Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 1931-1934
Received: 16-11-2020
Accepted: 18-12-2020

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Long-term impact of sewage irrigation on chemical properties of soils

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Abstract
The study was done in order to observe the effect of long-term use of sewage irrigation on chemical properties of soils viz. pH, EC, OM and CEC. Three sites of sewage irrigated soils of Prayagraj were these sites selected for the study Beligaon, Buxibhanth, Kulbhaskar Ashram PG College farm. The representative soil samples were collected from different depths 0-10, 10-20 and 20-30 cm. The sewage irrigated soil samples were analyzed in lab to determine the chemical properties of soils. The pH, EC, OM and CEC of sewage irrigated soils decreased with increasing soil depth up-to 7.09±0.21, 0.67±0.19 dSm^{-1}, 1.02±0.12% and 19.92±0.79 Cmol (p+) kg^{-1} in 20-30 cm soil depth respectively. The EC, OM and CEC of sewage irrigated soils of all sewage irrigated selected sites were found as follows Beligaon 1.01±0.12 dSm^{-1}, 1.10±0.16%, 20.86±0.74 Cmol (p+) kg^{-1} Kulbhaskar Ashram PG College farm 1.04±0.21 dSm^{-1}, 1.03±0.11%, 20.17±0.76 Cmol(p+)kg^{-1} and Buxibandh 1.09±0.24 dSm^{-1}, 1.10±0.14%, 22.22±0.95 Cmol (p+) kg^{-1} found more in comparison to sewage non-irrigated soils respectively but pH are less in sewage irrigated soils than non-irrigated soils are Beligaon 7.56±0.25, Kulbhaskar Ashram PG College farm 7.46±0.25, and Buxibandh 7.31±0.11. Thus, it may be concluded that sewage irrigated soils accumulated more organic matter and salts on surface layer and consequently decreased with increased soil depth. This Organic matter decomposed by various soil microorganisms and release of various organic acids. These organic acids lower down the soil pH. Finley the sewage water influence the chemical properties of soils.

Keywords: sewage water, accumulation, organic carbon, organic matter

Introduction
The practices of adding sewage-sludge to the agricultural land is well established. They contain heavy metals in varying concentrations depending on the nature of the local industry and the proportion of domestic and industrial wastes. Food production and security for the ever increasing population are becoming a key challenge for the scientists. The food security demand enhanced agricultural productivity, which depends on soil quality. Unfortunately, industrialization and technological advancement have put and increasing burden on the soil by of the releasing large quantities of hazardous wastes, heavy metals, and organic contaminates that have in inflicted serious damage on the ecosystem the buildup of heavy metals (Cd, Cr, Pb) in soils and waters continuous serious health problems, as heavy metals con not be degraded in non-toxic forms, but persist in the ecosystem. Therefore, there is an urgent need to research the effects of sewage sludge and influence from treatment plants on heavy metal accumulation in soils, their mobility in the soil profile, determination of ground water quality and metals accumulation in plants. Sewage water is used as a source of irrigation for growing crops specially vegetables and fodder crops around the sewage discharge sites which are directly or indirectly consumed by human beings. Sewage is a rich source of organic and inorganic nutrients for plant growth, sewage irrigated farming is more common in all urban areas in India. Use of sewage water for irrigation purposes influence chemical properties and fertility level of the soil. Sewage water contains nutrients essential for plant growth and also contains heavy metals which may be toxic for human and animals if their concentration exceeds than the permissible limit. Irrigation with sewage water can increase water supply for alternative use. The irrigation with sewage water also contributes to cleaning of the environment, as the water doesn't discharge into water bodies that could otherwise get polluted. In addition to these direct economic benefits that conserve natural resources, this water contains a lot of nutrients that can serve as an alternative source to chemical fertilizers which are expensive (FAO, 1992, Avemelech, 1993) [6]. It has been estimated that typical wastewater from domestic sources could supply all the nutrients that are normally required for agricultural crop production (FAO 1992) [22].

The suitability of soils for receiving waste waters without deterioration varies widely, depending on certain properties of the soil such as their infiltration capacity, permeability, cation and anion exchange capacities, water holding capacity and texture (Schneider and Erickson, 1972, Brady and Weil 1999). The analysis showed that the irrigation with sewage water induces significant decrease of soil pH and increase soil EC, OM and CEC. Sewage irrigation has been practiced for centuries throughout the world (Shuval *et al.,* 1986; Tripathi *et al*., 2011) [25, 28]. It provides farmers with a nutrient enriched water supply and society with are liable and inexpensive system for waste water treatment and disposal (Feigin *et al.*, 1991) [7]. The composition of sewage water is variable depending upon the contributing source, mode of collection. The sewage water generated in India contains more than 90% water. The solid portion contains 40-50% organics, 30-40% inert materials, 10-15% bio-resistant organics and 5-8% miscellaneous substances on oven dry weight basis (Antil & Narwal, 2008).

Materials & Methods

Description of study area

The study was conducted in Prayagraj (Allahabad) which is located between latitudes 25º 20'-20º 57'N and longitudes 81º 52'-81º 86' E, Elevation above sea level 295 ft and belong to tropical sub-humid region indo-Gangetic plain. These soils of Gangetic plain are Alluvial (Entisols) having some recent origin. It is located in the north part of India, and in the southern part of Uttar Pradesh, at the junction of the Ganga and Yamuna rivers. Prayagraj has a humid subtropical climate and alluvial soil. The annual mean temperature is 26.1 °C (79.0 °F), Allahabad has three seasons: a hot, dry summer, a cool, dry winter and a hot, humid monsoon. Summer lasts from March to September with daily highs reaching up to 48 °C in the dry summer (from March to May) and up to 40 °C in the hot and extremely humid monsoon season (from June to September). The monsoon begins in June, and lasts till August; high humidity levels prevail well into September. Winter runs from December to February, with temperatures rarely dropping to the freezing point. The daily average maximum temperature is about 22 °C (72 °F) and the minimum about 9 °C (48 °F). Its highest recorded temperature is 48 °C (118.4 °F), and its lowest is −2 °C (28 °F).Rain from the Bay of Bengal or the Arabian Sea branches of the southwest monsoon falls on Allahabad from June to September, supplying the city with most of its annual rainfall of 1,027 mm (40 in), The highest monthly rainfall total, 333 mm (13 in), occurs in August.

Soil sampling and analysis

Representative soil samples had been collected from different soil depths (0-10, 10-20 and 20-30 cm) from sewage irrigated sites Beligaon, Kulbhaskar Ashram PG College farm and Buxibandh of Prayagraj. The larger fields were divided into suitable and uniform parts, and each of these uniform parts was considered a separate sampling unit. In each sampling unit, soil samples were drawn randomly from several spots, leaving about 2 m area along the field margins. Soil samples collected from the study area were dried and crushed with the help of wooden rod and passed through 2 mm sieve and well prepared then used for the determination of soil chemical properties such as EC, pH, OC, and CEC of soil were determined by adopting standard laboratory methods.

Methods of soil analysis

Table 1: Procedure used for analysis of chemical properties of soil

Properties	Method applied	Reference
Mechanical analysis of soils	Hydrometer method	
pH	Glass electrode pH meter	Jackson (1973)
EC (dSm-1)	Electrical conductivity meter	Jackson (1973)
Organic carbon (%)	Wet oxidation method	Walkey and Black (1934)
CEC (C mol (p+) kg-1)	Ammonium acetate method	Schollenberger and Dreibelbi (1930)

Result and Discussion

Soil pH

Table No.02 show the Soil pH decreased with increasing soil depth in all selected sites of sewage irrigated and non-irrigated soils are 7.94±0.21, 7.29±0.17, 7.09±0.22 and 8.52±0.61,7.86±0.40,7.34±0.30 at 0-10,10-20 and 20-30 cm soil depth respectively. Soil pH is less in sewage irrigated soil of all selected sites Beligaon 7.56±0.25, Kulbhaskar 7.46±0.25, Buxibandh 7.31±0.11 in comparison to non-irrigated sites 7.90±0.30 respectively. Among all sites of sewage irrigated soil maximum soil pH was recorded at Beligaon of all soil depths up to pH 7.56±0.25 and minimum soil pH 7.31±0.11 recorded at Buxibandh of all soil depths. Soil pH decreasing in increasing soil depth because of more accumulation of organic matter and various salts on soil surface resulting surface layer has higher pH than lower layer. this accumulated organic matter are decomposed to release of different organic acid these acid leach down in lower horizon resulting soil pH decreasing gradually increasing soil depth. It is evident from the data that frequent sewage-irrigation contributes to the build-up of soil fertility to some extent and can mitigate the scarcity of water in the dry and tropical regions (Annu *et al*., 2015; Mani *et al*., 2013a) [3, 17]. Such changes in pH and EC were also reported by Kumar *et al*. (2010). The reason for low pH in some sewage water irrigated soils may be due to the decomposition of organic matter and production of organic acids (Alghobar and Suresha, 2016) [19].

Table 2: pH of sewage irrigated and un-irrigated soils

Depth of soil profile (cm)	Selected sites				Mean
	Sewage un-irrigated soils	Sewage irrigated soils			
		Beligaon	Kulbhaskar	Buxibandh	
0-10	8.52±0.61	8.03±0.13	7.92±0.31	7.89±0.20	7.94±0.21
10-20	7.86±0.40	7.45±0.10	7.31±0.31	7.12±0.12	7.29±0.17
20-30	7.34±0.24	7.21±0.27	7.15±0.18	6.92±0.21	7.09±0.22
Mean	7.90±0.30	7.56±0.25	7.46±0.25	7.31±0.11	

Electrical Conductivity (dSm^{-1})

Table No.03 show the Soil EC decreased with increasing soil depth in all selected sites of sewage irrigated and non-irrigated soil are 1.22±0.18,1.16±0.15,0.67±0.19 and 0.78±0.15, 0.65±0.20, 0.39±0.15 dSm^{-1}at 0-10,10-20 and 20-30 cm soil depth respectively. Soil EC are more in sewage irrigated soil of all selected sites Beligaon 1.01±0.12, Kulbhaskar 1.04±0.21, Buxibandh 1.09±0.24 dSm^{-1} in comparison to non-irrigated soils 0.60±0.17 dSm^{-1} of all soil depth. Maximum soil EC 1.09 were recorded at Buxibandh of all soil depths and minimum soil EC 1.01dSm^{-1} recorded at Beligaon of all soil depths. Soil EC decreased in the increasing soil depth and higher soil EC in sewage irrigated soils than un-irrigated soils because in sewage irrigated soils more deposition of organic matter and bases on upper soil profile than lower profile. Such changes in pH and EC were also reported by Kumar *et al*. (2010) [14]. The high organic carbon in most of the sewage irrigated soils is due to a very high organic load of sewage water (Singh *et al*., 2012) [11] and also due to organic compounds of living beings in sewage effluent which are rapidly decomposed in the soil. Similar results were reported by Salakinkop and Hunshal (2014).

Table 3: Electrical Conductivity (d S m^{-1}) of sewage irrigated and non-irrigated soils

Depth of soil profile (cm)	Selected sites				Mean
	Sewage unirrigated soils	Sewage irrigated soils			
		Beligaon	Kulbhaskar	Buxibandh	
0-10	0.78±0.15	1.18±0.18	1.22±0.17	1.28±0.19	1.22±0.18
10-20	0.65±0.20	1.14±0.10	1.16±0.13	1.19±0.23	1.16±0.15
20-30	0.39±0.15	0.73±0.20	0.76±0.20	0.82±0.19	0.67±0.19
mean	0.60±0.17	1.01±0.12	1.04±0.21	1.09±0.24	

Organic matter (%)

Table No.04 show the Soil organic matter decreased with increase soil depth in all selected sites of Sewage irrigated and non-irrigated soil are 1.12±0.19, 1.09±0.17, 1.02±0.12 and 0.49±0.16, 0.43±0.13, 0.36±0.14 % at 0-10, 10-20 and 20-30 cm soil depth respectively. Soil OM was higher found in sewage irrigated soil of all selected sites Beligaon 1.10±0.16, Kulbhaskar 1.03±0.11, Buxibandh 1.10±0.14 in comparison to non-irrigated soils 0.42±0.10 % respectively. Highest soil OM 1.10±0.16 % was recorded at Beligaon and minimum soil OM 1.03±0.11 % recorded at Kulbhaskar. Soil OM decreased in increasing soil depth and more OM found in sewage irrigated soils because sewage irrigated soils more accumulation of organic matter on soil surface than lower horizon. The high organic carbon in most of the sewage irrigated soils is due to a very high organic load of sewage water (Singh *et al*., 2012) [11] and also due to organic compounds of living beings in sewage effluent which are rapidly decomposed in the soil. Similar results were reported by Salakinkop and Hunshal (2014).

Table 4: Organic Matter (%) of sewage irrigated and non-irrigated soils

Depth of soil profile (cm)	Selected sites				Mean
	Sewage un-irrigated soils	Sewage irrigated soils			
		Beligaon	Kulbhaskar	Buxibandh	
0-10	0.49±0.16	1.13±0.20	1.12±0.18	1.13±0.20	1.12±0.19
10-20	0.43±0.13	1.12±0.16	1.03±0.13	1.12±0.22	1.09±0.17
20-30	0.36±0.14	1.06±0.12	0.94±0.14	1.06±0.11	1.02±0.12
mean	0.42±0.10	1.10±0.16	1.03±0.11	1.10±0.14	

Cation Exchange Capacity (C mol (p+) kg^{-1})

Table No.05 show the Soil CEC decreased with increasing soil depth in all selected sites of sewage irrigated and non-irrigated soil are 22.11±0.94, 21.22±0.82, 19.92±0.79 and 19.04±0.96, 18.10±0.90, 17.50±0.69 Cmol $(P^{+})kg^{-1}$at 0-10, 10-20 and 20-30 cm soil depth respectively. Soil CEC higher in sewage irrigated soil of all selected sites Beligaon 20.86±0.74, Kulbhaskar 20.17±0.76, Buxibandh 22.22±0.95 in comparison to non-irrigated soils18.21±0.96 respectively. Among all sites of sewage irrigated soil maximum soil CEC 22.22±0.95 was recorded at Buxibandh and minimum soil CEC 20.17±0.76 recorded at Kulbhaskar Soil CEC decrease in increases soil depth because sewage irrigated soils more accumulation of organic matter on soil surface than lower soil horizon. Soil OM in sewage irrigated is more than non-irrigated soils due to more accumulation of organic matter in sewage irrigated soils. Organic matter has maximum CEC than other constitute of the soils.

Table 5: Cation exchange capacity (C mol (p+) kg^{-1}) of sewage irrigated and non-irrigated soils

Soil profile depth (cm)	Selected sites				Mean
	Sewage unirrigated soils	Sewage irrigated soils			
		Beligaon	Kulbhaskar	Buxibandh	
0-10	19.04±0.96	22.03±0.97	21.21±0.79	23.10±0.90	22.11±0.94
10-20	18.10±0.90	21.20±0.80	20.14±0.91	22.34±0.77	21.22±0.82
20-30	17.50±0.69	19.36±0.64	19.17±0.82	21.23±0.91	19.92±0.79
Mean	18.21±0.96	20.86±0.74	20.17±0.76	22.22±0.95	

Conclusion

Sewage irrigated soils of all selected sites of Prayagraj influence the chemical properties of soil. Sewage water of prayagraj city is generally discharge from households, industries, contain most of the organic and inorganic matter higher proportion of organic materials about 40-50%, inorganic matter contain essential nutrients likes N, P, K, etc. and heavy metals. These organic and inorganic materials loaded sewage water is used in irrigation of crops specially vegetables crops. Continuous use of sewage water influences the soil properties like decreasing soil Ph and increases the EC, CEC and OM due to accumulation of organic and inorganic matter in sewage water irrigated soils. Organic matter decomposition released various organic acids resulting lower the soil Ph. Soil Ph, EC, OM and CEC of soil gradually decreased with increased soil depth because accumulation of organic and inorganic matter decreased with increased soil profile depth. Humus substances has for a long time been known to form the complexes with metal ions. The exact nature of the chemical bonds between humic substances and metal ions is still uncertain but at least some of the linkage is of the chelate type, with the metal linkage to two adjacent functional groups. As the content of organic matter generally decreases with depth in the profile, the removal is attributable to the increasing content and /or activity of the inorganic colloids. Any downward movement of metals by leaching will also be influenced by soil physical properties.

References

1. Ambika SR, Ambica PK, Govindaiah. Crop growth and soil properties affected by sewage water irrigation a review. Agril. Reviews 2010;31(3):203-209.
2. Angin I, Yaganoglu AV, Turan M. Effects of long-term wastewater irrigation on soil properties. Sustain Agriculture Journal 2005;26:31-42.
3. Annu, Urmila, Garg A. Variation of heavy metal accumulation with physiochemical properties of industrial soil of Rohtak City, Haryana. Int. J. Sci. Engin. Technol 2015;3(1):333-340.
4. Chopra SL, Kanwar JS. Analytical Agricultural Chemistry, Kalyani Publication, New Delhi 1999.
5. Darvishi HH, Manshouri M, Farahani HA. The effect of irrigation by domestic wastewater on soil properties. J. Soil Sci. Environ. Manage 2010;1(2):030-033.
6. FAO. Waste water treatment and use in agriculture, Food and Agricultural Organization of the United Nation, FAO, 47, Rome 1992.
7. Feigin A, Ravina I, Shalhevet J. Irrigation with treated sewage effluent. Management for Environmental Protection. Advanced Series in Agricultural Sciences, Springer-Verla 1991;17:224.
8. Gupta AP, Narwal RP, Antil RS. Sewer waters composition and their effect on soil properties. Bioresource Technology 1998; 65:171-173.
9. Gupta AP, Narwal RP, Antil RS, Singh A, Poonia SR. Impact of sewage water irrigation on soil health. In: Impact of Modern Agriculture on Environment, RK Behl, SK Arora & P Tauro (Ed.), CCS Haryana Agricultural University, Hisar and Max Muller Bhawan, New Delhi 1994,109-117.
10. 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 2005.
11. Kannaujia R, Singh S. Levels, Spatial Distribution and Possible Sources of Heavy Metal Contamination of Suburban Soil in Jhansi. Orient. J. Chem 2012;28(4):1913-1918.
12. Khai NM, Tuan PT, Vinh NC, Oborn I. Effects of using wastewater as nutrient sources on soil chemical properties in peri-urban agricultural systems. V.N.U. J. Sci., Earth Sci 2008;24:87-95.
13. Kharche VK, Desai VN, Pharande 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. Kumar C, Mani D. Enrichment and management of heavy metals in sewage-irrigated soil. Lap LAMBERT Acad. Publishing, Dudweiler, Germany 2010.
15. Mani D, Patel NK, Mourya VK, Pal N. Accumulation and uptake of heavy metals (Cd, Pb and Zn) in vegetable crops grown in sewage contaminated soils. J Nat. Res. Dev 2013;8(2):1-12.
16. Kumar V, Prasad RK, Prasad B, Singh AP. Depth wise distribution and horizontal movement of Cadmium and Nickel in sewage-effluent-irrigated soils and their uptake by vegetable crops grown thereon. J. Indian Soc. Soil Sci 2010;58(3):286-292.
17. Mani D, Sharma B, Kumar C, Balak S. Depth-wise distribution, mobility and naturally occurring glutathione based phytoaccumulation of cadmium and zinc in sewage-irrigated soil profiles. Int. J. Environ. Sci. Technol 2013;10:1167-1180.
18. Mathan KK. Studies on the influence of long-term municipal sewage effluent irrigation on soil properties. Bio-resource Technology 1994;48:275-276.
19. Mohammed A, Alghobar, Lathamani Ramachandra, Sidduraiah Suresha. 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 2014.
20. Narwal RP, Singh M, Gupta AP. Effect of different sources of irrigation on the physico-chemical properties of soil. Indian Journal of Environment and Agriculture 1988;3:27-34.
21. Narwal RP, Gupta AP, Singh A, Karwasra SPS. Composition of some city waste waters and their effect on soil characteristics. Annals of Biology 1993;9:239-245.
22. Pescod MB. Waste water treatment and use in agriculture. Bull FAO, Rome 1992;47:125.
23. Ramesh M. Soil and water resource characteristics in relation to land disposal of sewage effluents and suitability of sewage water for irrigation. M.Sc. (Ag.) Thesis. Acharya N.G. Ranga Agricultural University, Hyderabad 2003.
24. Rana L, Dhankhar R, Chhikara S. Soil characteristics affected by long term application of sewage wastewater. Int. J Environ Res 2010;4(3):513–518.
25. Shuval HI, Adin A, Fattal B, Rawitz E, Yekutiel P. Waste water irrigation in developing countries, Health effects and technical solutions, World Bank Technical Report 51, 1986,325.
26. Singh J, Kansal BD. Effect of long term application of municipal waste water on some chemical properties of soil. Journal of Research Punjab Agricultural University 1985;22:235-242.
27. Tripathi DR, Misra. International Journal of Environmental Sciences, India 2012,2(4)
28. Tripathi DM, Tripathi S, Tripathi BD. Implications of secondary treated distillery effluent irrigation on soil cellulose and urease activities. Journal of Environment Protection 2011;2:655-661.
29. Vaseghi S, Afyuni M, Shariatmadari H, Mobli M. Effect of sewage sludge on some nutrients concentration and soil chemical properties. Journal of Isfahan Water and Waste water 2005;53:15-19 (in Persian)