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Evaluation of Ground Water Quality and Suitability for Irrigation Purposes in Alagilat Area, Libya

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Abstract: *The current study aims at evaluating the ground water quality in Alagilat area, Northwest Libya, for irrigation application. Sixty-fife samples were collected from ground water wells at different depths. The samples were analyzed for* $Ca^{2+,}$ K^{+}, $Mg^{2+,}$ Na^{+}, Cl^{-}, HCO_3^{-}, CO_3^{2-} , SO_4^{-2}, NO_3^{-}, *EC, TDS and TH. For classification purpose, some chemical indices like EC, Sodium percent (SP), Sodium adsorption ratio (SAR), residual sodium carbonate (RSC), Permeability index (PI), Magnesium ratio (MR) and Kelly`s ratio (KR), were calculated. The results indicated that the 83.1% and 12.31 % of the samples EC level fall under doubtful and unsuitable category. This in turn implies to the importance of carrying out a pre-treatment and monitoring of the studied samples if they were to be utilized in irrigation. One option is to grow salt tolerant crops to overcome this issue. Regarding the remaining indices, the results showed that more than 95% of the samples were found to be within the safe limit and likely suitable for agricultural irrigation purposes.*
Keywords: *Alagilat, water quality, irrigation, quality indices*

I. Introduction

Water is a valuable natural resource and essential factor for sustainability. Groundwater resource is one key factor that play important role in sustaining the socio-economic standards in any society . It supports various phases of development, including agriculture and industry. In arid and semi-arid regions, groundwater quality is considered a critical issue that is emphasized strongly in the governments' agendas. The shortage of precipitation, unsustainable human activities and environmental pollution, are few examples of the challenges faced in this region of the globe. The groundwater of the northwestern part of Libya is the major water supply for all daily applications. Specifically, the groundwater in the Jiffarah Plain Basin in this part of the Libyan geography, has been under heavily use over decades by the rapidly expanding development. This development has affected adversely the quality of the groundwater, in terms of chemical, physical and biological aspects.

Characterizing the properties of groundwater for specific application by its industrial or human consumption is considered vital for deciding the feasibility of the resource and its safeness for the public health and the environment. For agricultural application, the chemical parameters of ground water should comply with the irrigation requirements (WHO 1996). If these parameters exceeded the recommended values, the resource is considered unsafe. In many countries, different studies related to groundwater quality assessment have relied on using different indices for judging 'how safe is safe'. For example, Talukder et al. (1998), Shahidullah et al. (2000), Sarkar and Hassan,(2006); Obiefuna and Orazulike, (2010) employed the indices like Electrical conductivity (EC), Sodium absorption ratio(SAR), Residual sodium carbonate(RSC), Magnesium ratio(MAR) and Kelly`s ratio(KR) and permeability index(PI) for deciding the feasibility of the groundwater in agricultural irrigation. However, in Libya, including the Northwestern region, the data similar to such studies are not made on a major scale in the country. Therefore, the present study investigates the hydro-chemical qualities of groundwater in the Northwestern region, particularly Alagilat area for irrigation purposes. The described area is known as an urban and rural area that the society largely depends on its land resource for agriculture.

II. Study Area

The study area is located in the area coordination of latitude 32^{o} 45` 25`` and longitude 12$^{o}$ 22` 34`` in Alagilat area, Northwestern Libya. It is around 85 km from Tripoli and about 4 meters above the sea level ″ Fig″ The maximum temperature is about 45^{o}C and minimum 20 ^{o}C with an average annual rainfall of 150mm.It has a dry climate with hot summer and cold winter. Ground water is considered the main source of water supply in the study area. The dominant soils are of sandy type. The agriculture is considered one of the main activities in the area where barley, wheat, lattice, sparsely, carrots and fodder crops are grown.

III. Methodology

A total of 65 ground water samples were collected during 2013 from 26 villages of Alagilat area, Libya using Global positioning system (GPS). The samples were collected from public wells, private wells, water sources in the health centers, and schools. First, the water was left to run for few minutes from the wells to pump out the standing water before taking the final samples. The samples were collected in pre cleaned sterilized polyethylene plastic bottles of 1L capacity then the samples were placed in clean containers and immediately put in ice boxes. The ice boxes were shipped to Syracuse, Italy where the analyses were done by standard techniques in the laboratories of Ecocontrol Sud Company ″Table1″. The ground water samples were analyzed for hydro- chemical parameters of Calcium (Ca), Magnesium (Mg), Potassium (K), Sulfate (SO_4), Phosphate (PO_4), Chloride (Cl), Sodium (Na^+) and Nitrate (NO_3). The physical parameters like pH, Electrical conductivity (EC), temperature and dissolved oxygen were measured in situ using field kit.

All chemical parameters are expressed in mg L^{-1} except pH and EC. In order to achieve the aim of this research, several indices for irrigation such as Sodium absorption ratio (SAR), Permeability index (PI), Sodium percentage (SP), Magnesium ratio (MAR), Residual sodium carbonate (RSC), Kelly`s ratio (KR) and Electrical conductivity (EC) have been used. The parameters were converted from milligram per liter to milliequivalent per liter. The concentrations of the ions were interpreted and calculated from standard equations ″ Table 2″ and used in the assessment of the groundwater suitability in agricultural irrigation.

IV. Results And Discussion

The calculated parameters results are presented in ″ Table 3″ and the summary statistics of the indices used to evaluate the ground water for irrigation purposes are presented in ″ Table 4″. The following projections can be made based on the results:

The electrical conductivity is a powerful criterion to measure the salinity hazard to the crops. It conveys information about the soluble salts in the water samples and potential risk to the productivity of the crops. The higher values of the electrical conductivity the less the amount of water that is available to the crops. The EC values in this study ″Table 5″ indicated that 83.1% (54 samples) fall within the doubtful category; while 8 samples (12.31%) and 3 samples (4.62%) fall within the unsuitable and permissible categories, respectively.

Kelly`s ratio. Based on Kelly (1951) categorization scheme, Kelly`s ratio > 1 is considered unsuitable for irrigation purposes; whereas, samples of ratio < 1 are considered suitable for irrigation. In the studied samples, the range of Kelly`s ratio was between 0.14 and1.63 %. The lowest value was in sample numbered 23; while the highest one was in sample numbered 19. The majority of the collected samples fall within the permissible limit of < 1 and thus are considered suitable for the agricultural irrigation. Exception is made to samples numbered 10, 14, 19 and 23 ″Table 6″.

Sodium adsorption ratio is an important parameter to determine the suitability of the ground water for irrigation. This parameter gives a clear idea about the soil alkalinity. In this study, a total of 60 samples (92.31%) of the ground water samples were < 10 and fall within the excellent class ″ Table 7″. However, 7.69% (5 samples) fall within the good class.

Sodium percentage is one of the major parameters used to assess the suitability of ground water for irrigation purposes. High Soluble Sodium percentage in the ground water can stunt the plant growth and decrease the soil permeability (Joshi et al 2009). In this study, the Soluble Sodium percentage varied from 12.09 to 62.35 % with an average of 36.76%. According to the classification proposed by Todd 1995 ″Table 8″ 69.23% of the collected samples fall within the good class, while 27.69 % and 1.54% of the samples were within permissible and excellent classes respectively. Only one sample fall within the doubtful class

Permeability index of the soils can be affected by the long term use of the irrigation water when it contains high concentrations of salts. The values of the permeability index obtained in the present study are presented in ″ Table 9″ the values varied from 13.69 to 106.76 with an average of 47.66%. The highest value was in well numbered 39 and the lowest one in well numbered 22. Around 95.38% of the samples fall within the class II, 3.08% within the class I and 1.54% within the class III.

Magnesium ratio in the ground water is considered one of the important indexes in evaluating the quality agricultural water. Usually, calcium and magnesium sustain the equilibrium in most water types. When water Mg increases, the soil salinity increases; therefore, the crop yield is reduced. According to the classification proposed by Ayers and Westcot, (1985) ″Table 10″ 92.31% of the samples were less than 50%, except for samples numbered 19, 22, 33, 49 and 61.

Residual Sodium Carbonate (RSC), the ground water for irrigation purposes can be influenced by high levels of carbonate and bicarbonate. The classification for residual sodium carbonate was given by (Richard 1954). In the present study, all RSC values fall within the safe class ″ Table 11″ suggesting that all water samples are considered safe for agricultural irrigation.

V. Figures And Tables

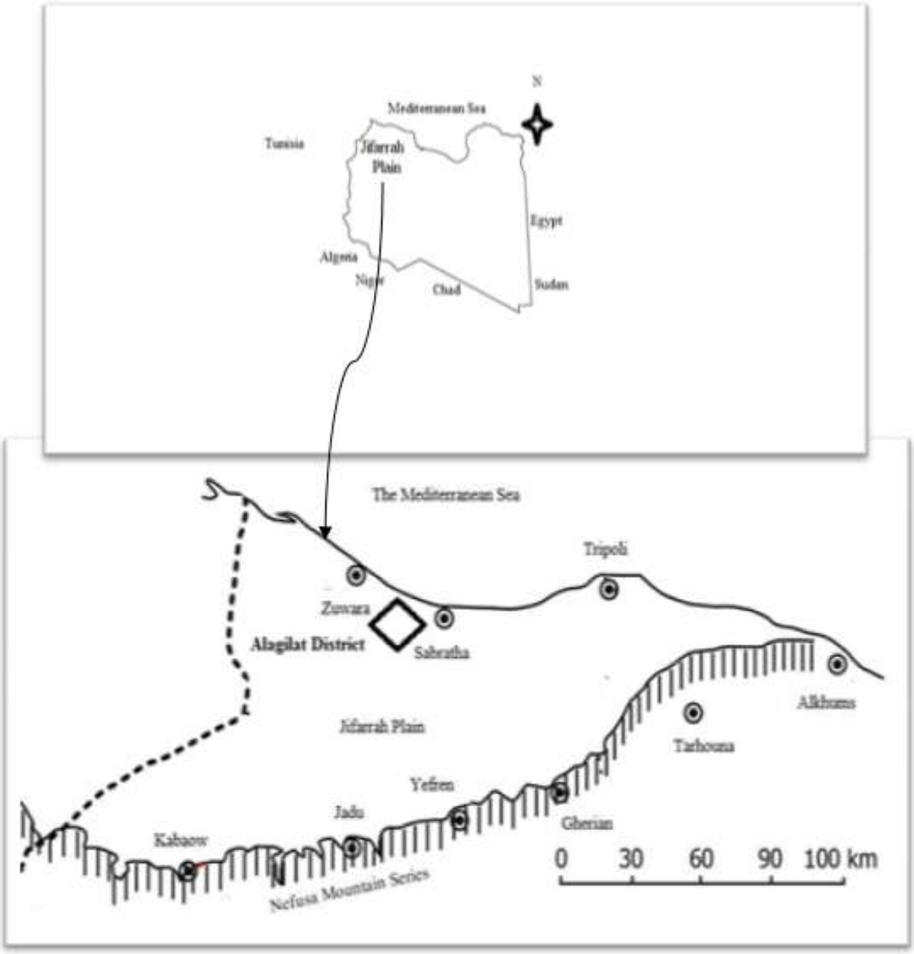

Fig1. Map of Jifarrah plain showing Alagilat area (study area)

Table .1 Standard Methods and Equipments used to analyze the Parameters

*Inductively coupled plasma optical emission spectrometry, **Ion chromatography

Parameter	Test method	equipment
Ca	EPA 6010C : 2007	ICP-OES*
Mg	EPA 6010C : 2007	ICP-OES
K	EPA 6010C : 2007	ICP-OES
Na	EPA 6010C : 2007	ICP-OES
Cl	UNI EN ISO 10304 – 1 : 2009	IC**
F	UNI EN ISO 10304 – 1 : 2009	IC
PO_4	UNI EN ISO 10304 – 1 : 2009	IC
SO_4	UNI EN ISO 10304 – 1 : 2009	IC
NO_3	UNI EN ISO 10304 – 1 : 2009	IC
EC	---	EC-meter model 470
pH	---	pH-meter model 370

Table.2 The equations used to calculate the irrigation induces

Index	Equation	Reference
Sodium adsorption ratio	$SAR = \frac{Na^{+}}{\sqrt{Ca^{2+} + Mg^{2+}}}$	Raghunath,1987
Kelly`s ratio	$KR = \frac{Na^{+}}{(Ca^{2+} + Mg^{2+})}$	Kelly,1963

Sodium percentage	$Na\% = \frac{(Na^{+} + K^{+})}{(Ca^{2+} + Mg^{2+} + Na^{+} + K^{+})} \times 100$	Todd,1995
Permeability index	$PI = \frac{(Na^{+} + HCO_3^{-})}{(Ca^{2+} + Mg^{2+} + Na^{+})} \times 100$	Doneen, 1964
Residual Sodium Carbonate	$RSC = [(CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})]$	Eaton,1950
Magnesium ratio	$Mg\,ratio = \frac{Mg^{2+}}{(Ca^{2+} + Mg^{2+})} \times 100$	Ayers & Westcot, 1985

The concentrations are expressed in terms of meq / l

Table.3 Calculated parameters indexes for irrigation water quality

Well no	MAR	Na%	KR(meq/l)	SAR(meq/l)	PI(meq/l)	RSC(meq/l)	EC(µs/cm)
1	38.50	35.37	0.53	3.89	49.03	-20.34	3670
2	43.50	29.08	0.40	3.77	37.11	-38.72	4880
3	38.86	29.01	0.40	3.11	40.38	-25.44	3700
4	33.95	24.42	0.32	2.98	32.66	-39.89	4550
5	40.49	35.34	0.52	4.59	43.77	-33.46	4550
6	30.46	21.20	0.26	2.41	29.84	-37.57	4080
7	42.35	34.17	0.51	3.65	47.88	-20.29	3450
8	7.81	53.31	0.94	4.44	72.78	-5.85	3030
9	3.66	47.07	0.70	5.39	51.20	-24.77	3730
10	37.08	58.01	1.36	7.01	72.43	-8.64	2530
11	30.86	27.70	0.37	3.15	36.81	-30.89	4000
12	39.75	32.87	0.48	3.87	43.00	-27.04	4030
13	43.02	26.75	0.36	3.61	32.65	-46.52	5030
14	6.04	58.32	1.19	6.55	72.90	-9.04	3650
15	47.73	44.67	0.80	6.80	55.00	-29.30	4650
16	42.49	40.91	0.67	3.45	65.48	-7.57	2430
17	41.73	47.98	0.90	3.73	82.13	-2.92	1540
18	45.53	41.46	0.69	4.38	62.91	-12.65	3070
19	90.96	62.35	1.63	15.42	68.70	-36.82	10680
20	42.50	33.50	0.49	3.20	52.13	-15.38	2730
21	38.21	32.47	0.47	3.37	45.01	-20.76	3220
22	97.89	12.09	1.37	3.10	13.69	-250.82	1380
23	35.90	35.34	0.53	3.43	49.25	-16.21	2790
24	33.00	36.26	0.55	3.00	50.75	-14.53	2550
25	25.49	33.14	0.48	3.34	43.76	-20.13	3020
26	31.76	31.63	0.45	3.95	39.85	-33.28	3940
27	39.14	24.57	0.32	3.16	31.70	-44.07	4130
28	29.32	32.15	0.46	3.93	40.63	-31.33	4000
29	29.80	31.91	0.46	4.35	38.77	-40.10	4670
30	26.52	26.32	0.35	3.22	33.90	-37.91	4110
31	25.99	26.95	0.36	3.49	37.89	-39.90	3110
32	48.51	45.54	0.81	5.72	65.84	-15.39	3330
33	61.57	50.63	0.98	10.16	54.42	-48.41	8860
34	35.82	32.37	0.46	3.65	43.37	-26.43	3680
35	33.37	39.62	0.64	4.32	57.37	-15.95	3360
36	36.01	33.60	0.49	3.65	45.53	-23.59	3550
37	31.47	35.03	0.52	3.53	46.41	-18.47	3180
38	37.93	38.51	0.61	3.71	58.13	-12.50	2830
39	6.33	55.56	1.21	3.58	106.76	0.66	1320

40	31.39	37.79	0.59	3.62	53.26	-13.80	2790
41	26.71	33.63	0.49	3.30	45.25	-18.51	2480
42	27.80	30.32	0.43	3.63	38.51	-31.87	3400
43	24.17	26.18	0.36	2.98	33.72	-33.22	3040
44	28.26	33.46	0.49	4.52	38.05	-38.71	3970
45	23.32	32.74	0.48	4.17	38.84	-34.74	3360
46	30.67	28.19	0.38	3.64	33.78	-41.31	3590
47	47.45	42.64	0.72	7.27	50.14	.43.72	4750
48	40.86	39.58	0.63	5.33	50.34	-28.65	4450
49	56.10	47.15	0.87	10.62	51.12	-68.02	7000
50	39.90	35.19	0.53	3.74	49.94	-19.24	2600
51	45.03	42.04	0.71	6.34	54.95	-30.68	4280
52	41.05	42.47	0.72	6.80	49.46	-38.44	4440
53	45.52	45.24	0.82	9.82	48.45	-67.86	7000
54	32.74	29.96	0.42	3.62	36.53	-34.05	3510
55	30.02	33.12	0.48	4.19	41.77	-32.41	3340
56	27.81	35.03	0.53	4.32	40.88	-30.44	3490
57	41.52	21.87	0.27	2.70	28.29	-44.85	3330
58	28.57	36.29	0.55	3.67	47.01	-18.13	2390
59	35.78	38.38	0.61	4.86	45.92	-27.90	3510
60	36.96	36.23	0.55	4.71	43.69	-31.98	3520
61	50.62	47.09	0.87	10.09	51.32	-61.50	6660
62	40.52	38.16	0.60	6.45	41.53	-54.25	5620
63	44.83	45.70	0.83	10.84	48.43	-80.67	7870
64	38.37	37.12	0.57	5.43	42.48	-40.42	4240
65	32.52	36.57	0.56	5.56	41.45	-44.45	4480

Table.4 Summary statistic of different indexes of the ground water

Index	minimum	average	maximum	SD
KR(meq/l)	0.14	0.6	1.63	0.26
Na%	12.09	36.76	62.35	9.42
SAR(meq/l)	2.41	4.84	15.42	2.39
PI(meq/l)	13.69	47.66	106.76	14.1
RSC(meq/l)	-250.82	-33.73	0.66	31.6
EC(µs/cm)	1320	3940.31	10680	1607.49
MAR	3.66	36.92	97.89	14.87

Table.5 Irrigation water quality based on electrical conductivity values

Category	Range	No of samples	% of samples
Excellent	< 250	Nil	Nil
Good	250 - 750	Nil	Nil
Permissible	750 - 2250	3	4.62
Doubtful	2250 - 5000	54	83.10
Unsuitable	> 5000	8	12.31

Table.6 classification of irrigation water based on Kelly's ratio

KR (me/l)	Class	No of samples	% of samples
< 1	Safe	60	92.31
> 1	Unsuitable	5	7.69

Table.7 Classification of irrigation water based on sodium adsorption ratio

SAR	Class	No of samples	% of samples

< 10	Excellent	60	92.31
10 - 18	Good	5	7.69
18 - 26	Fair	Nil	Nil
> 26	Poor	Nil	Nil

Table.8 Quality of irrigation water based on sodium percentage

SP	Class	No of samples	% of samples
< 20	Excellent	1	1.54
20 - 40	Good	45	69.23
40 - 60	Permissible	18	27.69
60 - 80	Doubtful	1	1.54
> 80	Unsuitable	Nil	Nil

Table.9 classification of irrigation water based on permeability index

PI (%)	Class	No of samples	% of samples
>75	I	62	95.38
25 - 75	II	2	3.08
>25	III	1	1.54

Table.10 classification of irrigation water based on Magnesium ratio

MR (%)	Class	No of samples	% of samples
> 50	Suitable	60	92.31
<50	unsuitable	5	7.69

Table.11 classification of irrigation water based on residual sodium carbonate

RSC(me/l)	Class	No of samples	% of samples
< 1.25	Safe	65	100
1.25 - 2.5	Marginal	Nil	Nil
> 2.5	Unsuitable	Nil	Nil

VI. Conclusion

Assessment of ground water quality in Alagilat area for agricultural irrigation was conducted based on different indices like RSC, PI, SP, SAR, KR, Mg ratio and EC. The analysis showed that these indices were complied with the recommended standards. More than 95% of the studied samples from spatially observed sites were suitable for irrigation purposes. However, for EC, 95.4% of the samples contained high concentrations of salts and, therefore, were considered unsafe for crop irrigation. This suggests that such ground water wells require special care and applying an alternative solution to mitigate the salination, the authors recommend the option of growing salt-tolerant plant species (hyper accumulators)

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References

[1]. Ayers, R.S and D.W., Westcot (1985). Water quality for agriculture FAO irrigation and drain. Paper No 29(1): 1-109.
[2]. Doneen LD (1964). Notes on Water Quality in Agriculture, Department of Water Scienceand Engineering, University of California, Water Science and Engineering, p.400
[3]. Eaton FM (1950). Significance of Carbonate in Irrigation Water, Soil Sci, 67: 112- 133
[4]. Joshi DM, Kumar A, Agrawal N (2009). Assessment of the Irrigation Water Quality of River Ganga in Haridwar District India.J. Chem. 2(2): 285 – 292.
[5]. Kelly WP (1963). Use of Saline irrigation Water, Soil Sci. 95(4): 355- 39.
[6]. Obiefuna, G.I. and D.M. Orazulike (2010). Assessment of groundwater quality of Yola for irrigation purposes, Water resources. J. Nigerian Assoc. Hydrology., 20(1): 32 - 52
[7]. Quddus, k.G. and M.W. Zaman(1996). Irrigation water quality in some villages of Meherpur in Bangladesh.J. Agric. Sci., 23(1): 51-57.
[8]. Railan, F. and J.B. Alam(2008). Assessment of ground water quality in sunamganj Bangladesh Iranian.J. Environ. Health Sci. Eng., 6(3): 155-166.
[9]. Raghunath HM (1987). Groundwater, 2^{nd} Ed. Wiley Eastern Ltd. New Delhi, India, pp. 344- 369.
[10]. Sarkar, A.A. and A.A Hassan (2006). Water quality assessment of a groundwater basin in Bangladesh for irrigation use.Pak.J. Biol.Sci., 9(9): 1677- 1684.

[11]. Shahidullah, S.M., M.A. Hakim, M.S. Alam and A.T.M. Shansuddha (2000). Assessment of groundwater quality in aselected area of Bangladesh. Pak.J.Biol.Sci., 3(2): 246- 249.
[12]. Todd DK (1995). Ground water Hydrology, John Wiley and Sons Publication, 3rd Ed, New York.
[13]. Talukder, M.S.U., S.M. Shirazi and U.K. Pual(1998). Suitability of groundwater for Irrigation at Kirimganj Upazila Kishoreganj. Progress Agric., 9: 107-112.
[14]. Wilcox LV (1955). Classification and Use of irrigation water, Washington: US Department of Agriculture, Circular No. 969, p.19
[15]. WHO (1996). Guidelines for drinking water quality, Recommendations, World Health Organization, Geneva, 1,pp 188.