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Impact Of Groundwater Quality On Soil Properties And Crop Production Under Khartoum State Condition

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ABSTRACT: The objective of this study was to evaluate the impact of ground water (wells) quality on soil properties and okra (Abelmoschusesculentus) productivity under Khartoum state conditions, Sudan. The experiment was organized in a complete randomized design with three replicates. Samples of groundwater and soils nearby the water source were taken from: Khartoum, Khartoum North and Omdurman. The measured parameters for both water and soil were K, Na, Ca, Mg, CO3, HCO3, SO4, pH and EC, as well as crop yield (kg/ha). Chemical analysis showed that the level of different constituents of ground water at the three locations was conforming to FAO standards for irrigation water except SAR which was found higher than the standard. On the other hand there were significant differences ($P < 0.05$) among them. Khartoum North recorded the highest values of pH, EC, HCO3 and SAR, while the lowest values of (SAR and EC) and (pH, HCO3 and SO4) recorded with Khartoum and Omdurman, respectively. The soil analysis revealed that the ground waters have noticeable effect on soil chemical properties. Whereas, Khartoum North revealed the highest values of pH and EC, while the lowest values of EC were recorded in Khartoum. The amounts of yield as collected from Khartoum, Khartoum North and Omdurman were 384, 288, 324 kg/ha respectively. The values of yield loss per unit of` salinity were found to be 71.52, 36.24 and 21.84 kg/ha/ds/m for Khartoum, Omdurman and Khartoum North, respectively. Hence, it was concluded that the groundwater in Khartoum state has slight variation in quality from location to location inside the state.

Keywords :groundwater, water quality, yield losses, soil properties

INTRODUCTION

The quality of groundwater is of paramount importance for irrigation purposes especially in arid regions. The water used for irrigation differs greatly in its quality, depending on the concentration and composition of the dissolved salts [1]. Water quality refers to the characteristics of water supply that influence its sustainability for specific use. Quality is defined by certain physical, chemical and biological characteristics [1]. Irrigation waters whether obtained from springs, diverted from streams, or pumped from wells, contain appreciable quantities of chemical substances in solution that may reduce crop yield and deteriorate soil fertility [2]. Scherer et al, (1996) reported that water quality for irrigation purposes is defined by its salt content, cation (calcium, magnesium) and anions (bicarbonates, carbonates, sulfate, and chloride). Total dissolve salts and sodium adsorption ratio (SAR) are the most important factors for irrigation quality evaluation. Generally the main categories of potential irrigation problems associated with water quality are salinity, permeability, ion toxicity [3]. Crop production in the arid and semi-arid regions depends on irrigated agriculture. The hot and dry climates of these regions require irrigation water which does not contain soluble salt in the amounts which have adverse effects on the soil and crops. Growth, yield, and quality reduction may occur through a decrease in the ability of crops to take up water from the soil solution and the destruction of soil structure [4], toxicity resulting from excessive concentration of certain ions, principally Na^+, Ca^{2+}, Mg^{2+}, $Cl^–$, $SO_4^{2–}$, and $HCO_3^–$ as well as nutritional imbalances [5]. The ground water aquifers of Sudan are either in a simple or complex form, according to their geological formation. There are six aquifers, two in the alluvial deposits, two in the Um Rawaba formation and two in the Nubian / Basalt formation. The Nubian basin occupies 28.15% of the country area. Its water is of high quality and suitable for human and animal consumption. The basin is shared with Egypt, Chad and Libya. While the major alluvial aquifers are seasonal streams (Khors), which the runoff of those streams does not exceed three months/year. The runoff during this period is substantial, and the aquifers are completely recharged after the rainy season. The alluvial deposits are characterized by high values of transitivity and storability figures. This study is conducted with the objective of evaluating the effect of groundwater quality on soil properties and crop productivity under Khartoum State condition.

MATERIALS AND METHODS

The soil and water samples were collected from three locations; Khartoum, (15°37'N and 32°3'E), Khartoum North (15°38'N and 32°38'E), and Omdurman, (15°39'N and 32°3'E), during the period April – June 2009. Soil and water samples were collected from the three different afore-mentioned locations. The water samples were collected from wells while the soil samples were collected by augering at three successive depths (0-10, 10-20 and 20-30 cm). All samples were analyzed chemically for Bicarbonate (HCO3), Carbonate and (CO3), Sulfate (SO4), Chloride (Cl), Sodium (Na), Potassium (K), Magnesium (Mg) Calcium (Ca), pH, Electrical conductivity (EC) and soil Organic Carbon (OC) and Sodium Adsorption Ratio (SAR). EC, pH, Cl, Na, Mg, Ca, K, SO4 and OC% were measured using the methods described by Page et al. (1999). Bicarbonate and carbonate (HCO3 and CO3) were quantified by titrating the samples with 0.05 normal sulfate acid (H2SO4). Sodium Adsorption Ratio (SAR) was estimated from the concentration of sodium, calcium and magnesium, using the following equation as described by Ayers and Westcott, (1994):

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}} \text{ --- --- (1)}$$

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Where
Na^+ is the concentration of sodium ions (meq/l),
Ca^{2+} the concentration of calcium ions (meq/l)
Mg^{2+} is the concentration of magnesium ions (meq/l).
Yield was estimated for each site by weighing the yield of 1square meter, which was selected randomly and replicated three times, using a sensitive balance, then the total average yield was determined in kg/ha. The loss of yield per unit increase in salinity was calculated using the following equation as stated by Maas and Hoffman (1977) :

$Y = 100 - b\,(EC_e - a)$ …………………………..(2)

Where
Y = relative crop yield
EC_e = salinity of the soil saturation extract in ds/m
a = salinity threshold value
b = yield loss per unit increase in salinity

RESULTS AND DISCUSION

Groundwater from different locations in Khartoum State was chemically analyzed for EC_w , SAR, Na, Cl, HCO3 and pH, and compared with the standard values of FAO for irrigation water as recommended by Ayers and Westcot (1994), (table 1). The quality was found consistent with standard of FAO. Whereas the above mentioned parameters were found within the levels: non, slight and moderate. On the other hand as shown in(table2) the comparison among the three sites, revealed that Khartoum North location has highly significant differences at $P< 0.05$ in content of EC_w, Na, Mg, HCO3, SAR and pH, while the highest values of Ca were observed in Khartoum location, and Cl and K were recorded in Omderman location.

Table 1 Khartoum State groundwater characteristics in comparison with FAO standard

Potential Irritation Problem	Units	FAO			Khartoum	Khartoum North	Omdurman
		Degree of restriction on use					
		None	Slight to Moderate	Severe			
Ec_w	dS/m	<0. 7	0. 7 – 3. 0	>3. 0	0.55	1.03	0.88
SAR (Ec_w in range (0-3))		>0. 7.	0. 7- 0. 2	<0. 2	0.7	2.1	1.7
Sodium (Na)	me/l	< 3	3-9	>9	1.2	3.9	3
Chloride (Cl)	me/l	<4	4-10	>10	3.7	4	6
Bicarbonate (HCO_3)	me/l	<1. 5	1. 5-8. 5	>8. 5	2.4	3.5	2
pH	Normal range 6. 5 – 8. 4				7.4	7.8	7.1

Table 2 comparison among the groundwater contents of the three sites

Site	Water quality parameters									
	pH	EC	Na	Mg	Ca	Cl	K	HCO_3	SO_4	SAR
Khartoum	7.4^b	0.55^c	1.2^c	1.8^b	3.5^a	3.7^c	0.07^b	2.7^b	7.85^a	0.7^c
Khartoum North	7.8^a	1.03^a	3.9^a	3.5^a	3.0^b	4.0^b	0.05^c	3.5^a	3.00^b	2.1^a
Omdurman	7.1^c	0.88^b	3.0^b	1.05^c	2.5^c	6.0^a	2.30^a	2.0^c	0.78^c	1.7^b
LSD	0.18	0.011	0.01	0.01	0.01	0.001	0.00001	0.001	0.01	0.001

Means with the same letters in the same column are not significantly different at $P \leq 0.05$.

As shown in figures (1a,b, 2c,d and 3e,f) the application of groundwater on the soil of three sites increased the levels of pH, EC, Na, Mg, Ca, HCO3, Cl, and SAR compared with the situation before groundwater was applied. On the other hand it is easily observed that the level of HCO3 in the soils was highly increased, and the soil content of organic Carbon was decreased in the three locations after groundwater was applied, this may be due to increasing in the soil salinity, which lead to decreasing the Carbon inputs by plants as stated by Lal (2001) and Setia et al. (2012). Dry and hot climatic zone are characterized by high evaporation which induces salt accumulation in the surface soil layers. Physical and chemical properties may be altered due to accumulation of such salts in soils, including soil structure, porosity and hydraulic conductivity [6].

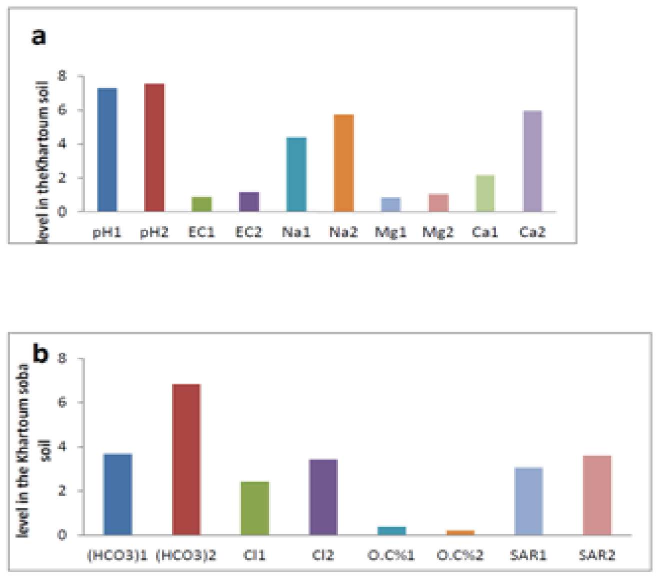

Fig. 1 (a and b) components of Khartoum soil befor[1] and after[2] applying Groundwater

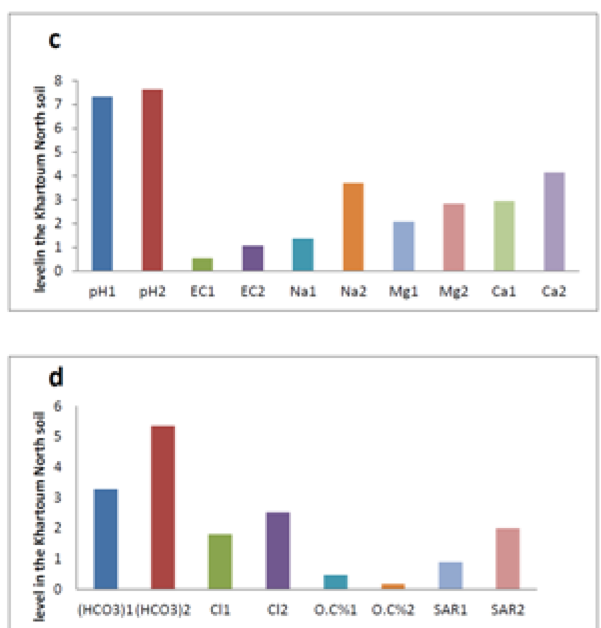

Fig. 2 (c and d) components of Khartoum North soil befor[1] and after[2] applying Groundwater

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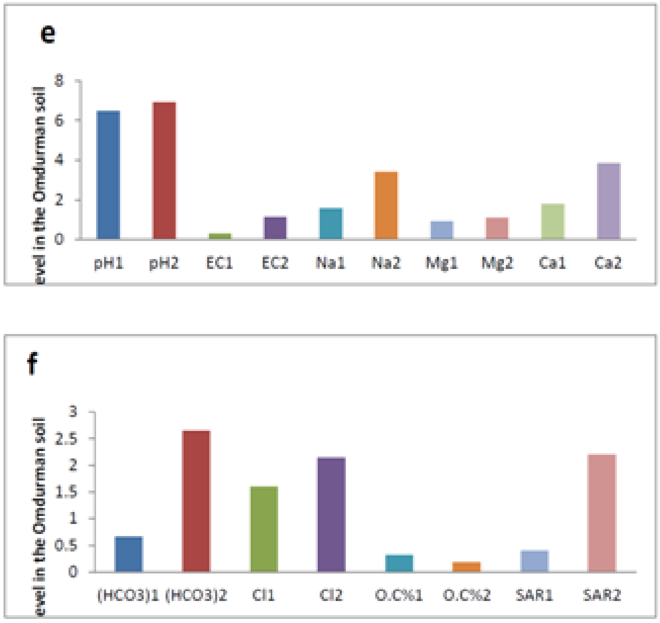

Fig. 3 (e and f) components of Omdurman soil befor[1] and after[2] applying Groundwater

The okra crop is cultivated in Khartoum state in wide areas, most of this areas irrigated by groundwater using surface method (short furrow). The yield in the studied areas is highly affected by salts content of ground water, whereas Khartoum North recorded the lowest values (288 kg/ha), followed by Omderman (324 kg/ha), while Khartoum revealed the highest values of okra yield (384 kg/ha), Figure 4. This result may be due to high content of salts in Khartoum North compared with Khartoum site. This result is supported by the finding of Maas and Hoffman (1977), who stated that “approximately yield decreased linearly as salinity increases”. From the equation (2) and by considering value of (a=3) according to Ayers and Westcott (1994), the values of yield loss per unit increase in salinity (b) are found to be 71.52, 36.24 and 21.84 kg/ha for Khartoum, Omdurman and Khartoum North, respectively.

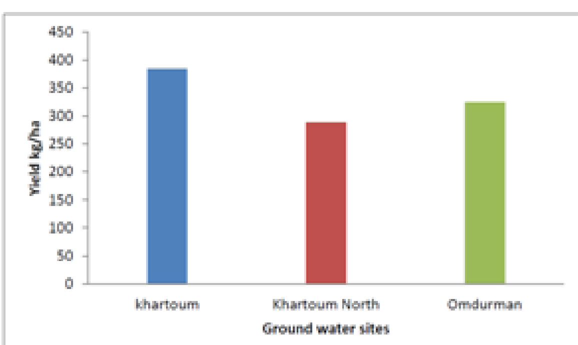

Figure 4 the yield of Okra crop in different sites in Khartoum state

CONCLUSION

1.The groundwater that collected from the different locations in Khartoum State varies slightly in quality with respect to irrigation purposes.
2.the quality of the three locations was found within the acceptable range as recommended by FAO standards for irrigation water.
3.Groundwater should be checked for quality before being used for irrigation purposes particularly if the soil is saline or the cultivated crop is sensitive to salinity.
4.Further studies is highly recommended

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