EFFECT OF MUNICIPAL SEWAGE EFFLUENT ON SOIL AND CROPS CULTIVATED ON A HYPER-ARID ZONE SANDY SOIL

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ABSTRACT
The effects of sewage effluent from Sebha Municipal Area in the Fezzan region of Libya on certain physicochemical properties of a hyper-arid zone sandy soil and growth of two plants were studied. The soil had been treated daily with 25, 50, 75 and 100% effluent; and barley (Hordeum vulgare) and broad beans (Vicia faba) had been grown on the soils in pots. Soil samples were analysed for water-soluble salts, electrical conductivity, cation exchange capacity, pH, organic matter, sodium, potassium and phosphorus. At all the concentrations of effluent used there was a significant increase in all the soil properties tested. The greatest changes were observed with 100% effluent. The soils supporting crops were found to have lower concentrations of nutrients than those without crops. There was an increase in dry matter production by plants grown in effluent treated soils. The results indicate that sewage effluent could be considered as one of the possible and alternate sources of irrigation water.

Keywords: *municipal sewage effluent, irrigation, hyper-arid zone, sandy soil*

INTRODUCTION

The application of sewage sludge and effluents on agricultural soils is increasingly receiving attention (Harivandi, 1982; Jiries, 2001; Arar, 1991). This has become an important routine of urban and industrial wastes disposal programmes with substantial ecological and recreational benefits (Day *et al*., 1972; Gorden *et al*., 1975; D'Itri *et al*., 1981; FAO, 1992; Strauss, 2000).
The use of sewage water for irrigation is a positive way to dispose off sewage. Such large volumes of water in a country with persistent droughts and unreliable rainfall can be of great agronomic and economic importance. Irrigation with sewage water can increase water supply for alternative use. The utilization of sewage water also contributes to cleaning of the environment, as the water is not discharged into water bodies that could otherwise get polluted. In addition to these direct economic benefits that conserve natural resources, this water contains a lot of nutrients that can serve as an alternative source to chemical fertilizers which are expensive (FAO, 1992; Avemelech, 1993). It has been estimated that typical wastewater from domestic sources could supply all the nutrients that are normally required for agricultural crop production (FAO, 1992).

Many workers have monitored the effects of sewage effluents on the chemical properties of soils, the germination of seeds and growth and development of plants (Bole and Bell, 1978; Feigin *et al*., 1979; El-Nennah and El-Kobbia, 1983; Hillel *et al*., 1986; Siebe, 1995; Emongor *et al*., 2005; Aganga *et al*., 2005). Other workers have reported significant effects of various industrial and sewage effluents on the chemical composition of different soils and the germination of seeds and growth of different crop plants (Ajmal and Khan, 1984; Ajmal *et al.,* 1984; Aganga *et al*., 2005). The suitability of soils for receiving waste waters without deterioration varies widely, depending on certain properties of the soil such as their infiltration capacity, permeability, cation and anion exchange capacities, water holding capacity and texture (Schneider and Erickson, 1972; Brady and Weil, 1999). In hyper-arid Fezzan region of Libya (UNESCO, 1977) in the central sahara desert where groundwater is the only natural water resource available, increasing water demand has necessitated reusing treated municipal waste water for irrigation of sandy soils. This study was therefore designed to assess the effects of sewage effluent on a hyper-arid soil and two cultivated crops in the central sahara.

MATERIALS AND METHODS

Sewage Effluent and Soil Characterisation

The sewage effluent used for the study was obtained from the Sebha Municipal Waste Treatment Plant located at the outskirts of Sebha city. The wastewater resources originate from mainly household activities, as very limited industrial activities exist in the municipality. The effluent was analysed for some physicochemical properties based on standard methods (Standard Methods for the Examination of Water and Wastewater, 1975). Table 1 presents the results of the parameters tested.

The soil used in this study was collected by gathering samples from the surface layer (0-15 cm) of uncultivated fields around the treatment plant. The soil was air-dried and passed through a 2-mm plastic sieve to remove rocks and other large particles. A representative sub-sample of the soil was used for characterisation and preparation for a pot-culture experiment. Soil pH and electrical conductivity were measured in deionised water using a 1:1 (w:v) soil:solution ratio and $CaCO_3$ content was measured by the standard HCl neutralisation test (Jackson, 1974). Organic matter in the soils was determined by a Walkley-Black procedure (Nelson and Sommers, 1982). Soil texture was determined by the pipette method (Kilmer and Alexander, 1949), and cation exchange capacity (CEC) was determined following the method of Rhoades (1982). Sodium and potassium concentrations were determined by flame photometry after extracting with 1M ammonium acetate solution (pH=7). Some physico-chemical properties of the soil are presented in Table 2.

Pot-culture experiment

Pot experiments were conducted to assess the effect of the sewage effluent on the chemical changes in the soil with diluted and undiluted effluent after cultivation and without cultivation. Two kilograms of air-dried soil was put into each of 30 pots, 18 cm in diameter and 16 cm high. The soils were irrigated daily with 100 ml of 25%, 50%, 75% and 100% treated sewage effluent. Control pots were similarly irrigated with distilled water. Seeds of broad beans (*Vicia faba*) and barley (*Hordeum vulgare*) were sown in each pot. After germination, the pots were thinned out to three seedlings per pot. One set of pots was left without plants for each concentration to monitor the effect of irrigation on soil alone. The experiment was a completely randomised design with three replications.

The plants were harvested at soil level 50 days after planting, and the shoots were washed with deionised water, dried in an oven at $70^{o}C$ for 24 h and weighed for dry matter determination. The dried samples were ground and digested in a mixture of nitric and perchloric acids. The soil from the pots were air-dried and analysed for various parameters.

Statistical treatment of data

Analysis of variance (ANOVA) and Duncans multiple range test (LSD) were carried out on soil properties in the treated soils to test for significant variation between the treatment pots. Data on dry matter production was analysed by t-test. All the statistical tests were carried out using the Statgraphics Plus Statistical Package version 6.0.

RESULTS AND DISCUSSION

Effects of effluent treatment on pot soils

Some characteristics of the effluent and soil used in this study are presented in Tables 1 and 2 respectively.

Table 1: Some Characteristics of the Sewage Effluent used in the experiment

pH	6.93
TDS (mg l^{-1})	858
Mg^{2+} (mg l^{-1})	18.24
Ca^{2+} (mg l^{-1})	51.2
Cl^{-} (mg l^{-1})	205.3
SO_4^{2-} (mg l^{-1})	1.60
EC (mmhos cm^{-1})	2.5
Organic P (mg l^{-1})	1.45
Total P (mg l^{-1})	2.02
Hydrolyzable P (mg l^{-1})	1.05

Table 2: Some physico-chemical properties of the experimental soil

Soil Texture	Sandy
pH (1:1 H_2O)	8.13
Organic Matter (%)	0.19
CEC meq $100g^{-1}$	2.38
EC mhos cm^{-1}	0.99
CaCO3 (%)	0.26
Clay (%)	3.2
Silt (%)	2.69
Sand (%)	94.11

The effluent was colourless and had low Biological Oxygen Demand (BOD). The effects of the different dilutions (0, 25, 50, 75 and 100%) of the effluent on certain chemical properties of the pot soils after 50 days are shown in Table 3. The results of the study indicated that the application of effluent to soil had significant effects on all parameters tested. There was a significant increase in the water soluble salts ($P < 0.001$), pH ($P < 0.001$), electrical conductivity ($P < 0.001$), cation exchange capacity ($P < 0.001$), organic matter ($P < 0.001$), ammoniun acetate (pH=7) extractable sodium and potassium ($P < 0.001$) The greatest changes in the soil composition were observed when the soil was irrigated with 100% of the effluent followed by 75, 50 and 25%. The pot soils supporting beans and barley plants irrigated with the various effluent concentrations were also analysed and the results presented in Table 4. The concentrations of the tested parameters increased significantly ($P < 0.001$) with increasing effluent concentration, but the nutrients were lower in the soils supporting these plants as compared to the pots without plants irrigated with the same effluent concentrations

Table 3: Effects of Different Dilutions of Sewage Effluent on Certain Properties of Pot Soils

Treatment (% Effluent)	PH (1: 1 H_2O)	CEC (meq 100 g^{-1})	Soluble Salts (mg l^{-1})	EC (mmhos cm^{-1})	Organic matter (%)	Sodium (μg g^{-1})	Potassium (μg g^{-1})	Total P (μg g^{-1})
0	7.83	2.45	550.4	0.86	0.188	168.2	191.1	93.34
25	8.04	2.60	716.8	1.12	0.196	228.0	213.1	95.42
50	8.05	3.14	787.2	1.23	0.215	241.8	207.1	98.59
75	8.07	3.65	972.8	1.52	0.221	235.6	213.3	98.70
100	8.07	3.92	1068.8	1.67	0.359	295.4	229.0	111.87

Table 4: Effects of Different Dilutions of Sewage Effluent on Certain Properties of Pot Soils Supporting Different Crops

Treatment (% Effluent)	pH (1: 1 H_2O)		CEC (meq 100 g^{-1})		Soluble Salts (mg l^{-1})		EC (mmhos cm^{-1})		Organic matter (%)		Sodium (μg g^{-1})		Potassium (μg g^{-1})		Total P (μg g^{-1})	
	Beans	Barley	Beans	Barley	Beans	Barley	Beans	Barley	Beans	Barley	Beans	Barley	Beans	Barley	Beans	Barley
0	7.78	7.82	2.08	1.81	512.0	537.6	0.80	0.84	0.188	0.194	46.6	61.1	164.5	159.6	105.0	100.0
25	7.91	8.03	2.11	1.88	582.4	595.2	0.91	0.93	0.196	0.208	94.5	79.4	173.1	153.9	115.2	109.6
50	8.00	8.09	2.30	1.99	633.6	672.0	0.99	1.05	0.215	0.209	103.9	124.7	171.9	166.4	118.9	110.2
75	8.02	8.20	3.11	2.78	697.6	755.2	1.09	1.18	0.237	0.330	175.7	157.5	182.4	178.7	114.6	111.1
100	8.04	8.23	3.53	3.09	736.0	832.0	1.15	1.30	0.378	0.331	184.5	171.3	194.6	165.2	121.9	112.1

These results indicate uptake of water-soluble salts and available nutrients from the effluents, through the soil by plants. Similar results have been reported by other authors (Igbounamba, 1972; Ajmal and Khan, 1984; Emongor *et al*., 2005).

The average dry matter production is presented in Table 5. Shoot weight was considered as a measure of dry matter production in this study. The results indicate that plants grown in effluent irrigated soil produced significantly higher ($P < 0.001$) dry matter yield than in the control soil. The highest concentration of effluent treatment produced the highest dry matter per pot for both crops. *Vicia faba* gave significantly ($P < 0.001$) higher shoot weight than *Hordeum vulgare* (Table 5). The increase in dry matter could be attributed to the nutrients contained in the effluent.

Table 5: Comparison of Dry Matter Production by Beans and Barley Shoots

Treatment	Shoot weight (g)	
(% Effluent)	Beans	Barley
0	0.83*	0.32
25	1.11*	0.55
50	1.25*	0.66
75	1.79*	0.86
100	2.46*	0.91

** Indicates significantly higher value (P < 0.001)*

Data illustrating the relationship between effluent concentration and dry matter is presented in Fig. 1. The shoot of both plants showed linear increase in weight as the effluent concentration increased. For Beans, the equation was $y=0.0158x + 0.6984$ with r^2 of 0.8396; and for Barley the equation was $y=0.0059x + 0.3629$ with r^2 of 0.9232.

Considering the results of this study sewage effluent could be considered one of the possible and alternate sources of irrigation water. But the accumulation of heavy metals and their uptake by plants should be considered, although in this study no symptoms of toxicity have appeared on the plants within the period of investigation.

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