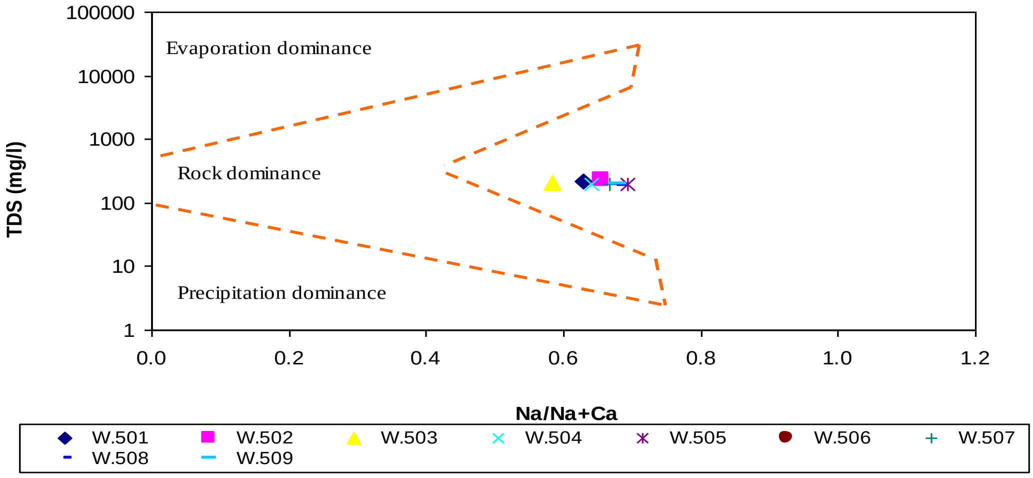

Fig.3 : Dominance of precipitation, rock and evaporation on Na/Na+Ca vs. TDS of the water samples (fields after Gibbs, 1970).

3.3.Electrical Conductivity (EC)

The EC is believed to be an excellent indicator of the amounts of TDS in water, with a high EC indicating a high level of TDS in the water (Ackab,M. et al.,2011). The values of EC of the water samples of Shebna region range between 249 to 359 µs/cm, with a mean 313 µs/cm. The US Salinity Laboratory (1954) classified groundwater on the basis of EC (Table 4). Based on this classification, the ground water samples belong to the good category.

3.4.Total Alkalinity (T-Alk)

The term total alkalinity refers to the amount of salt in a water samples. The main source of this salt is surrounding rocks. The values of T-Alk in the studied wells range from 93 to 119 mg/l with a mean average 103 mg/l, these values compering with WHO (2018), the results showed of total alkalinity for all samples were below the permissible limit. The bivariate plot of pH vs. Al kalinity showed the samples are classified, as corrosive water, this process is natural occurs when the metals react with oxygen and form oxygen oxides (Fig.4).

3.5.Water Hardness (TH)

Water hardness is the measure of the ability of water to react with soap and produce froths. It is based on Ca and Mg salts and can be calculated as follows:

$$TH\ (mg/l\ CaCO_3) = 2.5\ Ca\ (mg/l) + 4.1\ Mg\ (mg/l)$$

In the studied wells, TH ranges from 69.2 to 78.3 mg/l with a mean of 72.3 mg/l. all the studied ground water samples were within the permissible limit. Ca and Mg are essential minerals for human health, deficiency or excess can result in adverse health consequences. Continuous use of hard water may cause cancer, cardiovascular disease, urolithosis and other kidney ailment (Meena et al., 2012).

3.6.Sodium (Na) and Potassium (K) content

The sodium content display within range 14 – 21 mg/l with a mean 18.11 mg/l. the concentration of K in the studied water ranges from 24 to 31 mg/l with a mean concentration 27 mg/l. the results showed the Na and K content were below the safe limit. In the present study, K is negativity correlated Na and SO4 (r = -0.5 – 0.6, Figs.5-6). According to Freeze and Cherry (1979) Na can be produce through dissolution and weathering of Na bearing minerals (e.g. halite and sodium plagioclase) along with anthropogenic sources including industrial, domestic, and animal wastes, whereas the K is mainly originated from K-bearing minerals such as rain water, clay minerals together with agricultural fertilizers and domestic wastes (Prasanna et al., 2010).

3.7.Calcium (Ca) and magnesium (Mg) content

Ca and Mg range from 8 to 10 mg/l and 12 to 13 mg/l, respectively. According to WHO (2018) the results were below the safe limit. The low Ca/Mg ratio (0.3) may indicate seawater influence (Hem, 1989). In the studied wells, Ca is weakly positively correlated with Mg (r = 0.35, Fig.7), suggests the may not the same origin of Ca and Mg. The Ca/Mg ratio ranges from 0.7 to 1.32, indicating, in agreement with Naseem et al., (2010), complexity in the budget of Ca and Mg of groundwater due to interaction with rocks and the semi-arid climate of the studied wells.

3.8.Sulfate (SO4)

In the studied ground water, the SO4 values range from 19 to 24 mg/l, with a mean average 21.3 mg/l. WHO (2018) has established 500 mg/l as desirable and permissible limit in the drinking water. The result revealed were below the permissible limit. Humans may suffer a laxative effect after drinking water with a high SO4 level (WHO, 2004).

3.9.Chloride (Cl)

The concentration of Cl in the studied wells range from 20 to 24 mg/l with a mean 21.1 mg/l. These values are less than permissible limit by WHO (2018), which indicates the studied in the studied wells were not affected by Industrial inputs, domestic effluents, inorganic fertilizers, septic tanks, and leachates from landfills, these factors causing the increase in Cl levels. The Cl is weakly positively correlated with Na (r = 0.15, Fig.8).

3.10.Iron (Fe)

The Fe values in the studied wells range between 1.9 to 3.31 mg/l with a mean average 2.2 mg/l. the safe value should be less than 0.3 according to WHO (2018). All the studied ground water samples were above the permissible limit and should be treated. Higher concentration level of Fe in drinking water due to the presence of Fe in lateritic rocks. The lateritic rocks are major geogenic source of Fe in groundwater from the studied wells (Golekar, et al., 2014). According to metal index, the iron (Fe) is more than 6 mg/l, which classified as seriously affected (Class VI) on human health (WHO, 2011).

Table.4: Types of groundwater according to EC (US Salinity Laboratory ,1954)

Class	Water quality	Salinty	EC (m/cm)	Use in irrigation
C1	Excellent	Low	250	Can be used for almost all crops and for almost all kinds of soils
C2	Good	Medium	250 - 750	Can be used if a moderate amount of leaching occurs: normal salt tolerant plants can be grown without much salinity control
C3	Fair	High	750 - 2250	Can be used in soils with restricted drainage. Special precautions and measures are to be undertaken for salinity control
C4	Poor	Very High	2250	Generally not suitable for irrigation

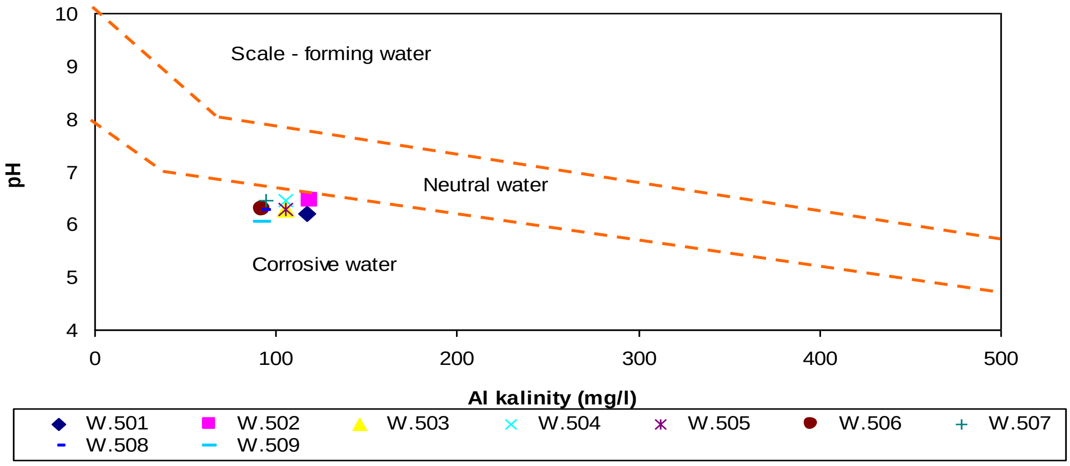

Fig.4: Relationship between pH, alkalinity and water stability standard in studied water samples (fields after Singh and Hussian, 2016).

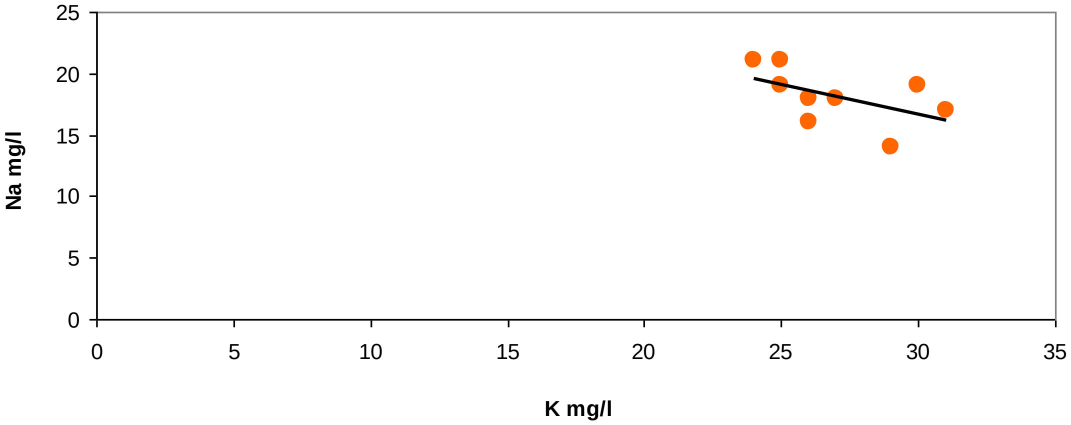

Fig.5: Relationship between K and Na in the studied water samples

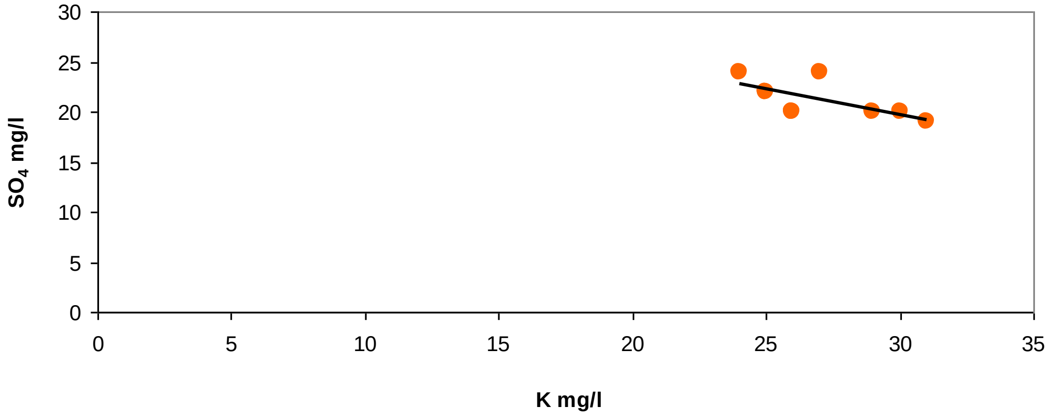

Fig.6: Relationship between K and SO4 in the studied water samples

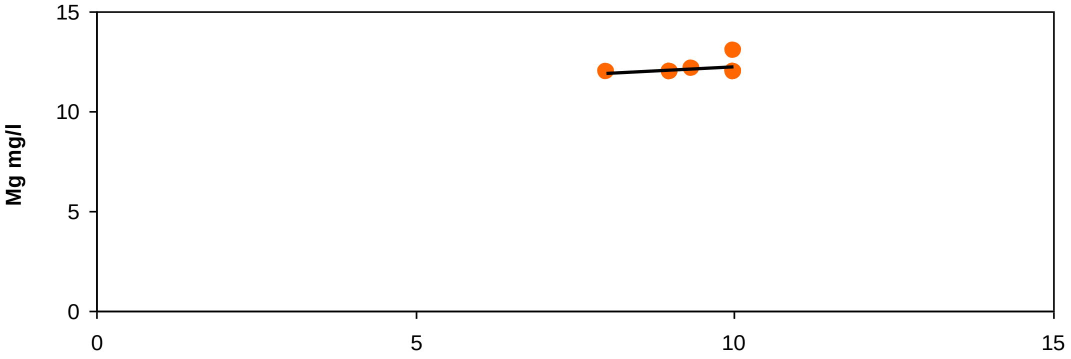

Fig.7: Relationship between Ca and Mg in the studied water samples

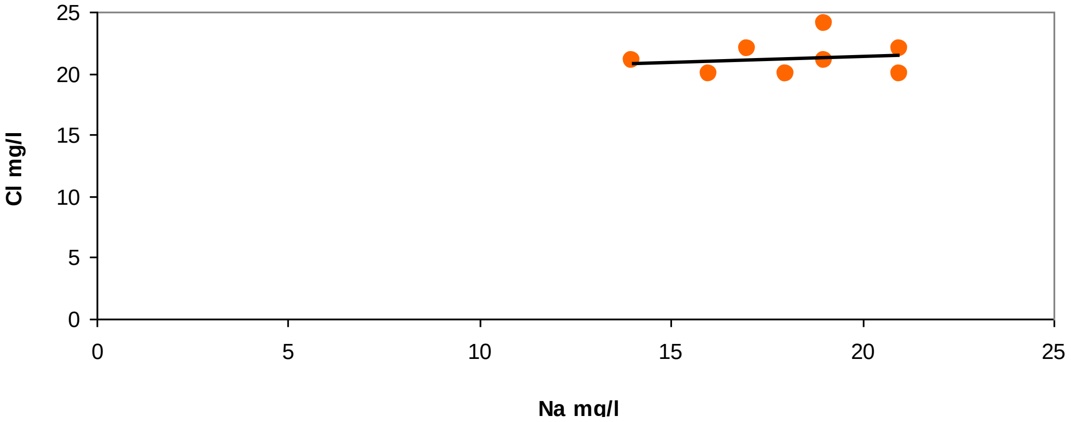

Fig.8: Relationship between Cl and Na in the studied water samples

4.Irrigation water quality

To assess the irrigation water quality, we used the irrigation parameters such as electrical conductivity (EC) in average, 313.3, is classified as class2, low salinity (Table 5).Sodium percent (Na %) in average, 20.8 is suitable for irrigation (Table 6). Sodium adsorption ratio (SAR) in average, 9 is classified as excellent quality for irrigation (Table 7). Kelley's ratio (KR) in average, 0.78 is classified as suitable for irrigation (Table 8).these results is supported by plot EC vs. Na% showing the studied ground water is excellent quality for irrigation uses (Fig.9). These parameters were calculated as follows:

$$\text{Na\%} = (\text{Na}*100)/(\text{Ca}+\text{Mg}+\text{Na}+\text{K})$$

$$\text{SAR} = \text{Na} /\sqrt{(\text{Ca}+\text{Mg})/2}$$

$$\text{KR} = \text{Na}/(\text{Ca}+\text{Mg})$$

(All concentrations were expressed in meq/l).

5.Conclusion

In this paper, the hydrogeochemical characteristics and assessment of groundwater for drinking and irrigation uses were determined. The studied ground water belong soft fresh water and desirable for drinking. The EC in ground water samples were classified as good water quality. Most of the major ions were originated from different source of rocks regards to correlation coefficients. All the physicochemical parameters were below the safe limit except the iron (Fe). The metal index classification is classified the Fe as class VI (seriously effected). The electrical conductivity (EC), Sodium percent (Na %), Sodium adsorption ratio (SAR) and Kelley's ratio (KR) calculations suggest that groundwater in the studied wells were suitable for irrigation use.

6. Recommendation

Should purify water from iron (Fe) before using it, especially in drinking areas.

Table.5: Types of ground water according to Na % (Hakim et al., 2009).

Water quality	Na %
< 60	Suitable for irrigation
> 60	Unsuitable for irrigation

Table.6: Types of ground water according to Sodium Adsorption Ratio (SAR) (Gholami and Srikantaswamy, 2009).

Water quality	SAR
Excellent	< 10
Good	10 - 18
Moderate	18 - 26
Hazardous	> 26

Table.7: Salinity hazards of irrigation waters based on EC values (Richards,1954).

EC of irrigation water (µmohs/cm)	**Salinity Class**	**Salinity Hazards**
100 - 250	C1	Very low
250 - 750	C2	Low
750 - 2500	C3	Medium
2500 - 4000	C4	High salinty

Table.8: Types of ground water according to Kelley (1940).

Water quality	**KI**
< 1	Suitable for irrigation
> 1	Unsuitable for irrigation

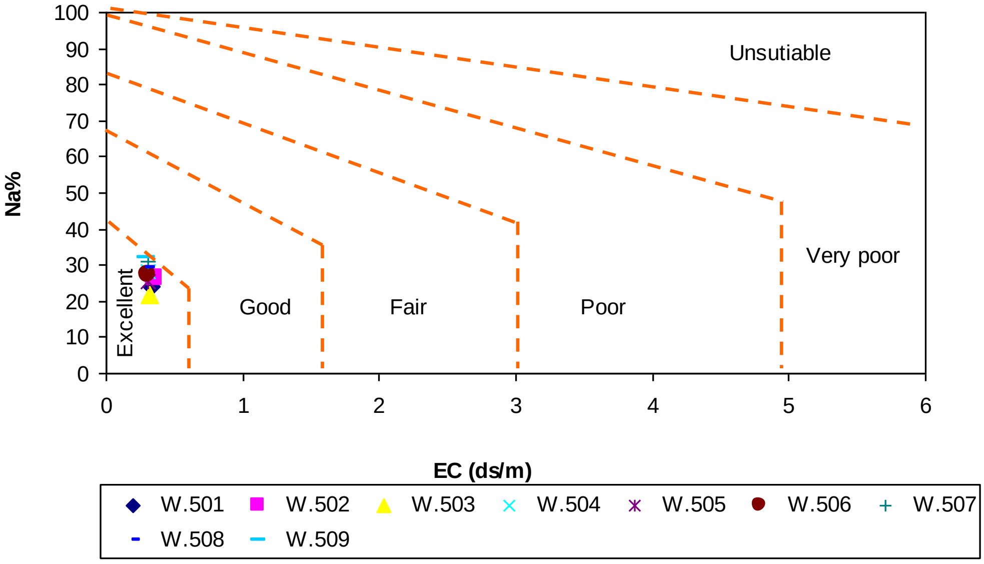

Fig.9: Classification of irrigation water on EC vs. Na % and its suitability for agriculture (fields after Johnson and Zhang, 1990).

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