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Research Article

Impact of Irrigation with Sewage Water on Heavy Metal Content in Soil and Crops of Raver Area in Khandesh Region of Maharashtra, India

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ABSTRACT

In the present investigation, the study was carried out to know the status of addition of heavy metals into an agricultural field through sewage water irrigation for crops in the farmlands of selected areas of Raver in Jalgaon district (M.S.). We observe that the use of sewage water for irrigation improved chemical properties and fertility status in soil because sewage water contains essential elements for plant growth, but the adverse effect of sewage water is that heavy metals also contribute in soil which may be toxic for animals if their concentrations exceed than permissible limits. The concentration of heavy metals in sewage water was in the proposed food and agriculture organization range. Our results show that soil concentration with sewage and irrigation water and treated sewage water induces a significant decrease of soil pH when compared to mixed water and control treatment with groundwater. The accumulation of heavy metals such as Fe, Mn, Cu, Zn, and Pb in crops was significantly increased by sewage water irrigation. It may be due to the uptake of metals which may increase nutritional values and improve the soil properties, plant growth, and yield without any contamination in soil and toxicity in crops. The wastewater irrigated soil and vegetable grown on sewage water zone show extent of heavy metals which was enriched with Fe, Mn, Cu, Zn, and Pb.

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INTRODUCTION

Sewage has most of the organic and inorganic nutrients for plant growth, and it is used cogently by the formers to gain more productivity from the farmlands. The drawbacks can be seen in the form of gradual absorption of heavy metals in the soil. Domestic sewage water with high organic matter dissolved solids and unwanted chemicals causes huge groundwater (GW) problems during the past decade, and widespread reports of GW contamination have increased public concern about drinking water quality. Sewage provides water and valuable plant nutrients; it leads to the potential accumulation of heavy metals in agricultural soils. The concentration of heavy metals such as Cu, Pb, and Co in plant tissue was low as compared to standards limits for irrigation. These heavy metal concentrations are well below hazardous levels.[1,2] The effect of continuous irrigation with sewage water increases exchangeable cations to a large extent.[3,4]

In the present investigation, we have studied the situation of Zadi river in Faizpur area which is gradually converted into a Nalla. The wastewater that flows after the use for domestic and other purposes is discharge into this Nalla. The investigation of chemical parameters of untreated sewage water (TSW) was carried out in the study area to assess TSW. Sewage has high values of temperature, pH, hardness, alkalinity, chemical oxygen demand, total soluble salts, nitrates, nitrites, and cations such as sodium, potassium, calcium, and magnesium.[5] Sewage comprises water as the main constituent, while other constituents also contain organic waste and chemical which shows that the untreated sewage discharge is one of the main problems in the present conditions.

The wastes and wastewaters are discharged into the water bodies and then eventually pose a risk to human and routine functioning of ecosystem. In addition to these, sewage water also contains significant amounts of toxic metals such as arsenic, chromium, cadmium, copper, lead, nickel, zinc, cobalt, magnesium, and iron,[6] and after accumulating in the soil, it get transferred to vegetables grown on these soils.[7] Comparable results were reported.[8] Many studies have shown that sewage water irrigation has elevated the levels of heavy metals in receiving soils.[9,10] Some of these metals after accumulating in the soil are

transferred to food chain which can cause serious health hazards to human beings and animals. Soil is a bio-filter that can reduce a large part of domestic sewage contaminants, but this sieving increases EC, SAR, Na, Ca, and Mg of soil. Besides, these metals induce a deficiency of other nutrients, for eample, copper, iron, and manganese inhibiting plant uptake of zinc, possibly because of competition for the same carrier site in soil-water system.[11] Metals such as iron, manganese, cobalt, copper, and nickel are essential nutrients; however, their permissible limits are quite low and in living organisms.[12] The uptake of heavy metals also depends on season and presence of other heavy metals in soil.[13,14] Now, it is our responsibility to support the proper use of sewage effluents to avoid soil contamination.[15] Our main objective was to study and assess the impact of irrigation with sewage water on heavy metal content in soil and crops of Raver area of Khandesh region, which accumulates the level of chemical elements in soil and crop which was irrigated by sewage water as compared to TSW, mixed water (MW), and GW.

MATERIALS AND METHODS

The present study was conducted to know the status of pollution load in river Zadi which is situated in Jalgaon district of Khandesh region having latitude 21.162222 and longitude 75.863236. Cane sugar industry exists in an around Faizpur city, and the sewage and unused materials, for example, organic waste of this Faizpur area are responsible for humiliating the quality of river Zadi and converted into a Lendi Nalla. Samples of water used for irrigating soil and crop and cultivation were randomly collected from the farmlands in January–August of the year 2016. The water sampling and analysis are carried out for each of the different water types used for irrigating the crops during the experiment. The samples were collected from four sites, i.e. sewage water (SW), (sewage water and pure water) (MW), TSW, and GW. For collection of samples, the sterilized plastic cans were used and brought to the laboratory for analysis. The physiochemical parameters and heavymetal analysis were determined according to the study of NEERI.[16] The filtrate was analyzed for the contents of Fe, Mn, Zn, Cu, Ni, Pb, and Cd using AAS. Soil samples were also collected randomly at each place and time, the crop was plucked using an Auger and uprooted tomixed soil thoroughly. The soil samples were air-dried ground and sieved through 2 mm sieve. The prepared soil samples were then stored in polyethylene bottles for analysis of pH, EC, exchangeable bases (K, Ca, Mg, and Na), Cl, TN, TP, SO_4, and heavy metals, and the samples were digested using nitric acid. Crop leaves samples were hand-picked, and all collected samples of crop leaves were washed with double-distilled water to remove airborne contaminants. The samples were then oven-dried in a hot air oven at 70–80°C for 24 h, to remove moisture. Dried samples were powdered using a mortar and pestle and sieved through a muslin cloth. Digestion of samples, the dry ash method[17] was used to prepare the samples for determination of heavy metal concentration in the GW and wastewater irrigated crops of the study area.

RESULTS AND DISCUSSION

The present study is to quantitate some of the physiochemical characteristics of raw sewage as summarized in Table 1 to suggest the environmentally safe method of sewage application as irrigation water in agriculture and to estimate the nutrients supplying potential of the sewage. This will also minimize the water pollution problems resulting due to direct discharge of sewage waste in water bodies. The sewage water analyzed for different physiochemical properties in that the sewage water exhibited almost neutral hydrogen ion concentration values pH 7.52 (SW), whereas pH for TSW was 8.14, MW 9.21, and GW 8.32 which show alkaline in nature, respectively. The electrical conductivity for SW, TSW, MW, and GW is less than the irrigation standard as shown in Table 1. Similarly, DO, COD, BOD, and TDS are high as compared to standard values. All the physico-chemical parameters of sewage show higher values as compare to standards limits for irrigation [Table 1]. The related results were observed by the study of NEERI[16] which shows that sewage has often high values of temperature, pH, hardness, alkalinity, COD, TSS, nitrates, nitrites, and cations such as Na, P, Ca, and Mg.

As far as heavy metals in the soils concern, the concentrations of heavy metals in the sewage water were found within the permissible limit of irrigation water according to standard proposed by FAO 1985 as presented in Table 2. However, with continuous application of wastewater, these metallic elements could get accumulated in the soil and crop. The concentrations of different heavy metals vary because it depends on the nature of industries and domestic uses.[18] After irrigated with different concentrations of sewage water, pH was decreased significantly. The reason for decreasing of soil pH may be due to decomposition of organic matter and production of organic acids in soils irrigated with wastewater.[19-21] The SW and TSW affect significantly the EC. Indeed, in comparison with GW, EC is greater with SW and TSW treatment. These results agreed with several authors like FAO, Bharose *et al*.[22,23] Similarly, the dried sample of Wheat, Gram, Palak, Methi, and Brinjal was powdered and digested to know the heavy metal concentration accumulated by the plants in the GW and wastewater irrigated crops as presented in Table 3. The heavy metal accumulation in crops impacts on food chain. Some researchers stated that the sewage water reuse showed no effect on the increase of these elements during the growing season.[24] On vegetables Vaseghi *et al*.,[25] showed that sewage water irrigation treatments increase the availability of phosphorus and micro-elements as well as N, P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu, to plant which lead to increase of cauliflower and red cabbage yields Bafna and Thorat[26] showed that irrigation with TSW led to significant increase of major elements contents as Na, Cl, Ca, and Mg, fertilizer elements as N, P, and K, and heavy metals such as Cu, Zn, Co, Cd, Pb, and Ni on corn Mishra *et al*.[27] revealed that wastewater irrigated soil wastewater and vegetables grown at wastewater zone.

Nutrients and heavy metals concentration of sewage water sample and crop irrigated with sewage in Raver area were observed (Tables 2 and 3). It reveals that, the irrigation with SW leads to a significant increase ($P < 0.05$) of N, P, K, Ca, Mg and Na content in crops. The accumulation of heavy metals such as of Fe, Mn, Cu, Zn, and Pb in crops was significantly increased by sewage water irrigation.

The above results indicate that sewage water was rich in nutrients but has some salinity hazards as well as bicarbonate, chloride, and sulfate toxicity. Despite their high nutrient status, the sewage wastewater indicates high toxicity because of the absence of dissolved oxygen. Hence, sewage wastewater either

Table 1: Status of physiochemical characteristics of sewage water samples of Raver area

Parameters	Unit	Sewage water (SW)	TSW	MW	GW	Standard limit for irrigation
T	°C	26	25	26	25	-
pH	-	7.52	8.14	9.21	8.32	6.5–8.4
EC	$\mu s/cm^{-1}$	1036	1229	908	1098	<3000
DO	mgL^{-1}	Nil	2.4	3.4	6.11	<9
COD	mgL^{-1}	968	147	282	18	80–500
BOD	mgL^{-1}	658	32	63	3	100
TDS	mgL^{-1}	562	625	506	698	2000
Ca	mgL^{-1}	43.39	62.67	27.33	56.24	400
Mg	mgL^{-1}	29.01	31.89	44.46	69.51	60
Na	mgL^{-1}	51	63	59	58	900
K	mgL^{-1}	27	23	15	23	0.2
CO_3	mgL^{-1}	Nil	Nil	51	43	6
HCO_3	mgL^{-1}	298	393	206	547	600

SW: Sewage water, TSW: Treated sewage water, MW: Mixed water, GW: Ground water

Table 2: Status of heavy metal concentrations of sewage water samples of Raver area

Parameters	Unit	SW	TSW	MW	GW	Standard limit for irrigation
Fe	mgL^{-1}	2.97	2.51	2.41	0.077	5
Mn	mgL^{-1}	0.159	0.044	0.071	0.047	0.2
Cu	mgL^{-1}	<0.05	<0.05	<0.05	<0.05	0.1
Zn	mgL^{-1}	0.134	0.281	0.358	0.365	2
Pb	mgL^{-1}	0.057	0.057	0.056	0.053	2
Cd	mgL^{-1}	0.049	0.049	0.050	0.049	0.01
Ni	mgL^{-1}	0.043	0.039	0.041	0.037	5

SW: Sewage water, TSW: Treated sewage water, MW: Mixed water, GW: Ground water

Table 3: Status of heavy metal concentrations on crops irrigated with sewage in Raver area

Irrigation sources	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Pb (mg kg^{-1})
Wheat					
SW	26.72±1.11	13.97±2.26	17.91±3.30	5.48±0.84	4.88±0.54
GW	20.39±0.83	12.28±1.52	14.69±1.19	4.68±0.27	1.49±0.33
Gram					
SW	34.88±4.53	15.22±2.18	16.73±2.48	2.19±0.44	7.30±0.48
GW	27.02±2.59	13.49±1.35	15.12±1.72	1.25±0.25	4.36±0.69
Palak					
SW	42.56±6.48	59.54±1.27	28.70±0.90	6.48±0.49	9.13±0.76
GW	41.17±7.63	41.59±2.14	24.17±2.14	4.52±1.54	4.58±0.54
Methi					
SW	30.95±4.48	21.98±1.50	26.72±0.48	1.38±0.33	8.16±0.64
GW	27.67±6.76	18.46±0.76	26.47±1.10	1.15±0.14	5.56±0.82
Brinjal					
SW	26.60±4.45	24.11±2.64	28.12±3.62	9.28±0.77	5.42±0.14
GW	24.35±0.68	19.95±0.86	24.58±1.44	7.98±0.43	3.87±0.64

SW: Sewage water, TSW: Treated sewage water, MW: Mixed water, GW: Ground water

should not be used for irrigation or should be use after dilution. When sewage water will be applied on crops, it will certainly improve physical condition and nutrient status of the crops and soil, but the toxicity due to micronutrient and other heavy

metals, which were possessed by sewage wastewater, must be seriously taken in the consideration before their application to soil, though it is showing a significant impact on human health.

CONCLUSION

The sewage wastewater can be used for both as potential source of nutrients as well as water used for irrigation. Although the sewage wastewater was rich in nutrients, the toxicity due to micronutrients and other heavy metals which they generally possess must be a seriously taken into consideration before applying it. The sewage grown crops and uptake of metals may increase nutritional value and improve soil properties as tested for SW, TSW, MW, and GW in the study area of Raver district, Jalgaon of Maharashtra.

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