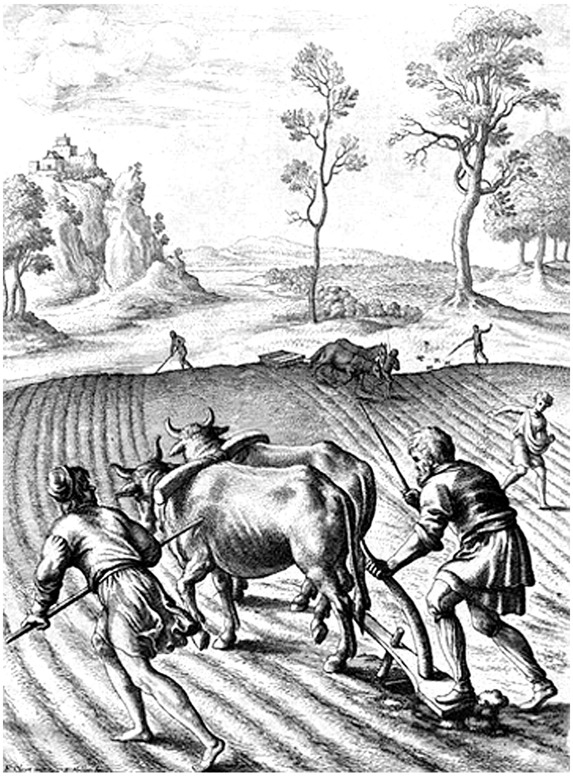
ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY



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Journal of Agronomy 4 (4): 345-348, 2005
ISSN 1812-5379

Evaluation of Effluent Quality Used for Irrigation of Vegetable Production in Different Districts of Potowar, Pakistan

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Abstract: A study was conducted in different districts of Potowar region to evaluate the quality of sewage for irrigation purposes and heavy metal contents in sewage water. Sewage samples were collected from 25 sewage irrigated farms around Rawalpindi, Attock and Abotabad districts. Electrical conductivity of the samples ranged from 0.55-2.36 dS m^{-1}. Sixty percent of the samples did not pose salinity hazard while forty percent were marginally fit for irrigation. Sodium adsorption ratio ranged from 0.24 to 4.36 showing that all the samples were low in Na contents. RSC varied from 0.0-8.1 mmol L^{-1} in the sewage samples under study; 59% of the samples had < 2.0 mmol L^{-1} of RSC showing that sewage represented by these samples had no risk of $NaHCO_3$ hazard when applied to soils. Chloride contents in the samples were in the range of 0.5 to 4.7 mmol L^{-1} and were within safe limits. Zn and Pb contents in the sewage of various locations were found within safe limits (< 2.0 and 5.0 mg L^{-1}, respectively) while Cu, Cd, Ni and Cr concentrations were found to exceed the maximum permissible limits. The effluent of areas under investigation are mixture of both domestic and industrial wastewater, high levels of HCO_3^- from washing soaps and detergents and excess of heavy metals from different industrial sources were present in the effluent. Therefore, sewage irrigation may cause deterioration of soil quality by causing salinity and introducing excessive contents of HCO_3^- in soils and poses health hazards by increasing heavy metal contents in vegetables and crops.

Key words: Effluent, irrigation, sewage, heavy metals

INTRODUCTION

Effluent irrigation has been practiced for centuries throughout the world[1]. It provides farmers with a nutrient enriched water supply and society with a reliable and inexpensive system for wastewater treatment and disposal[2]. Vegetable crops are often grown under sewage effluent irrigation. Normally domestic sewage contains 99.9% water and 0.1 suspended, colloidal and dissolved solids of organic and inorganic nature[3]. About 70% of the impurities are organic and include proteins and urea, sugars, starches and cellulose, soap, cooking oil and greases[4]. Dissolved salts in the form of ions such as Na^+, K^+, Ca^{++}, Mg^+, NH_4^-, Cl^-, NO_3^-, HCO_3^-, SO_4^{2-} and PO_4^{2-} are main inorganic constituents of sewage and other wastewaters besides some other metallic contaminants like Cd, Ni, Cr, Cu and Zn[5]. Crops are both irrigated and fertilized by the water and nutrients in sewage. The average concentrations of Nitrogen, Phosphorus and Potassium in Indian sewage is estimated as 60, 20 and 40 mg L^{-1}, respectively sewage irrigation can supply all or even more Nitrogen, Phosphorus and Potassium also valuable micronutrients than what the crops require[3].

Many advantages from the use of sewage on cropped land have been reported in the literature. According to USDA[6], sewage has value both as a fertilizer and as a soil conditioner. It may supply large portion of the nitrogen required for crop growth it increases cations exchange capacity of soil and thus its capacity to retain nutrients[7]. It can provide substantial amount of phosphorus[8] and can be a good source of micronutrients (Fe, Zn, Mn, Cu) for plants[9]. Many researchers[10,11] have reported increased in crop yields due to sewage applications. Increased crop production from incorporation of sludge into the soil is considered due to improved soil fertility, as well as increased soil aeration, permeability, water retention and water infiltration, better aggregation and less surface crusting. Increased water retention is especially noted for sandy soils. Improvement in the soil physical properties is due to organic matter of the sewage.

Although sewage has a great fertilizing value and causes higher yield of crops by increasing soil fertility and water availability, yet it may be harmful for plants and animals if it contains toxic levels of heavy metals or excessive soluble salts etc. Qadir *et al.*[12], revealed that

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levels of Cu ions in the effluent irrigated vegetable and soils were higher than their respective permissible limits, which could induce severe health effects in human beings. According to Ahmad *et al.*[13], adverse effect of the use of sewage effluent was the increase in total soluble salts and Sodium Adsorption Ratio (SAR), in soil. Since not much work has been done in Potowar region to study the quality of sewage irrigation. The objectives of this study were to know; (I) Irrigation quality of sewage (ii) Status of heavy metals contents in sewage water used for irrigation.

MATERIALS AND METHODS

To evaluate the quality of sewage or irrigation purpose and heavy metals contents in sewage water, 25 sewage irrigated farms (Table 1) were surveyed around Rawalpindi, Attock and Abotabad districts during 2004-2005.

Sewage samples: The sewage at a particular site was sampled from the point where it was being supplied to the field. Three samples from each site were collected in polyethylene bags and the composite sample was analyzed for different chemical properties.

Analytical procedures

Effluent analysis: Quality of sewage for the purpose of irrigation was assessed on the basis of (a) total soluble salts to check salinity hazard, (b) RSC and SAR to check sodium hazard and (c) chloride and heavy metal contents to check their toxicity levels. Sewage samples were analyzed according to the methods described by US Salinity Lab Staff[14] except heavy metals determination.

Total soluble salts: Total soluble salts were assessed by measuring electrical conductivity of the sewage directly by conductivity meter at 25°C.

Soluble cations and anions

Soluble calcium plus magnesium: These were determined by titrating the sample with 0.01N EDTA in the presence of NH_4Cl/NH_4OH buffer solution using Eriochrome Black T indicator.

Calcium: Calcium was determined by titrating the sample with 0.01N EDTA in the presence of 0.04 N NaOH using ammonium purpurate as indicator.

Magnesium: Magnesium was found by subtracting the calcium from calcium plus magnesium.

Carbonate and bicarbonate: Carbonate and bicarbonate were determined by titrating the sample with 0.1 N H_2SO_4 using phenolphthalene and methyl orange as indicators, respectively.

Chloride: Chlorides were determined by titrating the sample with 0.05 N $AgNO_3$ solution using K_2CrO_4 as an indictor.

Sodium Adsorption Ratio (SAR): SAR was calculated by

$$SAR = \frac{Na}{\sqrt{Ca + Mg/2}}$$

Residual Sodium Carbonate (RSC): RSC was calculated by:

$$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

Heavy metals: The sewage samples were filtered through Whatman No. 42 filter paper. The filtrates were analyzed by atomic absorption spectrophotometer[15].

RESULTS AND DISCUSSION

The data with respect to different irrigation quality parameters that electrical conductivity of the samples ranged from 0.55-2.36 dS m^{-1}. According to the guide lines given by Muhammad[16], 60% of the samples did not pose salinity hazard (EC < 1.5 dS m^{-1}) while 40% (with EC from 1.5 to 2.36 dS m^{-1}) were marginally fit for irrigation. Sodium adsorption ratio ranged from 0.24 to 4.36 showing that all the samples were low in Na contents hence, there was no risk of sodium hazard from irrigation with such type of waste water. Residual Sodium Carbonate varied from 0.0-8.1 mmol L^{-1} in the sewage samples under study; 59% of the samples had < 2.0 mmol L^{-1} of RSC which showed that the sewage represented by these samples had no risk of sodium bicarbonate hazard when applied to soils. Six percent of the total samples were marginally suitable for irrigation (RSC 2-4 mmol L^{-1}) and 35% of the samples were unsuitable as they contained > 4.0-8.1 mmol L^{-1} of RSC[16]. Chloride contents in the samples were in the range of 0.5 to 4.7 mmol L^{-1} and were within safe limits[17].

From the data it is observed that contents of different heavy metal were in the range of Zn (0.43-0.83), Cu (0.21-0.84), Cd (0.012-0.046), Pb (0.24-0.84), Ni (0.27-0.45) and Cr (0.62-1.08) mg L^{-1}. According to the criteria by FAO[18] for toxicity of heavy metals, Zn and Pb contents in the sewage of various locations were found within safe limits (< 2.0 and 5.0 mg L^{-1}, respectively) while Cu, Cd, Ni and Cr concentrations were found to exceed the maximum permissible limits of 0.20, 0.01, 0.2 and 0.10 mg L^{-1}, respectively.

Table 1: Irrigation quality parameters of sewage from different locations[a]

Locations	EC (dS m^{-1})	CO_3 (mmol L^{-1})	HCO_3 (mmol L^{-1})	CI (mmol L^{-1})	Ca+Mg L^{-1}(mmol L^{-1})	RSC (mmol)	SAR
District Rawalpindi							
Site I	2.20	Nil	16.5	3.8	10.8	5.7	3.50
Site II	2.36	Nil	16.8	4.7	11.5	5.3	3.00
Site III	1.52	2.5	9.0	3.4	10.5	1.0	1.40
Site IV	2.13	Nil	18.5	2.30	10.5	8.1	4.36
District Abotabad							
Site I	0.65	0.4	2.8	3.3	3.4	Nil	0.24
Site II	0.55	0.6	4.3	2.5	4.9	Nil	0.35
Site III	0.64	0.4	2.3	3.5	3.5	Nil	1.00
District Attock							
Site I	0.67	0.7	4.0	4.4	5.6	Nil	1.50
Site II	0.81	3.2	12	5.1	7.1	8.1	2.50
Site III	0.79	3.0	10.2	4.5	7.0	6.2	2.00

[a]Average of three samples

Table 2: Heavy metal contents in sewage of different locations[a]

Locations	Zn (mg L^{-1})	Cu (mg L^{-1})	Cd (mg L^{-1})	Pb (mg L^{-1})	Ni (mg L^{-1})	Cr (mg L^{-1})
District Rawalpindi						
Site I	0.62	0.58	0.021	0.84	0.45	1.08
Site II	0.83	0.40	0.026	0.38	0.39	0.99
Site III	0.59	0.37	0.022	0.32	0.43	1.04
Site IV	0.83	0.62	0.031	0.24	0.41	0.84
District Abotabad						
Site I	0.43	0.33	0.012	0.36	0.38	0.89
Site II	0.62	0.21	0.029	0.25	0.44	1.02
Site III	0.59	0.49	0.034	0.42	0.39	0.92
District Attock						
Site I	0.52	0.62	0.032	0.73	0.33	0.62
Site II	0.46	0.69	0.046	0.59	0.27	0.69
Site III	0.64	0.84	0.024	0.61	0.41	0.84
FAO critical levels[b]	2.00	0.20	0.01	5.00	0.20	0.10

[a]Average of three samples [b]FAO (1985)

From the results regarding irrigation quality of sewage from different areas, it is assessed that about 50% of the sewage samples were not suitable for irrigation either due to salinity or bicarbonate hazards. Moreover, all of these samples were found to have higher levels of heavy metals like Cu, Cd, Ni and Cr, which exceeded the maximum permissible limits of these metals as recommended[18]. Since sewage of our towns are mixture of both domestic and industrial wastewater, high levels of HCO_3^- from washing soaps and detergents and excess of heavy metals from different industrial sources could be expected, which is confirmed by the present study. Therefore, sewage irrigation may cause deterioration of soil quality by causing salinity and introducing excessive contents of bicarbonate in soils and pose health hazards by increasing heavy metals contents in vegetables and crops. The farmers of our country are generally not aware of the bad quality of sewage and its effects on soils and crops when used for irrigation purpose. Even if they have such idea, they may not hesitate to use such irrigation because it is free most of the time. In this way, it is possible that such farmers may waste their precious land in the long run. It is therefore, recommended that sewage samples be got analyzed off and on to verify and check the quality of sewage for irrigation purpose.

ACKNOWLEDGMENT

We are obliged to the Soil Science and SWC, University of Arid Agriculture, Rawalpindi for supporting this experimental study. Thanks are also extended to the Department of Horticulture of the University.

REFERENCES

1. Shuval, H.I., A. Adin, B. Fattal, E. Rawitz and P. Yekutiel, 1986. Wastewater irrigation in developing countries. Health effects and technical solutions. World Bank Tech. Pap., pp: 51.
2. Feigin, A., I. Ravina and J. Shalhevet, 1991. Irrigation with Treated Sewage Effluent. Management for Environmental Protection. Advanced Series in Agricultural Sciences. 17. Springer-Verlag, pp: 224.
3. Panicker, P.V.R.C., 1995. Recycling of Human Waste in Agriculture and Aquaculture: In Recycling of Wastes in Agriculture Tandon, H.L.S. (Eds.). Fert. Dev. Consultation Org., New Delhi, India, pp: 68-90.
4. Alloway, B.J. and D.C. Ayres, 1997. Chemical Principles of Environmental Pollution. 2nd Edn. Chapmann and Hall Inc. London, UK., pp: 208-211.

5. Misra, S.G. and D. Mani, 1991. Soil pollution. ASHISH Publishing House, New Delhi, India, pp: 43-80.
6. USDA, 1978. Improving Soils with Organic Wastes. Office of the Secretary of Agriculture.
7. Epstein, E., J.M. Taylor and R.L. Channey, 1976. Effects of sewage sludge compost applied to soil on some physical and chemical properties. J. Environ. Qual., 5: 422-426.
8. Sommen, L.E., 1977. Chemical composition of sewage sludge and analysis of their potential use as a fertilizer. J. Environ. Qual., 6: 225-235.
9. Chen, Y. and F.J. Stevenson. 1986. Soil Organic Matter Interactions with Trace Elements. The Role of Organic Matter in Modern Agriculture, Chen, Y. and Y. Avnimellech (Eds.). Martinus Nijhoff Publishers, Dordrocht, The Netherlands, pp: 73-116.
10. Scheaffer, C.C., A.M. Decker, R.L. Chaney and L.W. Douglass, 1979. Soil temperature and sewage sludge effects on corn yield and macronutrients content. J. Environ. Anal., 8: 450-454.
11. Tisdale, S.L., W.L. Nelson, J.D. Beaton and J.L. Hevlin, 1993. Soil Fertility and Fertilizer. 5th Edn. Macmillan Publishing Co. New York.
12. Qadir, M., A. Ghafoor, S. I. Hussain, G. Murtaza and T. Mahmood, 1997. Metal ion contamination in vegetables and soils irrigated with city effluent. In: Proc. NSMTCC 97 on Environmental Pollution, Feb. 24-26, 1997, Islamabad, Pakistan.
13. Ahmad, N., M. Ibrahim and A. Khan, 1994. Sewage effluent for raising vegetables. In: Proceedings 4th Soil Sci. National Cong. Islamabad, Pakistan, pp: 593-597.
14. US Salinity Lab. Staff, 1954. Diagnosis and improvement of saline and alkali soils. USDA Hand Book No. 60, Washington D.C.
15. AOAC., 1984. Official Methods of Analysis. 15th Edn. Arlington, VA., USA.
16. Muhammad, S., 1996. Soil Salinity, Sodicity and Water Logging. In: Soil Science Memon, K.S. and A. Rashid, (Eds.). National Book Foundation, Islamabad, Pakistan, pp: 471-506.
17. Bohn, H.L., B.L. McNeal and G.A., O'Connar, 1985. Soil Chemistry. 2nd Edn., John Wiley and Sons. New York.
18. FAO, 1985. Water Quality for Agriculture. Paper No. 29 (Rev. 1) UNESCO Publications, Rome, pp: 96.