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Save Disposal of Wastewater in Irrigation and its Effect on Soil Properties under Khartoum Conditions

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***Abstract*— The objective of this study is to investigate the effect of disposal of wastewater in irrigation on soil properties. Samples of treated wastewater were analyzed for *pH, SAR, EC* in dS/m, while, *Na, Cl, NH_4-N, HCO_3, CO_3 and heavy metals* in mg/l. The soil samples were taken from three depths D_1(0-20), D_2 (20-40) and D_3 (40-60) and analyzed for fore mention parameters. The results showed that the concentration of fore mentioned parameters showed different scenarios with soil depth. On the other hand, the levels of fore mention parameters in the soil received wastewater for a long time were very high compared with that never received wastewater. This study concluded that reusing of wastewater in irrigation is a safe disposal and conserving water from pollution.**

***Keywords*— Wastewater, Irrigation, Soil Depth, pollution, Trace Elements**

I. INTRODUCTION

The treatment and reuse of the wastewater can remove a potential cause of environment**,** ground and surface water pollution and at the same time can help in solving the expected water scarcity (Eltoum, 2002). Municipal wastewater is one of the most readily available alternative water sources for mitigating the damage of the present natural resources (Pollice *et al.*, 2004).

Reuse of wastewater in irrigation could free a large amount of fresh water currently used for irrigation and make this resource available to meet the growing needs for fresh water of cities and towns in developing countries (Khouri *et al.*, 1994). Pescod (1992) Reported that use of wastewater in agriculture could be an important consideration when its disposal is being planned in arid and semi- arid regions. Singh *et al.*, (2004), considered that wastewater and sludge have both positive and negative impacts on agriculture as it is loaded with high levels of toxic heavy metals and pesticides, but also enriched with several useful ingredients such as Nitrogen, Phosphorus, and Potassium.

Mathan (1994), stated that raw sewage used for irrigation in India over a 15 year period was reported to have improved the soil structure. Sheikh et al., (1990) showed that irrigation with well-treated wastewater has no adversely effect on soil permeability, accumulation of heavy metals in soil. Moreover, reuse of wastewater, can improve the physical properties and agricultural productivity of soils, and its agricultural use provides an alternative to disposal options, such as incineration and land fill (Martens and Westermann, 1991). Land application of wastewater can help to remedy the trace elements deficiencies in soil (Logan and Chany, 1983). The physical properties of soil, such as dispersion of particles stability of aggregates, soil structure and permeability, are very sensitive to the type of exchangeable ions present in irrigation water (Pescod, 1992). The content of Nitogen, Phosphorus, and organic matter in the soil were increased after the utilization of sewage sludge (Wang *et al.*, 2002). Sludge has significant nutrient value and that its effect on soil physical properties can increase crop yield, (Logan and Chaney, 1983). Martens and Westemann (1991) stated that the addition of organic matter through successive sludge applications improves the physical properties and productivity of soils. Organic matter can increase soil porosity because of improved soil aggregation (Pagliai, 1981). Giller et al., (1989) found that an increasing amount of organic matter in soil caused by the heavy metal induced inhibition of microbial decomposition of soil organic matter. Environmental Protection Agency "EPA" (2002), stated that organic chemicals, when added to the soil may volatilize, decompose or be adsorbed. On the other hand the application of wastewater, for long time to soil, Leads to increase sodicity and salinity, and pose a threat to the future of crop production, (Ramirz *et al.*, 2002). In semiarid and arid regions, continued using wastewater in irrigation in the absence of leaching will Lead to an accumulation of salts in the soil profile to levels that will inhibit the growth of crops (EPA, 2002). Longtime use and poor practices of wastewater application to soil Lead to some negative effects on soils and crops (Cajuste et

al., 1991). Irrigation with wastewater for long-term resulted in high load of pollutants such as dissolved mineral salts, suspended solids, pesticides and other organism in soil (Filip et al., 1999).The heavy metal content in the soil repeatedly irrigated with treated water increased, because wastewater is a better source of it (Hayat et al., 2002). Ramirz et al., (2002) reported that when soil was amended with wastewater or drainage water concentration of total Mangenese, Murcury, Molybdenium, Calcium, Copper, and Chromium available and concentration of Lead, Cadmium, and Copper increase significantly with length of irrigation. Wastewater irrigation for 15 years increased soil nutrients and organic carbon content without increasing heavy metals to toxic levels, (Gupta et al., 1998). The effect of accumulation of heavy metals in soil is long lasting and even permanent (Ingwersen and Streck, 2005).

Irrigated agriculture is the largest consumer of water in the world. In areas with dry climates, irrigation water use is 50-85% of total water use (Hamdy, 2001). Where it is more difficult to meet the agricultural water demand with conventional water resources, wastewater reuse represents a viable option (Capra and Scicolone, 2004). Reuse of wastewater for irrigation is increasingly gaining popularity worldwide as one of the non-conventional water resources targeted to overcome the envisaged international water crises. In big towns such as Khartoum**,** substantial quantities of wastewater are usually dumped to waste around the town which may cause very serious pollution hazards. This problem increases day by day due to the increase of population and industrial sector in such towns. This study is concerned with seeking the potentialities of safe disposal of wastewater in irrigation with evaluating the prevalence of treated wastewater constituents in soil and its impact on soil chemical properties on long and short terms under Khartoum state conditions.

II. MATERIALS AND METHODS

The Experiment was conducted in the Demonstration Farm of the Faculty of Agriculture**,** University of Khartoum**,** at latitude 15.40° N and longitude 32.32° E in an area of 132 m^2 during two consecutive seasons.

The experiment data was analyzed statistically using Statistical Analysis System (SAS) package under windows.

The treated wastewater was transferred for treatment plant to experiment location using a tanker of 5000-gallon capacity. The soil samples were collected by auger of 10 cm size. The method of irrigation used was surface irrigation. On the other hand, composite water samples were taken from the effluent at the final treatment point from three locations at Soba sewage treatment plant, whereas standard method was followed in cleaning the bottles which used to collect the samples. The analysis was made to give in mg/l each of the following: Total Dissolved Solids (*TDS*)**,** Bicarbonate (HCO_3)**,** Chloride (*Cl*)**,** Ammonia and Nitrate (NH_4-N and NO_3-N)**,** Phosphate PO_4**,** Hardness and Heavy Metals. Also the analysis included potential of Hydrogen (pH)**,** Electrical Conductivity (*EC*) dS/m, and Sodium Adsorption Ratio (*SAR*)**.**

The soil samples were taken at depths of D_1 (0-20)**,** D_2 (20-40) and D_3 (40-60). The measured parameters were pH**,** EC_e**,** Nitrogen N%**,** Total Phosphorus TP%**,** Organic Carbon OC % and Trace Elements. The same analysis was made for the samples taken from two locations one of them irrigated with treated wastewater for several years and the other never received treated wastewater.

RESULTS

As shown in tables 1 and 2, the analysis of the treated wastewater under investigation showed that most of the water quality parameters lie within slight to moderate levels according to the international standard for irrigation water. Moreover, HCO_3, *Co* and *Cu* revealed higher values than the maximum permissible level recommended in irrigation water.

As presented in tables 3 and 4, the appearance of wastewater constituents in soil after application of this water during two successive seasons, were showed different appearance with depth. Therefore, EC_e, *pH, Na, Ca, Cl* and *P* increased with depth. While, *N, OC, Mg, Cu, Mn, Fe, Zn* and *Pb*, were found decrease with depth.

Table 5. shows the comparison between application of treated wastewater on soil for ten years (S_2) with one never received treated wastewater (S_1) under Khartoum Condition. The results showed that the application of treated wastewater for a long time increased *pH, Ec, N, OC, K, Na, Ca, Mg, Cl, Cu, Mn, Fe, Zn* and *Pb* in the soil. The results also reflected that Na and Cl concentrations increased sharply while no increase was detected for phosphorus (*P*).

Table 1: The Quality Parameters as Detected in Khartoum Treated Wastewater

Potential Irritation Problem	Units	Khartoum wastewater
EC_w	dS/m	0**.** 9
TDS	mg/l	580
SAR	-	7
Sodium (Na)	me/l	0**.** 5

Chloride (Cl)	me/l	7
Boron (B)	me/l	-
Nitrogen (NO_3-N)[3]	me/l	4.2
Bicarbonate (HCO_3)	me/l	9. 5
pH	-	8. 1

- Not detected in the tested samples

Table 2: Concentration of the Chemical Elements in Khartoum Treated Wastewater

Elements	**Symbol**	Khartoum wastewater
Aluminum	Al	-
Arsenic	As	-
Beryllium	Be	-
Calcium	Ca	41. 73
Cadmium	Cd	-
Cobalt	Co	0. 1
Chromium	Cr	0. 03
Copper	Cu	0. 4
Fluoride	F	-
Iron	Fe	0. 3
Lithium	Li	-
Magnesium	Mg	19. 5
Manganese	Mn	-
Molybdenum	Mo	-
Nickel	Ni	-
Lead	Pd	0. 05
Selenium	Se	-
Zinc	Zn	0. 3

- Not detected in the tested samples

Table 3: Effect of Using Treared Waster in Irrigation on Soil Properties

Quality Parameters	**Units**	**Soil Depths**			**LSD**
		D_1	D_2	D_3	
EC_e	ds/m	1	1.3	1.5	0.004
pH	-	8^b	8.04^a	8.04^a	
N	mg/kg soil	9.11^a	8.6^b	8^c	0.18
O.C.	%	0.15^a	0.13^b	0.11^c	0.002
Na	me/l	6.41^c	6.67^b	10.94^a	0.016

Ca	me/l	2.5^{c}	2.55^{b}	2.56^{a}	0.018
Mg	me/l	1.44^{a}	1.28^{b}	1.21^{c}	0.017
Cl	mg/l	1.86^{c}	1.91^{b}	1.93^{a}	0.0065
HCO_3	mg/l	0.08^{a}	0.068^{b}	0.068^{b}	0.0019
P	%	0.016^{c}	0.018^{b}	0.019^{a}	0.00007

The means followed by the same letters in the same row are not significantly different at P≤0.05.

Table4: The Accumulation of Trace Elements in Soil after using Treated Wastewater

Quality Parameters	**Units**	**Soil Depths**			**LSD**
		D_1	D_2	D_3	
Cu	mg/l	0.06^{a}	0.054^{b}	0.053^{c}	0.00017
Fe	mg/l	0.181^{a}	0.177^{b}	0.172^{c}	0.0005
Zn	mg/l	0.082^{a}	0.079^{b}	0.077^{c}	0.00066
Mn	mg/l	0.09^{a}	0.08^{b}	0.07^{c}	0.00019
Pb	mg/l	0.11^{a}	0.09^{b}	0.08^{c}	0.00018
Co	mg/l	0.08^{a}	0.07^{b}	0.06^{c}	0.0004

The means followed by the same letters in the same row are not significantly different at P≤0.05.

Table 5: Long term (Ten Years) Effect of Using Treated Wastewater in Irrigation on Soil Chemical Properties

	S1*	**S2****
pH	8. 6	9. 13
Ec *dS/m*	2. 87	4. 46
N *mg/l*	3	8
OC *%*	0. 37	0. 55
P *%*	0. 10	0. 10
K *me/l*	0. 28	0. 513
Na *me/l*	65. 89	135. 86
Ca *me/l*	12	12. 5
Mg *me/l*	6. 5	8
Cl *me/l*	69. 85	115. 98
Fe *mg/l*	1. 22	1. 37
Cu *mg/l*	0. 70	0. 72
Zn *mg/l*	0. 28	0. 74
Mn *mg/l*	0. 5	0. 79
Pb *mg/l*	0. 42	0. 48

***S_1** soil which has not been subjected to irrigation by treated wastewater.
****S_2** soil which has been subjected to irrigation by treated wastewater for ten years.

III. DISCUSSION

According to results presented in tables 1 and 2, Khartoum State's treated wastewater can be accepted as suitable water for irrigation purposes, according to some international standards, but under strict supervision and effective monitoring system. The

increasing of EC_e, *pH, Na, Ca, Cl* and *P* with soil depth as shown in tables 3 and 4, may due to the mobility behavior of some contains and anions inside the soil such chlorine, this finding is supported by that of Jamieson *et al*,.(2002). It well documented that salinity increase with increasing in soil depth, and may also be due to the effect of leaching of some cations and anions (Scott *et al.,* 2000). McGrath *et al.,* (1994) stated that due to the high bicarbonate content and presence of some minerals mainly Na, and Ca, which tend to accumulate in the soil and increase its pH. Conversely, the concentration of *N, OC, Mg, Cu, Mn, Fe, Zn* and *Pb* were decreased with depth, this results supported by the finding of Luo *et al.,* (2004) who found that highest concentration of some nutrient elements near the soil surface. Also stated that the concentration of *Mg* and *K* decreased markedly with soil depth. The concentrations of *Cu, Fe, Zn, Mn, Pb* and *Co* tended to decrease with increase in depth. This finding agrees with that of McGrath *et al.,* (1994) and Lavado *et al.,* (1999) who showed that trace elements tend to accumulate in the soil surface and may also be due to the fact that the mobility of trace elements in the soil is relatively low and is distributed laterally (Scancar *et al.,* 2000).

The results of using wastewater for long time as explained in table 5 showed increasing in EC_e, *pH, , N, OC, K, Na, Ca, Mg, Cl, Cu, Mn, Fe, Zn* and *Pb* in the soil. The present result is expected, because wastewater has high contents of trace elements and heavy metals as well as nutrients. This agreed with the findings of EPA (1996), Mendoza et al.(1996), Filip *et al.*, (1999), Hayat et al. (2002), Ramirz *et al.,* (2002) and Abd elsabour (2003).

IV. CONCLUSION

With reference to some international standard for irrigation, treated can be used for irrigation purposes with effective monitoring system. Moreover, using this source of water in irrigation according the obtained results is the safe disposal than to be discharged in water course like River Nile. As well as, wastewater should be viewed as a resource which must be recovered and added to the water budget than to be lifted pollute the environment.

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