Review Article
CODEN (USA): IJPLCP

ISSN: 0976-7126
Kumar *et al.,* 14(10-12):30-35, 2023

International Journal of Pharmacy & Life Sciences
Open Access to Researcher

A review of the use of sewage water in crop production and how it affects the physical, chemical, and biological characteristics of soil

Vikas Kumar*, Vipin Kumar Saini, Ashu, Ankit Kumar and Saba Rana

Department of Biosciences, Shri Ram College, Muzaffarnagar, India

Article info

Received: 10/09/23

Revised: 19/10/2023

Accepted: 22/11/2023

© *IJPLS*

www.ijplsjournal.com

Abstract

As freshwater for irrigation becomes less available, creative solutions are required to address this pressing problem. This study compares fresh and sewage water, acknowledging the enormous amount of wastewater produced every day as a result of the fast industrialization and population growth. India's sewage water situation now poses a significant problem, underscoring the need for proactive management techniques going forward. The project looks at ways to use sewage water for farming in an effort to increase output. While recognizing the importance of waste water management on a global scale. Irrigating with sewage water can improve soil fertility and chemistry, but it may also increase electrical conductivity usually within reasonable bounds to reduce the risk of soil salinity. Nevertheless, sewage water usually includes high levels of heavy metals, including lead, nickel, cadmium, and chromium, which could be harmful to plant and soil health if they exceed safety limits. The accumulation of these dangerous metals may be made worse by ongoing sewage water use, endangering soil quality. as well as human health. Sewage water, however, becomes an essential resource during times of water scarcity that are critical for crop growth, potentially saving agricultural productivity. Sewage farming appears to be a viable strategy in this regard to reduce the need for fresh water while tackling the problems with wastewater. Using sewage water for irrigation has the potential to significantly reduce the spread of wastewater, highlighting its value as a long-term option to meet agricultural water needs.

Keywords: Sewage water, Soil, Heavy metals, Agricultural productivity, water scarcity

Introduction

Sewage water, however, becomes an essential resource during times of water scarcity that are critical for crop growth, potentially saving agricultural productivity. Sewage farming appears to be a viable strategy in this regard to reduce the demand for fresh water. Growing populations, urbanization, and industrialization have increased wastewater production, making sustainable water management more difficult. This surge is evident from the continuous rise in the world population from approximately 5.3 billion in 1992 to about 7.4 billion in 2016, with projections exceeding 8 billion by 2030 and 9 billion by 2050. Wastewater and sewage sludge output have significantly increased along with the rise in water demand brought on by the fast population development. In arid and semi-arid regions, agriculture accounts for about 92% of all water withdrawals, making it the world's largest user of water resources [1,2].

***Corresponding Author**
E.mail: vikas161983@gmail.com

ISSN: 0976-7126
Kumar *et al.,* 14(10-12):30-35, 2023

But there are issues with the entrance of pollutants such organic pollutants, viruses, and heavy metals, which might eventually jeopardize ecosystem health and soil fertility. It is essential to comprehend the complex relationships that exist between crop responses, soil characteristics, and sewage water application in order to create management plans that maximize agricultural output while preserving the environment and public health. Compiling the body of research on the use of sewage water in agricultural production, namely its impact on the physical and biological characteristics of soil, is vital for educating academics, policymakers, and agricultural professionals on its significance for a variety of agro ecosystems and its sustainable use. This method tackles trash disposal issues in addition to lessening the strain on freshwater resources, which are mostly used for industrial and human uses [3, 4]. The hydrodynamic properties of soil may be impacted by modifications in its composition brought about by irrigation with treated wastewater. According to [5], crop productivity, soil characteristics, and water management in agricultural operations are all impacted by the quality of irrigation water. Research has indicated that sewage water irrigation improves the physiochemical properties of soil [6]. Plant growth is positively impacted by domestic wastewater, which contains micronutrients, phosphorus, potassium, and nitrogen all vital plant nutrients [7, 8].

Table 1. Toxic effects of Metals/Metalloids in different Plant systems

Plant System	Metal/Metalloid	Toxic Effects
Root System	Lead (Pb)	Inhibition of root elongation, reduced nutrient uptake
Cadmium (Cd)	Reduced root growth, damage to root structure	
Arsenic (As)	Inhibition of root growth, oxidative stress	
Shoot System	Lead (Pb)	Reduced shoot biomass, chlorosis
Cadmium (Cd)	Chlorosis, necrosis, reduced photosynthesis	
Arsenic (As)	Leaf wilting, chlorosis, reduced photosynthesis	
Physiological System	Lead (Pb)	Disruption ofphotosynthesis, enzyme inhibition
Cadmium (Cd)	Oxidative stress, disruption of water balance	

Review of Literature

Growing industrialization and urbanization have highlighted the importance of sewer systems as key elements for effective wastewater disposal; sewage water, which is rich in macro and micronutrients, has the potential to improve soil fertility; in agricultural practices, irrigation water quality has a major impact on soil properties, which in turn affect crop yield. Nonetheless, the existence of common metals and metalloids in sewage water can affect living things, especially plants, in both positive and negative ways. Excessive levels of non-essential metals and metalloids can be poisonous and hinder plant growth and development, even while essential metals (including iron, zinc, and copper) are crucial for many physiological functions. It is crucial to comprehend how these elements affect various plant systems, such as root structures, aerial shoots, and overall plant physiology, in order to reduce environmental contamination and guarantee food safety. This thorough review attempts to clarify the various ways that metals and metalloids cause toxicity in plants across a range of physiological systems, such as roots, shoots, and overall plant physiology (Table 1). It is said that organic materials and vital nutrients are abundant in raw sewage water. About 99 percent of urban wastewater is made up of water, with comparatively small amounts of dissolved and suspended organic and inorganic particles. However, city sewage water may have higher concentrations of hazardous metals when industrial waste is dumped into sewer systems.

Chemical Composition of Sewage Water:

Maheshwari et al. (2008) found that industrial waste, sludge, and sewage samples from Karnal, Panipat, and Sonepat contained Cd, Cr, Pb, and Ni. Concentrations of soluble heavy metals included Cd (0.015–0.451 mg L-1), Cr (0.015–0.248 mg L-1), Pb (0.014–0.351 mg L-1), and Ni (0.023–0.624 mg L-1). For Cd (0.2 - 6.5 mg L-1), Cr (0.1 - 180 mg L-1), Pb (0.1 - 180 mg L-1), and Ni (0.3 - 125 mg L-1), the total concentrations of heavy metals varied. Sewage water (SW) and its effects on soil characteristics, vital nutrients, and the amount of heavy metals in agricultural plant leaves were also described by [9]. Lokhande et al. (2011) found that the paint manufacturing sector is the main source of toxic Cr, Zn, and Pb, with respective concentrations of 35.2, 33.1, and 31.4 mg L-1. In the industrial region of Naini, Allahabad, Yadav et al. (2013) measured the concentrations of many heavy metals (Fe, Cu, Zn, Cd, Ni, and Pb) in vegetables that were irrigated with water from various sources.

Sewage water use's effects on the physical-chemical characteristics of soil:

Uncontrolled sewage water use for irrigation, however, might cause potentially hazardous metals to build up in soil, which could have a major impact on the physicochemical characteristics of the soil. In the Rohtak district of Haryana, [10] carried out a long-term study on the impact of sewage water irrigation on soil characteristics and heavy metal concentrations.

Table 2. Tolerance limits of heavy metals in plants and its physiological impacts:

Heavy Metal	Tolerance Limit (mg/kg)	Plant Impact
Cadmium (Cd)	1.5 - 3	Inhibits photosynthesis and water absorption
Chromium (Cr)	5 - 10	Affects root growth and enzyme activity
Copper (Cu)	20 - 30	Essential in small amounts, toxic in excess
Nickel (Ni)	15 - 20	Affects seed germination and leaf growth
Lead (Pb)	5 - 10	Causes oxidative stress and damages cell membranes
Zinc (Zn)	50 - 100	Essential for plant growth, toxic at high concentrations
Mercury (Hg)	0.1 - 0.5	Impairs root and shoot growth

[11] Looked into how soil characteristics were affected by irrigation using canal water and sewage water. Bulk density (g/cm³) = 1.26, water holding capacity (%) = 53.60, temperature (ºC) = 16.33, electrical conductivity (dS/m) = 0.122, pH = 7.5, organic carbon (%) = 1.95, available phosphorus (mg/kg) = 108.44, available potassium (mg/kg) = 121.66, nitrogen (%) = 2.22, available calcium (%) = 2.18, and available magnesium (%) = 0.09 were the mean values of the various physicochemical parameters in sewage water-irrigated soil. On the other hand, over usage of sewage water can cause harmful metals to build up in soil, altering its physico-chemical characteristics. In Rohtak district, Haryana, prolonged sewage water irrigation led to increased levels of organic carbon, phosphorus, calcium, and magnesium. In the findings of Al-Jaboobi et al. [12], soil irrigated with wastewater had a pH range of 7.89 to 7.55, which was lower than the pH range of 8.27 to 8.08 in soil irrigated with ground water. Additionally, soil irrigated with wastewater had a rise in electrical conductivity (EC) from 893 to 943 µS/cm, while land irrigated with groundwater had an average EC value of 657 µS/cm, ranging from 600 to 705 µS/cm. There were organic matter compounds in wastewater, as evidenced by the increased organic matter concentration (2.00%) found in wastewater-irrigated soil as opposed to groundwater-irrigated soil (0.74%). Furthermore, soil watered with wastewater had substantially greater phosphorus levels (27.33 ppm) than soil irrigated with freshwater (6.22 mg L-1). Compared to groundwater-irrigated soil (16 mg kg-1), sewage-irrigated soil had a substantially greater total nitrogen level (40.33 mg kg-1).

ISSN: 0976-7126
Kumar *et al.,* 14(10-12):30-35, 2023

Impact of sewage water use on the characteristics of heavy metals in soil
Applying sewage water to agricultural fields over an extended period of time frequently raised the soil's levels of heavy metals and macronutrients. Heavy metals can enter the soil from a number of sources, such as sewage, industrial waste, urban or agricultural waste, and gasses released by businesses and automobiles. Because wastewater irrigation offers beneficial plant nutrients, it is becoming more and more popular, particularly in arid areas. Uncontrolled use, however, may cause hazardous metals to build up in soil and alter its physico-chemical characteristics. In Rohtak district, Haryana, prolonged sewage water irrigation led to increased levels of organic carbon, phosphorus, calcium, and magnesium.

On a similar vein, [13] discovered that prolonged use of sewage water had led to significant metal buildup on top soil. Heavy metal concentrations in cabbage cultivated on sewage-irrigated soil beyond tolerance standards. [16] documented heavy metal buildup in soil as a result of ongoing wastewater application, surpassing safe thresholds for vegetable intake by humans. The application of sewage sludge in conjunction with inorganic fertilizers was examined by Roy et al. (2013), who discovered that sewage sludge caused micronutrients (Fe, Zn, Mn, and Cu) to accumulate and Pb levels to rise, highlighting the necessity of using sewage sludge safely. [14] examined the Musi river basin in Hyderabad, Andhra Pradesh. Surface soils had higher levels of DTPA-extractable micronutrient cations and heavy metals than subsurface soils. In Bahrain, Ibrahim et al. [30] investigated the effects of long-term sewage irrigation on heavy metal absorption and accumulation in alfalfa crops and soil. The concentrations of Cu, Fe, Mn, and Zn extracted using DTPA extractant ranged from 0.63 to 2.85, 6.10 to 57.2, 1.17 to 21.72, and 0.38 to 2.15 mg kg-1, respectively. With the exception of Cd, the amounts of heavy metals in treated sewage wastewater did not above global norms. Other than Zn and Cd, no discernible variations were seen between soil depths.

Impact of Sewage Water on Soil Biological Properties of Soils: In soils from long-term reclaimed wastewater irrigation sites in southern California, microbial counts for bacteria, fungi, and actinomycetes were significantly higher (approximately 1.34, 1.52, and 1.18 times, respectively, for the 0-30 cm depth) than in normal soils. This increase may be explained by the suspended organic material introduced through sewage, which acts as an energy source for microorganisms [15, 16, 17]. [18] discovered that soil microbial biomass carbon and enzyme activity (dehydrogenase, urease, and phosphatase) were enhanced by continuous sewage water application.

Sewage Water's Impact on Crop Yield and Nutrient Uptake
Aljaloud emphasizes that plants receive vital nutrients (nitrogen, phosphorus, potassium, and micronutrients) from treated wastewater used for irrigation. It raises yields (11% for wheat and 23% for alfalfa) while drastically lowering fertilization costs (45% for wheat and 94% for alfalfa). In comparison to established norms, the quantities of heavy metals (copper, lead, and cobalt) in plant tissue continue to be below dangerous levels. However, because of the possibility of hazardous metal buildup in soils.

Table 4. Effect of heavy metals on Physico-chemical and biological properties of soil.

Heavy Metal	Physico-Chemical Effect	Biological Effect
Lead (Pb)	Decreased soil porosity and increased compaction	Reduced microbial activity and plant growth
Cadmium (Cd)	Lowered soil pH and increased acidity	Inhibition of enzyme activities in plants
Chromium (Cr)	Altered soil structure and reduced cation exchange capacity	Negative impact on soil microorganisms
Copper (Cu)	Affected organic matter decomposition rates	Toxicity to earthworms and other soil fauna.

Table 5. Yield impact of sewage water on different crops

Crop	Yield Impact	Nutrient Uptake
Pearl Millet-Wheat System	Yield reduction under saline conditions	Heavy metals accumulation affects nutrient content
Winter Wheat	Increased yield with optimal nitrogen application	Improved nitrogen use efficiency and water use efficiency
Forage Crops	Increased yield with treated wastewater irrigation	Higher nutrient content, especially nitrogen
Rice	Growth and yield enhancement with waste water irrigation	Enrichment and bioaccumulation of metals

In comparison to well-irrigated soils, cabbage cultivated on sewage-irrigated soils showed noticeably increased mean concentrations of Fe, Mn, Zn, Cu, Cd, Cr, and Ni, according to Kharche et al. Plant portions exhibited these higher soil levels, with the degree of accumulation differing according to the element type and plant component. Before using sewage water for irrigation, undesirable materials should be eliminated or their concentration should be decreased in order to prevent dangers.

Conclusion

There are both possible advantages and serious concerns associated with using sewage water in agriculture. Sewage water can improve soil fertility and possibly boost crop yields since it is a rich source of vital elements including potassium, phosphorus, and nitrogen. However, prolonged use of sewage water raises questions about the buildup of dangerous heavy metals in the soil, which can be absorbed by crops and make their way into the food chain, causing major health risks23. To protect consumer safety, strict monitoring and management procedures must be put in place, especially for crops like leafy vegetables that are more likely to absorb heavy metals. Pretreatment steps and ongoing quality evaluation procedures are crucial components of a proactive strategy to reduce these hazards. This will reduce potential risks and encourage the sustainable use of sewage water resources. Moreover, better and more effective use of this resource is being made possible by technical developments in risk assessment and sewage treatment. In summary, a comprehensive, interdisciplinary approach involving scientific study, policy creation, and active stakeholder participation is needed for the strategic use of sewage water in agriculture. Such a strategy is essential for managing the intricacies of sewage water use while preserving public health and the environment. Keeping up with the most recent research on sustainable wastewater application, related hazards, and technology advancements that promote safe irrigation techniques is essential.

References

1. FAO. FAO Statistical Yearbook; 2013 Forouzani M, Karami E, Zamani GH Moghaddam KR. Agricultural water poverty: Using Q-methodology to understand stakeholders' perceptions. Journal of Arid Environments. 2013; 97: 190-204.
2. Cheftez B, Ilani T, Schulz E, Chorover J. Waste water dissolved organic matter: characteristics and sorptive capabilities. Water Science Technology. 2006; 53 (7):51- 57.
3. Hajjami K, Ennaji MM, Fouad S, Oubrim N, Khallayoune K, Cohen N. Assessment of Helminths Health Risk Associated with Reuse of Raw and Treated Wastewater of the Settat City (Morocco). Resources and Environment. 2012; 2 (5):193-201.
4. Shainberg I, Oster JD. Quality of Irrigation Water. Pergamon Press; 1978.
5. Antil RS. Impact of sewage and industrial effluents on soil-plant health. In Industrial Waste, edited by Show KY, Xinxin G, Intech Open. 2012;53-72
6. Agrawal V, Bhagat R, Thikare N. Impact of domestic sewage for irrigation on properties of soil. International Journal of Research Studies in Science, Engineering and Technology. 2014;1(5):60–64.
7. Kiran DL, Krishna DL, Manik VS, Ramteke DS. Impact of Domestic Wastewater Irrigation on Soil Properties and Crop Yield."

International Journal of Scientific and Research Publications. 2012; 2(10):1–7.
8. Dash AK. et al. Effect of continuous use of sewage water on soil properties and plants. An Asian Journal of Soil Science. 2009; 4 (2):158-164
9. Rana l, Dhankhar R Chhikara S. Soil characteristics affected by long term application of sewage waste water International Journal of Environmental Research. 2010;4(3):513-518.
10. Rana l, Dhankhar R Chhikara S. Soil characteristics affected by long term application of sewage waste water International Journal of Environmental Research. 2010; 4(3):513-518.
11. Irandoust M, Tabriz AS. The Effect of Municipal Wastewater on Soil Chemical Properties. Solid Earth Discussions.2023; 1-13.
12. Al-Jaboobi, Mustafa, et al. Assessment of the impact of wastewater use on soil properties. Journal of Materials and Environmental Science. 2014; 5 (3): 747-752.
13. Kharche VK, et al. Effect of sewage irrigation on soil properties, essential nutrients and pollutant element status of soils and plants in a vegetable growing area around Ahmednagar City in Maharashtra. Journal of Indian Society of Soil Science. 2011; 59: 177-184.
14. Rani KU, Sharma KI, Reddy KS, Chandrika DS, Srinivas K, Nagasri K, Shankar KS, Munnalal, Srinivas B. Effect of sewage and ground water irrigation on physicochemical properties of Musi River Basin Soils. Annals of Plant and Soil Research. 2015; 17(2):137-141.
15. Chen W, et al. Soil enzyme activities of long-term reclaimed wastewater irrigated soils. Journal of Environmental Quality. 2008; 37: 5-36.
16. Joshi PK, Yadav RK. Effect of sewage on microbiological and chemical properties and crop growth in reclaimed alkali soil. Proceedings of the International conference on soil, water and environment quality, issues and strategies, New Delhi; Jan. 28 – Feb. 1, 2005.
17. Seaker EM, Sopper WE. Municipal sludge for minespoil reclamation. 1. Effects of microbial population and activity. Journal of Environment Quality. 1988; 17: 591-597.
18. Lal K, et al. Long-term impact of wastewater irrigation and nutrient rates II. nutrient balance, nitrate leaching and soil properties under peri-urban cropping systems. Agricultural Water Management. 2015; 156:110–117.
19. Minhas PS, Yadav RK. Long-term impact of wastewater irrigation and nutrient rates ii: nutrient balance, nitrate leaching and soil properties under peri-urban cropping systems. Agricultural Water Management. 2015; 156:110-117.
20. Charlton A, et al. Long-term impact of sewage sludge application on soil microbial biomass: An evaluation using meta-analysis. Environmental Pollution. 2016; 219: 1021-1035
21. Jogan H, Dasog GS. Effect of wastewaters on soil enzymes activity. International Journal of Current Microbiology and Applied Sciences. 2019; 8 (4):1080-1087.
22. Ankush, et al. Soil microbial and nutrient dynamics influenced by irrigation-induced salinity and sewage sludge incorporation in sandy – loam textured soil." International Agrophysics. 2020; 34 (4):451–462.
23. Aljaloud Abdulaziz A. Reuse of wastewater for irrigation in Saudi Arabia and its effect on soil and plant. 19th World Congress of Soil Science, Soil Solutions for a Changing World. 2010; 1-6.
24. Nauman M, Khalid SK. Heavy metals contamination of soils in response to wastewater irrigation in Rawalpindi region. Pakistan Journal of Agriculture Sciences.

Cite this article as:
Kumar V., Saini V.K., Ashu, Kumar A. and Rana S. (2023). A review of the use of sewage water in crop production and how it affects the physical, chemical, and biological characteristics of soil. *Int. J. of Pharm. & Life Sci.*, 14(10-12): 30-35.
Source of Support: Nil
Conflict of Interest: Not declared
For reprints contact: ijplsjournal@gmail.com