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Review Article

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A Review on Influence of Sewage Water on Soil Properties and Microbial Biomass Carbon

Sushil[*]**, Vikas Kumar, Deepak Kochar, Vikas and Kiran Khokhar**
Department of Soil Science, CCS Haryana Agricultural University, Hisar
*Corresponding Author E-mail: chauhan.sushil1367@gmail.com

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ABSTRACT

Presently the levels of groundwater are decreasing at an alarming rate. To avoid this problem, we use waste water/sewage water as a source of irrigation. The composition of waste water depends on type of source of water contributing this (like industrial, household and different types of city wastes). Composition of waste water is variable from area to area and site to site.

Waste water affects the physico-chemical properties of soils like hydraulic conductivity, infiltration rate, water retention, organic carbon. Waste water improves the status of available (N, P and K), micronutrients and microbial count. Waste water contains high amount of toxic heavy metals (Cd, Cr, Pb and Ni) which causes adverse effect on soil as well as plant. If the concentration of toxic metals is above than the permissible limits then this water is hazardous for humans and animals life. In this article, we have discussed future aspects of waste water and how to play a major role in modern agriculture. It is beneficial or not for particular purpose where industrial waste water is a big problem.

Keywords: *groundwater, Microbial Biomass Carbon, Sewage Water, Commercial Fertilizers*

INTRODUCTION

The growth of towns, cities, and development of industries by 19th century lead to problem of disposal of sewage, which encouraged the use of sewage wastewater in irrigation. Waste water is used as a source of irrigation water since it serves as a source of plant nutrients. The reuse of treated domestic wastewater in agricultural purposes has been increasingly considered to be beneficial for crop production due to its significant source of nutrients for the plants (Cisneros, 1995, NRC, 1996) as it can help to reduce the requirements for commercial fertilizers (Candela et al., 2007). Many studies confirm that treated sewage waste water can be useful as an additional water resource for irrigation (Palese et al., 2009, Mehrdadi et al., 2007). Application of sewage water improved the physico-chemical properties and nutrient status of the soil and increases crop production as it supplies N, P and K besides valuable micronutrients to crop (Panicker, 1995).

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On the other hand, the use of sewage water in agriculture is associated with health risks because of presence of pathogenic microorganisms (Toze, 2006), metallic contaminants like Cu, Ni, Cd, Cr, Zn (Misra & Mani, 1991) and polychlorinated substances (Bansal,1998). In India, sewage water generation is 29000 million liters per day against the existing treatment capacity of 6000 million liters per day (Central Pollution Control Board, 2004). The use of treated sewage in irrigation was emphasized in the Water (Prevention and Control of Pollution) Act, 1974. Bansal et al. (1992) compared the accumulation of Zn, Cu, Mn and Fe in soils irrigated with waste water and tube well water. Accumulation of heavy metals in agricultural soils is a subject of increasing concern due to food safety issues and potential health risks as well as detrimental effects on soil ecosystem (McLaughlin et al., 1999). Evidence for the impact of heavy metals on the soil microbial community was only beginning to emerge when the UK-SR were first drafted; therefore soil microorganisms were not considered when establishing the statutory limits. However, there was concern that a decrease in the diversity and activity of soil microorganisms due to heavy metal toxicity could disrupt biogeochemical processes essential to crop production (MAFF/DoE, 1993b).

The microbial biomass of soil comprises the total mass of fungi, bacteria, protozoa and algae, per unit weight of soil and is regarded as an undifferentiated single compartment for the purpose of studying energy flows and mineral fluxes within the soil environment. However, due to limitations in experimental methods, as well as the natural spatial and temporal variation in microbial growth and activity in soils, results are often difficult to compare (Broos et al., 2007, Martens, 1995).

Noureen et al. (2015) reported that vegetable crops have been contaminated with HM in the Hattar areas, Pakistan, and extractable HM in soils exceeded the prescribed limits. Food chain contamination is one of the major routes for entry of HM into the animal system, therefore, monitoring the available pools of metals in contaminated soils has generated huge interest (Datta et al., 2000, Yadav et al., 2002). HM, once accumulated in soils, are generally difficult to remove (Smith et al., 1996). Therefore, efforts are made to immobilize the metal concentrations in soils so that the accumulated HM may be curtailed to prevent them entering the food chain, contaminating surface or underground water. Keeping in view the abovementioned facts, an attempt has been made to review the pertinent literature concerning the influence of sewage water on soil properties and microbial biomass carbon.

Effects of wastewater use on soil physico-chemical properties

According to Gurjar et al., (2017) physical properties of soil irrigated with sewage water increase the bulk density (BD) 0.01g cm-3, particle density (PD) 0.02 g cm-3, porosity 1.03% and water holding capacity (WHC) 6.20 % as compared to ground water irrigated(table 1). The irrigation with groundwater (8.31) and sewage water (7.49) induces decrease of soil pH and increase OC in comparison to ground water. Similar results were noticed by (Gupta et al., 2010, Saffari et al., 2013) who reported that after irrigation with different dilution of sewage water, pH decreased significantly. The reason for decreasing of soil pH and increase of OC may be due to decomposition of organic matter and production of organic acids in soils irrigated with wastewater (Khai et al., 2008, Vaseghi et al., 2005). Sewage water led to an increase of N, P, K and Ca in comparison to the groundwater. Sulphur and Mg decrease with sewage water irrigation. in Nitrogen (37.71 kg ha^{-1}), P 0.70 kg ha^{-1}, K 19.48 kg ha^{-1}, Ca 2.33 Cmol (p+) kg^{-1}, S 0.70 Cmol (p+) kg^{-1} and Mg 0.02 Cmol (p+) kg^{-1} increased as comparison to the control (GW).

Table 1: Mean values of physico-Chemical properties of soils irrigated with different water

S. No	Parameters	Unit	Soil sewage water	Soil ground water
1.	BD	g cm^{-3}	1.34	1.35
2.	PD	g cm^{-3}	2.55	2.52
3.	Porosity	%	47.45	46.42
4.	WHC	%	42.93	36.73
5.	pH	-	7.49	8.31
6.	EC	dSm^{-1}	0.84	0.61
7.	OC	%	0.79	0.50
8.	N	kg ha^{-1}	231.13	193.42
9.	P	kg ha^{-1}	15.12	14.42
10.	K	kg ha^{-1}	458.48	439.18
11.	S	Cmol (p+) kg^{-1}	17.17	16.47
12.	Ca	Cmol (p+) kg^{-1}	9.13	6.80
13.	Mg	Cmol (p+) kg^{-1}	2.45	2.43

Narwal et al. (1993) conducted a study and reported that continuous irrigation with sewage water increased soil EC and OC whereas it decreased soil pH. Singh & Verloo, (1996) reported lower pH and higher OC in soils irrigated with sewage water compared to those irrigated with ground water.

Mohammed et al., (2014) ascertained that irrigation with sewage water (SW) and treated sewage water (TSW) induces significant ($P<0.05$) decrease of soil pH when compared to control treatment groundwater (GW). The SW and TSW affect significantly the EC indeed, in comparison with groundwater (GW), EC was greater with SW and TSW treatment.

Rai et al. (2011) studied the effect of sewage water and canal water irrigation in soil. They observed that concentration of Pb, Cu, Zn were below the Indian standards except Cd. The enrichment factors calculated for sewage water irrigated soil in Pb (3.79), Zn (4.12), Cu (3.12) and Cd (2.21) were moderate enrichment while pollution index values in the samples were calculated to be lower than permissible pollution limit of 1.

Al-Jaboobi et al. (2014) found that the wastewater soil pH ranged from 7.89 to 7.55 in soil irrigated with wastewater which was less than 8.27 to 8.08 in groundwater soil irrigation. An increase in EC from 893 to 943 μS/cm with an average of 921 μS/cm in soil irrigated with wastewater while the average value of EC in the soil irrigated with ground water varied from 600 to 705 μS/cm with a mean of 657 μS/cm. The higher content of organic matter was found in the soil irrigated with wastewater. It showed 2.00 % compared to 0.74 % obtained in the case of the soil irrigated with groundwater. This implies that wastewater contains organic matter compounds. Average values of phosphorus were high in soil irrigated with waste water, 27.33 ppm, compared to 6.22 mg/l in soil irrigated with groundwater. Total nitrogen in soil which was significantly high in SW with average of 40.33 mg/kg compared to those irrigated with groundwater 16 mg/kg. It was observed that there is increase in value of potassium in the soil irrigated with wastewater (519 ppm) than the other type of soil (115 ppm).

Haroon et al. (2019) reported that WW irrigation increased the pH values of soils. The pH of the WW-irrigated fields ranged from 7.6 to 8.7 whereas its values ranged from 6.4 to 7.1 in the rainfed fields. The EC of soils ranged from 554 to 728 μS m^{-1} in WW-irrigated fields whereas in the non-irrigated fields the EC values ranged from 182 to 368 μS m^{-1}. Elevated EC values indicated that the use of industrial WW for irrigation can lead to an accumulation of salts in the soils. Total carbon was recorded between 2.2 and 4.2% in the WW-irrigated fields. Carbon contents were lower in the non-irrigated fields, i.e. in the range of 1.2–2.1%.

Duan et al. (2010) studied the short-term effects of waste water land application on soil chemical properties at the same site by the water mass balance method. Soil samples were taken at the start and at the end of this study at different depths from soil surface down to 91 cm at the research site (54 × 18 m), and analyzed for pH, total Kjeldahl nitrogen, nitrate – nitrogen, ammonical–nitrogen, electrical conductivity, calcium, magnesium, sodium, and sodium adsorption ratio. The results showed that there was no negative change in soil chemical properties during the research period in this waste water land application system designed by water mass balance method.

Effects of wastewater use on soil heavy metals properties

Rusan et al. (2007) studied the effect of waste water irrigation for different duration on micronutrients and heavy metals content of barley plant. They reported that the Cu, Zn, Fe, Mn contents in the plant were the highest in the plant grown in the soil receiving waste water in the previous two years. However, the concentration of these micronutrients significantly reduced in the plants grown in the soil received waste water for longer period namely for 5-10 years. Whereas, the concentration of heavy metals (lead and cadmium) increased significantly with increase in duration of sewage water application upto 10 years as compared to control.

Singh et al. (2010) studied that continuous application of waste water for more than 20 years which had led to accumulation of heavy metals in the soil. Consequently, the concentrations of Cd, Pb and Ni had crossed the safe limits for human consumption in all the vegetables. Per cent contribution of fruit-vegetables to daily human intake for Cu, Ni, Pb and Cr was found higher than that of leafy vegetables, while the reverse was true for Cd and Zn. Target hazard quotient showed health risk to the local population associated with Cd, Pb and Ni contamination of vegetables.

Roy et al. (2013) in a study with sewage sludge along with inorganic fertilisers found that the application of sewage sludge resulted in accumulation of all the micronutrients *viz*. Fe, Zn, Mn, Cu. In addition, application of sewage sludge resulted in accumulation of Pb which indicated that there was a need to go for safe use of sewage sludge.

Pathak et al. (2011) studied that sewage water irrigation effect on physicochemical properties and accumulation of heavy metals and noted that concentration of heavy metals like Pb, Cd, Cr was found higher in waste water treated soils as compared to control. A positive effect of application of sewage sludge was also noticed on the concentration of Zn, Cu, Fe and Ni. They also reported an increase in electrical conductivity of the treated soil.

Effect of waste water on MBC

Dattamudi et al. (2018) examined the population of *E. coli* (an indicator organism) to quantify the waste water pathogens in applied water and in the soil and subsequently the suitability of the treated SW for irrigation. Fecal coliform community was measured by two methods, for instance, the most probable number method and plate count technique. Tube well water irrigation was used as control for this study. The average FC population was found > 100 times (MPN) and > 50 times (plate count) higher in sewage flood water as compared to TW just after irrigation. However, the average population of FC in the SW decreased (in 0 to 48 hrs) by 4 and 2 times in MPN and in plate count, respectively, for two years. The soils irrigated with treated sewage water had about 26 time's higher FC population than TW irrigated soils during different cycles of the study. When irrigated with different doses of sewage (3, 6, and 12 irrigations), rice production was about 50 - 60% higher than controlled plots indicates the substantial amount of nutrients provided by sewage water in the soil. The field was left to dry out for 2 weeks after rice harvesting and interestingly the difference of total coliform (TC) and FC concentration was found statistically insignificant ($P > 0.05$) in soils irrigated through TW and treated SW.

Kharche et al. (2011) ascertained that the microbial count in sewage-irrigated soils was higher for bacteria, fungi and actinomycetes which was about 1.34, 1.52 and 1.18 (for 0-30 cm) and 1.66, 1.55 and 1.14 (for 30-60 cm) times higher as compared to that in the normal soils, respectively. This may be due to the suspended organic material added to the soil through sewage which serves as a source of energy for microbial population (Seaker & Sopper, 1988, Joshi & Yadav, 2003).

Table 2: Mean soil microbial count of sewage- and well-irrigated soils

Soil depth (cm)	Soil microbial count		
	Bacteria (106 x g^{-1})	Fungi (105 x g^{-1})	Actinimycetes (104 x g^{-1})
	Sewage-irrigated soils		
0-30	20.8 (15-26)	10.7 (8-12)	5.33 (4-6)
30-60	19.2 (13-24)	9.3 (7-11)	4.0 (3-6)
	Well-irrigated soils		
0-30	15.5 (15-16)	7.0 (6-8)	4.5 (4-5)
30-60	11.5 (11-12)	6.0 (5-7)	3.5 (3-4)

Source: (Kharche et al., 2011)

Impact of sewage water on health status

Radhika & Kulkarni (2017) reported that almost near double number of household members in sewage water villages (33.96) than the fresh water village (19.65) household members was suffered from different ailments. Majority of the family members suffered from diarrheal diseases (67.25%), cholera (13.63%), malaria (5.85%) and typhoid (13.87%) in the sewage water villages. The incidence of these diseases among the fresh water village accounted 76.81 per cent suffered from diarrheal diseases, 8.69 per cent from cholera and 14.49 per cent from typhoid. Considerably a high proportion of family members suffering from health related problems/diseases could be due to the increased mosquito menace in these villages, greater chance of contamination of drinking water sources, consistent use of sewage water for crops that could have caused a greater chance of contamination of food.

CONCLUSION

From the pertinent literature it can be concluded that the use of waste water improves the physical, chemical and biological properties of soil. We use this water as a form of fertilizer due to high level of N, P, K and high micro-nutrients. But some time it gives adverse effect on crop and microbes due to high level of toxic heavy metals. So use this water in mixed with ground water or alternate way of irrigation.

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