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Review Article

Effects of Wastewater use on Soil Physico-chemical Properties and Human Health Status

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ABSTRACT

Freshwater scarcity with an increasing population is a debatable scenario at the present time. Change in rainfall pattern results in agriculture production demanding more water. To be concerned with both problems, irrigation wastewater use is a compatible strategy to overcome both conditions. Wastewater composition depends upon source type (domestic or industrial) and location (area or site) where does the water evolved. Wastewater composition varied from site to site and area to area due to location differentiation. Wastewater helps the farmers to increment in total available plant macronutrients, micronutrients, and replication of microbial community in soil. But wastewater use has some cons that they cause the soil physicochemical properties affection such as soil conductivity, water retention capacity, bulk density, organic carbon ratio and pH. Now, the critical concern is an accumulation of heavy metals in the soil-plant system. In addition, wastewater contains an excessive amount of many heavy metals (zinc, nical, lead and chromium), and if they present in the soil in excessive amounts, then they cause hazards to plants, animals and human life. In this articles discussion are made about the wastewater uses in future prospects for agriculture and how they are important in sustainable agriculture. Wastewater uses have pros and cons, but groundwater levels are decreasing at an alarming rate.

Keywords: *Sustainable agriculture, Soil Physico-chemical properties, Metal richness, Water retention, Hazardous.*

INTRODUCTION

The increasing population demands fresh water, food supply and more resource consumption. Due to freshwater scarcity, an increase in wastewater used for agriculture production was observed in arid and semi-arid regions. Agricultural production needs more water due to changes in rainfall patterns. Wastewater from either municipal or industrial sources near urban was also observed.

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The intensity of wastewater use near the urban areas is more due to poor access of freshwater availability sources (Jalali et al., 2007). In 50 different countries, the use of raw or partly treated wastewater use on 20 million hectares was observed (Hussain et al., 2001; & Scot et al., 2004).

In developing nations where the standards are not applied, farmers use the wastewater preferably due to its richness in organic and inorganic amendments and better crop production. However, where the standards are applied, the treatment is not affordable yet for their treatment and extensive use (Hussain et al., 2001).

In the scarcity of fresh water reliable substitute for irrigation is wastewater; if it handles with care and controlled management practices are done, then the positive aspects are achieved (WHO, 2006). Furthermore, if the wastewater used after treatment or its heavy metals concentration remains below the hazardous limit, monitored regularly and causes an increase in plant growth more rapidly than treated or freshwater (Makhadmeh et al., 2021). Wastewater irrigations increase growth, yield and plant nutritional level (Aghtape et al., 2011). Wastewater is valuable if applied in a controlled amount to the soil for agricultural crop production because it provides the organic and inorganic nutrients for crop production (Horswell et al., 2003).

The beneficial aspects of wastewater include reducing the demand for commercial fertilizer for agricultural crop production (Candela et al., 2007). The untreated wastewater produces many beneficial changes in soil potential, and an increment in organic and inorganic nutrients such as magnesium was observed (Rai et al., 2011). Ramirez et al. (2002) describe that the concentration of lead (Pb), cadmium (Cd) and copper (Cu) is increased to an impressive level but did not reach to hazardous level to affect the plant growth. Wastewater application improves the physicochemical properties and nutrient status by providing macronutrients (N, K, and P) besides of the excessive amount of micronutrients (Panicker, 1995). Mojiri, (2011) described that wastewater irrigation cause rapid increment in macronutrients (N, K and P) with iron (Fe) and sodium (Na) level in soil. Untreated industrial wastewater contains high exchangeable calcium with potassium as compare with treated water (Grag & Khushik, 2006). Increment in microbial activity or biomass with soil enzymes activity and microbial community in soil was observed (Liu & Haynes, 2010).

On the other hand, one of the main risks of wastewater use is the change in the composition of the soil-plant system with heavy metals. Smith et al. (1996) described that it is difficult to remediate the soil if once contaminated with heavy metals. The soil physicochemical properties with plant growth and human health status can be damaged if can't minimize use of untreated wastewater. The deterioration in soil properties or quality can be done very badly and this is another negative impact (Chen et al., 2005).

Irrigation with wastewater directly affects the soil environment and indirectly affects human health status via crops and soils (Butt et al., 2005). Sharma et al. (2007) described that repetitive wastewater irrigation to the soil without treatment increase the heavy metal concentration to a toxic level in the soil. Crop grown on the metals rich concentrated site are badly affected the metal concentration and also metal concentrated plants consumption poses a serious threat to human health (Tiller, 1996; & Ratan et al., 2005).

Vegetables are major's part of human nutrition because enriched with minerals, vitamins and fibers. Noureen et al. (2015) described that in Pakistan, vegetable quality are deteriorated with the concentration of heavy metals and also accumulation are exceeds to prescribed extractable limits. Praveen et al. (2015) described that vegetables produced from the heavy metal contaminated site are the main sign of risk for human health status. The edible and non-edible part of vegetables contains enough concentration of heavy metals to cause clinical problems to

human and animal health. High concentrations of heavy metals in soil adversely affect plant growth and their different biochemical processes such as metabolism, stomata opening, and photosynthesis. Depression is the root and shoots length, foliage yield or reduction in the grain yield of the crop observed due to repetitive wastewater irrigations. It was observed that heavy metal richness of soil and plant systems due to irrigation with wastewater is one of the major cons (Singh et al., 2009; & Singh et al., 2010).

Influence of wastewater use on soil Physico-chemical properties

Gurjar et al., (2017) described that many soil physical properties such as porosity, particle density (PD), bulk density (BD) and water holding capacity (WHC) of soil increased by using wastewater in comparison to fresh or groundwater.

Generally, the concentration of acidic and basic cation reflects the pH of the soil. Usually, it is said those irrigations with wastewater results in the increase of pH, soil organic matter, exchange calcium and in turn cause increment in heavy metals to toxic level. Madyiwa et al. (2002) showed that wastewater results in the increment in alkalization of soil because greater composition of exchangeable basic cations such as sodium and calcium. Long term use of raw or partially treated wastewater induces a significant depression of pH but at least higher the organic carbon with electrical conductivity of soil compared to ground or freshwater (Mohammad et al., 2014; & Singh & Verloo, 1996).

The second most significant indicator after pH is soil organic matter to show to fertility and productivity and plays a significant role in nutrient cycling. Organic matter is significantly increased by the continuous application of wastewater to the soil. Narwal et al. (1993) showed the value of the organic matter in wastewater-influenced soil is 2%, while groundwater has only 0.74%.

Qishlaqi et al. (2008) described that wastewater provides a confidential amount of organic matter and exchangeable calcium to the soil. Higher fluctuation in CEC was observed due to enrichment of organic matter and loading of exchangeable calcium, not by the variability of the clay content of the soil. Exchangeable calcium concentration decreases sharply with dept. This matter indicates that the upper layer of soil receives more calcium than other layers.

The total macronutrient concentration of wastewater irrigated soil is significantly higher than groundwater. Calcium, magnesium and sulphur value prominently increased in wastewater irrigated soil (Sushil et al., 2019). Soil Physico-Chemical properties values are given in Table no.1 with respect to their units. They show the comparison between the Ground water irrigation and Wastewater irrigation in units with respect to different soil properties.

Mean value of different physicochemical properties of soil that's irrigated with ground and wastewater

Soil Properties	Units	Ground Water irrigations	Wastewater irrigations
Soil bulk density	gcm^{-3}	1.35	1.34
Soil particle density	gcm^{-3}	2.53	2.56
Water holding capacity	%	36.74	42.94
pH	-	8.18	7.72
Electrical Conductivity	dSm^{-1}	0.61	0.84
Organic Matter	%	0.74	2.0
Nitrogen contents	Kg/ha	193.43	231.15
Potassium contents	Kg/ha	439.19	458.49
Phosphorus contents	Kg/ha	14.42	15.13
Sulphur contents	C mol(p+)/kg	16.48	17.18
Calcium contents	C mol(p+)/kg	6.82	9.14
Magnesium contents	C mol(p+)/kg	2.43	2.45

Heavy Metal Consequences of Soil

Heavy metals are such elements having a density greater than five in their elemental form. Metals are retained strongly in either organic or inorganic colloids. Highly concentrated wastewater was observed to add more toxic metals to soil than normal water (Qishlaqi et al., 2008). Rusan et al. (2007) observed that plants grown on wastewater-contaminated soil contain more heavy metals than fresh or ground water irrigated soil. Consequently, wastewater irrigated soil for 5-10 years significantly reduced the micronutrient concentration in soil.

It is reported that continuous long term (20 years) wastewater irrigation leads to the high saturation of heavy metals in the soil; if they are above the recommended limits can cause severe problems for humans (Singh et al., 2010). Wastewater applications are helpful in terms of additions of micronutrients such as zinc, nical and lead and high EC was also observed (Pathak et al., 2011).

Mean value of different heavy metals levels in soil irrigated with ground and wastewater

Names of heavy metal	Ground Water irrigations	Wastewater irrigations
Nical (Ni)	61.1	276.7
Zinc (Zn)	75.4	110.7
Cadmium (Cd)	0.22	0.36
Lead (Pb)	63.3	441.8
Chromium (Cr)	27.2	27.0

At last, some indigenous forces are needed to resist the entry of these hazardous (heavy metals) into the soil-plant system and surface or underground water.

Wastewater impact on human's health status

Population lives near the source of wastewater production areas are suffered from different diseases than freshwater areas. Diarrhoea, cholera, malaria, dengue, and typhoid occur in the majority of family members who live near the wastewater (sewage) producing areas. Incidences of these diseases are increased by the mosquito's habitation, crop contamination, and freshwater resource contamination. Heavy metal introduction to the food chain results in different problems from different ailments. More than in freshwater areas, almost double the number of family members suffer due to their interaction with wastewater (Radhika & Kulkarni, 2017).

CONCLUSION

This review concludes that wastewater use, either partially treated or untreated, enhances many soil properties (such as bulk density, water retention capacity, microbial population, and organic matter) and plant growth. The usage of wastewater as fertilizer for different crops or higher plants because of its richness in organic contents such as macro and micronutrients cause significant growth. But heavy metals enrichment in the food chain is in debatable concern. Sometimes, heavy metals concentrations above the recommended limits cause damage to soil microbes and crop growth. The scarcity of freshwater resources for agriculture can be eliminated by using wastewater with different proportions without disrupting the soil properties, plant growth, microbial diversity and human health.

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There is no conflict of interest between the authors.

Author's Contribution:

All authors contributed equally and an equal response was observed from all authors.

REFERENCES

Aghtape, A. A., Ghanbari, A., Sirousmehr, A., Siahsar, B., Asgharipour, M., & Tavssoli A. (2011). Effect of irrigation with wastewater and foliar fertilizer application on some forage characteristics of foxtail millet (Setaria italica). *Int. J. Plant Physiol. Biochem. 3*(3), 34–42.

Butt, M. S., Sharif, K., Bajwa, B. E., & Aziz, A. (2005). Hazardous effects of sewage water on the environment: Focus on heavy metals and chemical composition of soil and vegetables. *Management of Environmental Quality*, *16*, 338–346.

Candela, L., Fabregat, S., Josa, A., Suriol. J., & Vigués, N. (2007) Assessment of soil a groundwater impacts by treated urban wastewater reuse. A case study, application in a golf course (Girona, Spain). *Science of the Total Environment, 374*, 26-35.

Chen, Y., Wang, C., Wang, Z., & Huang, S. (2004). Assessment of the contamination and genotoxicity of soil irrigated with wastewater. *Plant and Soil, 261*, 189–196.

Garg, V. K., & Kaushik, P. (2006) Influence of short–term irrigation of textile mill wastewater on the growth of chickpea cultivars. *Chem Ecol 22(*3), 193–200.

Gurjar, O. P., Meena, R., Latare, A. M., Rai, S., Kant, S., Kumar, A., Kumar, A., & Sheshama, M. K. (2017). Effects of sewage wastewater irrigation compare to groundwater irrigation on soil physicochemical properties. *International Journal of Chemical Studies, 5*(6), 265-267.

Hussain, I., Raschid, L., Hanjra, M. A., Marikar, F., & Van der Hoek, W. (2001). A framework for analyzing socioeconomic, health and environmental impacts of wastewater use in agriculture in developing countries. *Working Paper 26*. Colombo: *International Water Management Institute* (IWMI).

Horswell, J., Speir, T. W., & van Schaik, A. P. (2003). Bioindicators to assess impacts of heavy metals in the land-applied sewage sludge. *Soil Biology & Biochemistry, 35*, 1501–1505.

Jalali, M., Merikhpour, H., Kaledhonkar, M. J., & Seatm, V. D. Z. (2007) Nickel in a tropical soil treated with sewage sludge and cropped with maize in a long-term field study. *Agric. Water. Manag. 95*, 143–153.

Liu, Y. Y., & Haynes, R. J. (2010) Long-term irrigation with dairy factory wastewater influences soil quality. *World Acad. Sci. Eng. Technol. 70*, 577–581.

Mojiri, A. (2011) Effects of municipal wastewater on physical and chemical properties of saline soil. *J. Biol. Environ. Sci. 5*(14), 71–76.

Madyiwa, S., Chimbari, M., Nyamangara, J., & Bangaria, C. (2002). Cumulative effects of sewage sludge and effluent mixture application on soil properties of a sandy soil under a mixture of star and Kikuyu grasses in Zimbabwe. *Physics and Chemistry of the Earth, 24*, 747–753.

Mohammed, A., Alghobar, Ramachandra, L., & Suresha, S. (2014). Effect of sewage water irrigation on soil properties and evaluation of the accumulation of elements in Grass crop in Mysore city, Karnataka, India. *American Journal of Environmental Protection, 3*(5), 283-291.

Makhadmeh, I. M., Gharaiebeh, S. F., & Albalasmeh, A. A. (2021). Impact of Irrigation with Treated Domestic Wastewater on Squash (Cucurbita pepo L.) Fruit and Seed under Semi-Arid Conditions. *Horticulturae, 7*, 226.

Noureen, R., Irshad, M., & ullah, F. (2015). Assessing selected heavy metals in

vegetables and soils irrigated with wastewater at Haripur, Pakistan. *Minerva Biotechnologies*, *27*, 99–105.

Narwal, R. P., Gupta, A. P., Singh, A., & Karwasra, S. S. (1993). Composition of some city wastewaters and their effect on soil characteristics. *Annals Biology*, *9*, 239–245.

Panicker, P. V. R. C. (1995). Recycling of human waste in agriculture. In, Tandon, HLS (Ed.), Recycling of Waste in Agriculture. Fert. Dev. Consultation Org., New Delhi, India, p 68-90.

Parveen, T., Hussain, A., & Rao, S. (2015). Growth and accumulation of heavy metals in turnip (brassica rapa) irrigated with different concentrations of treated municipal wastewater. *Hydrology Research*, *46*(1), 60-71.

Qishlaqi, A., Moore, F., & Forghani, G. (2008). Impact of untreated wastewater irrigation on soils and crops in Shiraz suburban area, SW Iran, Environ Monit. *Assess 141*, 257–273.

Rattan, R. K., Datta, S. P., Chhonkar, P. K., Suribabu, K., & Singh, A. K. (2005). Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater–a case study. *Agriculture, Ecosystem & Environment, 109*, 310–322.

Rai, S., Chopra, A. K., Pathak, C., Sharma, D. K., Sharma, R., Gupta, P. M. (2011). Comparative study of some physicochemical parameters of soil irrigated with sewage water and canal water of Dehradun city. *India Arc. App. Sci. Res. 3*(2), 318–325.

Ramirez-Fuentes, E., Lucho, C. C., Escamilla, S. E., & Dendooven L. (2002). Characteristics, and carbon and nitrogen dynamics in soil irrigated with wastewater for different lengths of time. *Bioresour Technol 85*, 179–187.

Rusan, M. J. M., Hinnawi, S., & Rousan, L. (2007). Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters. *Desalination*, *215*, 143-152.

Radhika & Kulkarni (2017). Impact of Sewage Water Irrigation on Soil Properties, Ground Water, Human Health and Quality of Produce, an Economic Analysis. *International Journal of Agriculture, Environment and Bioresearch, (2)*, (02).

Scott, C., Faruqui, N. I., & Raschid-Sally, L. (2004).Wastewater use in irrigated agriculture: Management challenges in developing countries. In C. A. Scott (Ed.), Wastewater use in irrigated agriculture: Confronting the livelihood and environmental realities. Ottawa, Canada: CAB International, *International Water Management Institute, and International Development Research Centre*.

Smith, C. J., Hopmans, P., & Cook, F. J. (1996). Accumulation of Cr, Pb, nCu, Ni. Zn and Cd in soil following irrigation with untreated urban effluents in Australia. *Environmental Pollution*, *94*(3), 317–323.

Sharma, R. K., Agrawal, M., & Marshall, F. (2007). Heavy metal contamination of soil and vegetables in suburban areas of Varansi, India. *Ecotoxicology and Environmental Safety*, *66*, 258–266.

Singh, A., Sharma, R. K., Agrawal, M., & Marshall, F. M. (2009) Effects of wastewater irrigation on physicochemical properties of soil and availability of heavy metals in soil and vegetables. *Common Soil Sci. Plant Anal. 40*, 3469–3490.

Singh, A., Sharma, R. K., Agrawal, M., & Marshall, F. M. (2010) Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropical area of India. *Food Chem. Toxicol. 48*, 611–619.

Singh, S. P., & Verloo, M. G. (1996). Accumulation and bioavailability of metal in semi-arid soils irrigated with sewage effluents. Meded. Fac. Landbouwkd. *Teogep. Biol. Wet. Univ. Gent. 61*, 63-67.

Sushil, Kumar, V., Kochar, D., Vikas & Khokhar, K. (2019). A Review on Influence of Sewage Water on Soil Properties and Microbial Biomass Carbon, *Ind. J. Pure App. Biosci. 7*(5), 83-90.

Tiller, K. G. (1986). Essential and toxic heavy metals in soils and their ecological relevance. Transactions of the XIII Congress of the *International Society of Soil Science, 1*, 29–44.

Wang, X. J., & Tao, S. (1998). Spatial structures and relations of heavy metal content in wastewater irrigated agricultural soil of Beijing's Eastern farming regions. *Bulletin of Environmental Contamination and Toxicology, 61*, 261–268.

World Health Organization (WHO) (2006). Guidelines for the safe use of wastewater, excreta and greywater: Wastewater use in agriculture (Volume II). Retrieved from persistent.
URL:http://www.who.int/water_sanitation_health/wastewater/gsuweg2/en/index.html.