
*International Journal of Plant & Soil Science*

*29(6): 1-7, 2019; Article no.IJPSS.51828*
*ISSN: 2320-7035*

# Chemical Properties of Soil Influence by Sewage Water Irrigation of Different District of Haryana

**Sushil[1*], R. S. Garhwal[1], Md. Sarware Alam[1], Deepika Rathi[1] and Dinesh[1]**

*[1]Department of Soil Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar-125004, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/IJPSS/2019/v29i630163
Editor(s):
(1) Dr. Francisco Cruz-Sosa, Department of Biotechnology, Metropolitan Autonomous University Iztapalapa Campus, Av. San Rafael Atlixco 186 México City 09340 México.
Reviewers:
(1) Fábio Henrique Portella Corrêa de Oliveira, Universidade Federal Rural de Pernambuco, Brazil.
(2) J. S. Tenywa, Makerere University, Uganda.
(3) P. Rahim Foroughbakhch, Autonomous Univ. of Nuevo León, Mexico.
Complete Peer review History: https://sdiarticle4.com/review-history/51828

***Original Research Article***

***Received 31 June 2019***
***Accepted 24 September 2019***
***Published 28 September 2019***

## ABSTRACT

The present study deals with the difference of chemical properties between sewage and tube well water irrigated soils. Samples were collected from sewage and tube well water irrigated soil of various site like Kaithal, Narwana and Jind district of Haryana state where these waters are directly used for irrigating the crops. Soil samples (0-15 and 15-30 cm) were also collected from fields irrigated with these waters and from nearby fields irrigated with non-sewage waters to determine the changes in soil chemical properties due to sewage irrigation. Total Zn, Cu, Mn, Fe, Cd, Pb, Co, and Cr along with nitrogen, phosphorus and potassium were estimated form the samples. The mean value of N (200.50 kg $ha^{-1}$) was found highest in the soils irrigated with sewage water of Kaithal. The mean value of P (35.85 kg $ha^{-1}$) and K (236.40 kg $ha^{-1}$) was found highest in the soils irrigated with sewage water of Jind. The mean value of K (236.40 kg $ha^{-1}$) was found highest in the soils irrigated with sewage water of Jind. The mean value of Zn (4.43 mg $kg^{-1}$), Cu (3.33 mg $kg^{-1}$) and Fe (19.43 mg $kg^{-1}$) was found highest in the soils irrigated with sewage water of Jind. The mean value of Mn (15.13 mg $kg^{-1}$) was found highest in the soils irrigated with sewage water of Kaithal. The DTPA extractable heavy metals like Cd, Pb and Co were found higher in the soils

**Corresponding author: E-mail: chauhan.sushil1367@gmail.com;*

irrigated with sewage water as compared to soils irrigated with non-sewage water. The value of Cr content was found nil all the soils samples collected from different cities from sewage and non-sewage water irrigated sites.

*Keywords: Available (N, P and K); heavy metals; macro-micronutrients and sewage water.*

## 1. INTRODUCTION

With the demand for food increasing day by day, more and more land is to be brought under cultivation. Thus increasing the demand for inorganic fertilizers as well as irrigated water [1]. Hence the focus is shifting towards various non-conventional sources of irrigation available easily [2]. Among others, one of the important irrigation as well as a nutrient source is municipal sewage water. About 97% of earth's water is saline and in the remaining freshwater, 68% is locked up in ice and glaciers, 30% is in the ground and the remaining constitute the surface water [3,4]. Begum et al. [5] stated that about 95%of the earth's water is in the ocean, 4 per cent is locked in the polar ice caps and remaining 1 per cent constitutes in a hydrological cycle including groundwater reserves. Only 0.1 per cent is available in as freshwater in rivers, lakes and streams which is suitable for human consumption. India supports about 1/6$^{th}$ of world population, 1/50$^{th}$ of the world's land and 1/25$^{th}$ of the world's water resources. It has a livestock population of 20 per cent of the world's total livestock population. The total utilizable water resources of the country are assessed as 1086 km$^3$. With increasing population, demand and utilization of water are also increasing. India has an agriculture-based economy; hence more than seventy per cent of water is being utilized for the irrigation [6].

Now-a days, in some areas around urban cities the untreated wastewater or sewage water is directly used for irrigating different crops which may raise some public health hazards like the outbreaks of some dangerous epidemics [7]. A most important parameter in sewage water is the different microbial populations which can cause various diseases. Wastewater is likely to contain high levels of bacteria, parasitic organism and other pathogens as well as heavy metals [8].

In developing countries like India, there has not been much emphasis on the installation of sewage treatment plants and all the industrial effluents are generally discharged into the domestic sewer system. In India, 16625 million litres of sewage water is generated daily [9]. Out of which only 24 per cent is treated and the remaining 76 per cent of sewage are discharged into the land without any treatment. In Haryana also about 485.2 million litres of sewage water is produced per day and could be utilized directly, without pre-treatment for irrigation purpose. For example, Rattan et al. [10] found a high amount of phosphorus, potassium, sulphur, zinc, and manganese in sewage water which improved the soil organic matter contents (38–79%) than the underground water.

The composition and volume of wastewater discharged vary from city to city, but broadly the effluents discharged into the sewage water is reported to contain toxic elements such as Cd, Cr, Pb, Cu, Zn, Fe, Mn etc. [11]. Developing countries, like India, require reliable and low-cost technology methods for acquiring new water supplies and protection against the contamination of water to be used for agricultural purposes [12].

## 2. MATERIALS AND METHODS

Soil samples irrigated with sewage water and groundwater were selected to compare the impact of water source on the soil from 3 sites across Kaithal, Narwana and Jind district of Haryana. The study area is located in Haryana in northern India, situated between 27°39' to 30°35' N latitude and between 74°28' and 77°36'E longitude. Under each district, four sites were selected for the sampling of sewage and non-sewage source of water for irrigation at 0-15 and 15-30 cm depth. From each site, two samples were taken from each depth and the mean values of the soil properties estimated in the laboratory were presented in tabulated form. The soil samples were first air-dried ground with wooden pestle and mortar and passed through 2 mm stainless steel sieve. After mixing thoroughly, the processed samples were stored in cloth bags and used for various chemical properties, using standard methods.

### 2.1 Samples Analysis

Available nitrogen in soil sample was determined by adopting the alkaline permanganate method of [13]. The phosphorus content of the soil was estimated following the method as described by

Olsen et al. [14]. Soil available phosphorus was extracted using 0.5 M NaHCO3 (pH 8.5) and determination was done by the ascorbic acid method as described by Miller and Keeney [15]. The transmittance or absorbance of the blue colour so developed was read after 10 minutes, on a spectrophotometer at 660 nm wavelength. The available potassium was extracted with neutral normal ammonium acetate with a flame photometer [16].

Total Zn, Cu, Mn, Fe, Cd, Pb, Co, and Cr were estimated in acidified digested samples using atomic absorption spectrophotometer (AAS). The statistical analysis was accomplished by the Statistical Software Package for Agricultural Research Workers [17].

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Sewage and Non-sewage Water on Soil Chemical Properties

The quality of sewage and well waters was assessed for irrigation concerning their different parameters. The data about Available macro-nutrients (N, P and K) of sewage and non-sewage water irrigated soils are presented in Tables 1 to 3.

### 3.2 Available Macro-nutrients (NPK)

The range of available nitrogen values of sewage water irrigated soil were recorded from 187 to 214, 135.20 to 154, 103.41 to 133 kg $ha^{-1}$ as compare to non-sewage water irrigated soil were recorded from 117.5 to 128, 83.30 to 93.76, 67.44 to 81.70 kg $ha^{-1}$ of Kaithal, Narwana and Jind respectively. The value of available nitrogen was found highest (187 to 214 kg $ha^{-1}$) in the sewage water irrigated soil of Kaithal followed by Narwana (135.20 to 154 kg $ha^{-1}$) and Jind (103.41 to 133 kg $ha^{-1}$). The mean value of available nitrogen was found highest (200.50 kg $ha^{-1}$) in the sewage water irrigated soil of Kaithal as compared to the non-sewage water irrigated soil (122.75 kg $ha^{-1}$) of Kaithal.

The range of available phosphorus values of sewage water irrigated soil were recorded from 22.74 to 28.36, 22.64 to 25.68, 35 to 36.70 kg $ha^{-1}$ as compare to non-sewage water irrigated soil were recorded from 14.88 to 16.10, 17.20 to 19, 16.20 to 26.99 kg $ha^{-1}$ of Kaithal, Narwana and Jind respectively. The value of available phosphorus was found highest (35 to 36.70 kg $ha^{-1}$) in the sewage water irrigated soil of Jind followed by Kaithal (22.74 to 28.36 kg $ha^{-1}$) and Narwana (22.64 to 25.68 kg $ha^{-1}$). The mean value of available phosphorus was found highest (35.85 kg $ha^{-1}$) in the sewage water irrigated soil of Jind as compared to the non-sewage water irrigated soil (21.60 kg $ha^{-1}$) of Jind.

The range of available potassium values of sewage water irrigated soil were recorded from 194.52- 216.56, 162.20-182.30, 227.50-245.30 kg $ha^{-1}$ as compare to non-sewage water irrigated soil were recorded from 118.70-130.30, 110.30-114.10, 114.10-171.10 kg $ha^{-1}$ of Kaithal, Narwana and Jind respectively. The value of available potassium was found highest (227.50-245.30 kg $ha^{-1}$) in the sewage water irrigated soil of Jind followed by Kaithal (194.52-216.56 kg $ha^{-1}$) and Narwana (162.20- 182.30 kg $ha^{-1}$). The mean value of available potassium was found highest (236.40 kg $ha^{-1}$) in the sewage water irrigated soil of Jind as compared to the non-sewage water irrigated soil (142.60 kg $ha^{-1}$) of Jind.

Nitrogen (N), P and K were higher in the soils irrigated with sewage water at 0-15 cm as well as at 15- 30 cm as compared to available N, P and K in the soils irrigated with non-sewage water. The increase in N content of soils irrigated with sewage water might be because sewage water contained more nitrogen as compared to non-sewage water which increases the available nitrogen in the soil. Similar results were reported by Datta et al. [18], Yadav et al. [11], Rattan et al. [10] and Gwenzi and Munondo [19].

### 3.3 DTPA Extractable Micro-nutrients and Heavy Metals of Sewage and Non-sewage Water

Data on the DTPA-extractable micronutrients like Zn, Cu, Fe and Mn and heavy metals like Cd, Cr, Pb and Co are presented in Tables 4 to 6. The highest mean value of micronutrients like Zn, Cu, Fe were found in the soils irrigated with sewage water at 0-15 cm depth in district Jind (4.43, 3.33 and 19.43 mg $kg^{-1}$) as compared to highest Zn, Cu and Fe contents in the soils irrigated with non-sewage water in district Jind (2.34, 1.27 and 9.88 mg $kg^{-1}$). The soils irrigated with sewage water at 0-15 cm resulted into higher Mn content in district Kaithal (15.13 mg $kg^{-1}$) whereas the highest Mn content in the soils irrigated with non-sewage water in district Kaithal (6.82 mg $kg^{-1}$). Likewise, the status of micronutrients at 15-30 cm depth of soils irrigated with sewage water was found higher as compared to soils irrigated with non-sewage water. The sewage water contained all these DTPA extractable microelements in higher amounts as compared to the non-sewage water. This resulted in their higher contents in the soils applied with the sewage water. Similar results were reported by Datta et al. [18], Rattan et al. [20], Patel et al. [21], Rattan et al. [10] and Suhag et al. [22], Oman et al. [23], Prakash et al. [24], Kharche et al. [25] and Zan et al. [26].

The DTPA extractable heavy metals like Cd, Pb and Co were higher in the soils irrigated with sewage water at both the depths (0-15 and 15-30 cm) as compared to soils irrigated with non-sewage water. The Cr content was nil all the soils samples collected from different cities from sewage and non-sewage water irrigated sites. The mean value of Cd and Pb content was approx. same all the sites not more difference in sewage irrigated soil but the content was higher as compare to non-sewage irrigated soil. The lead was found highest 0.21 mg kg -1 in the sewage water irrigated soils of Jind. The higher content of heavy metals was due to the higher quantity of these metals in the sewage water due to which they were diagnosed in higher amount in the soils irrigated with sewage water as compared to the non-sewage water. The major source of heavy metals in the sewage water is metal plating industries, combustion of fossil fuels and mining and electroplating. The direct discharge of the wastes from these industries into the sewage water increased the heavy metal which upon irrigation increased the heavy metals in the agricultural land. However, in the present study, all the heavy metals from all five sites were found below the permissible limit (FAO, 1985). Similar results were reported by Zan et al. [26], Kharche et al. [25], Oman [23], Prakash et al. [24], Suhag et al. [22], Rattan et al. [10], Tandi et al. [27], Rattan et al. [20], Datta et al. [18] and Kabata-Pendias [28].

**Table 1. Available macro-nutrients of sewage and non-sewage water irrigated soils of peri-urban area of Kaithal**

| Location | Depth (cm) | kg ha$^{-1}$ | | |
|---|---|---|---|---|
| | | **N** | **P** | **K** |
| SW-1 | 0-15 | 187.00 | 28.36 | 194.52 |
| | 15-30 | 158.20 | 22.36 | 171.00 |
| SW-2 | 0-15 | 214.00 | 22.74 | 216.56 |
| | 15-30 | 176.80 | 17.58 | 180.20 |
| NSW-1 | 0-15 | 117.50 | 16.10 | 130.30 |
| | 15-30 | 91.25 | 15.40 | 113.70 |
| NSW-2 | 0-15 | 128.00 | 14.88 | 118.70 |
| | 15-30 | 105.90 | 12.26 | 105.10 |
| Mean sewage | 0-15 | 200.50 | 25.55 | 205.54 |
| | 15-30 | 167.50 | 19.97 | 175.60 |
| Mean non-sewage | 0-15 | 122.75 | 15.49 | 124.50 |
| | 15-30 | 98.58 | 13.83 | 109.40 |

*SW - Sewage water, NSW - Non-sewage water*

**Table 2. Available macro-nutrients of sewage and non-sewage water irrigated soils of peri-urban area of Narwana**

| Location | Depth (cm) | kg ha$^{-1}$ | | |
|---|---|---|---|---|
| | | **N** | **P** | **K** |
| SW-1 | 0-15 | 154.00 | 25.68 | 182.30 |
| | 15-30 | 150.50 | 23.52 | 173.50 |
| SW-2 | 0-15 | 135.20 | 22.64 | 162.20 |
| | 15-30 | 125.51 | 22.10 | 160.90 |
| NSW-1 | 0-15 | 83.30 | 17.20 | 114.10 |
| | 15-30 | 36.12 | 14.86 | 107.80 |
| NSW-2 | 0-15 | 93.76 | 19.00 | 110.30 |
| | 15-30 | 67.00 | 18.96 | 102.30 |
| Mean sewage | 0-15 | 144.60 | 24.16 | 172.25 |
| | 15-30 | 138.01 | 22.81 | 167.20 |
| Mean non-sewage | 0-15 | 88.53 | 18.10 | 112.20 |
| | 15-30 | 51.56 | 16.91 | 105.05 |

*SW - Sewage water, NSW - Non-sewage water*

**Table 3. Available macro-nutrients of sewage and non-sewage water irrigated soils of peri-urban area of Jind**

| Location | Depth (cm) | kg ha$^{-1}$ | | |
|---|---|---|---|---|
| | | N | P | K |
| SW-1 | 0-15 | 133.00 | 36.70 | 245.30 |
| | 15-30 | 129.50 | 28.52 | 215.00 |
| SW-2 | 0-15 | 103.41 | 35.00 | 227.50 |
| | 15-30 | 76.52 | 21.20 | 170.30 |
| NSW-1 | 0-15 | 81.70 | 16.20 | 114.10 |
| | 15-30 | 41.90 | 13.66 | 101.50 |
| NSW-2 | 0-15 | 67.44 | 26.99 | 171.10 |
| | 15-30 | 55.17 | 12.40 | 138.30 |
| Mean sewage | 0-15 | 118.21 | 35.85 | 236.40 |
| | 15-30 | 103.01 | 24.86 | 192.65 |
| Mean non-sewage | 0-15 | 74.57 | 21.60 | 142.60 |
| | 15-30 | 48.54 | 13.03 | 119.90 |

*SW - Sewage water, NSW - Non-sewage water*

**Table 4. DTPA extractable micro-nutrients and heavy metals of sewage and non-sewage water irrigated soils of peri-urban area of Kaithal**

| Location | Depth (cm) | Zn | Cu | Fe | Mn | Cd | Cr | Pb | Co |
|---|---|---|---|---|---|---|---|---|---|
| | | (mg kg$^{-1}$) | | | | | | | |
| SW-1 | 0-15 | 2.15 | 2.74 | 19.88 | 14.31 | 0.05 | Nil | 0.25 | 0.12 |
| | 15-30 | 1.67 | 2.49 | 16.36 | 12.63 | 0.03 | Nil | 0.17 | 0.09 |
| SW-2 | 0-15 | 2.36 | 2.21 | 18.56 | 15.95 | 0.03 | Nil | 0.14 | 0.11 |
| | 15-30 | 1.81 | 2.03 | 15.62 | 14.41 | 0.02 | Nil | 0.13 | 0.10 |
| NSW-1 | 0-15 | 1.44 | 1.35 | 8.23 | 7.53 | 0.02 | Nil | 0.09 | 0.04 |
| | 15-30 | 1.29 | 1.05 | 7.81 | 5.19 | 0.01 | Nil | 0.06 | 0.03 |
| NSW-2 | 0-15 | 1.12 | 1.17 | 7.46 | 6.11 | 0.01 | Nil | 0.07 | 0.05 |
| | 15-30 | 1.02 | 1.15 | 8.06 | 5.48 | 0.01 | Nil | 0.06 | 0.03 |
| Mean sewage | 0-15 | 2.26 | 2.48 | 19.22 | 15.13 | 0.04 | Nil | 0.20 | 0.12 |
| | 15-30 | 1.74 | 2.26 | 15.99 | 13.52 | 0.03 | Nil | 0.15 | 0.10 |
| Mean non-sewage | 0-15 | 1.28 | 1.26 | 7.85 | 6.82 | 0.02 | Nil | 0.08 | 0.05 |
| | 15-30 | 1.16 | 1.10 | 7.94 | 5.34 | 0.01 | Nil | 0.06 | 0.03 |

*SW - Sewage water, NSW - Non-sewage water*

**Table 5. DTPA extractable micro-nutrients and heavy metals of sewage and non-sewage water irrigated soils of peri-urban area of Narwana**

| Location | Depth (cm) | Zn | Cu | Fe | Mn | Cd | Cr | Pb | Co |
|---|---|---|---|---|---|---|---|---|---|
| | | (mg kg$^{-1}$) | | | | | | | |
| SW-1 | 0-15 | 1.66 | 2.70 | 19.22 | 13.92 | 0.04 | Nil | 0.23 | 0.09 |
| | 15-30 | 1.50 | 2.62 | 17.51 | 11.70 | 0.03 | Nil | 0.21 | 0.06 |
| SW-2 | 0-15 | 1.36 | 2.20 | 18.08 | 11.21 | 0.03 | Nil | 0.14 | 0.08 |
| | 15-30 | 1.08 | 1.61 | 18.00 | 9.75 | 0.03 | Nil | 0.14 | 0.08 |
| NSW-1 | 0-15 | 0.58 | 0.77 | 8.35 | 4.89 | 0.02 | Nil | 0.08 | 0.02 |
| | 15-30 | 0.33 | 0.33 | 7.63 | 4.01 | 0.02 | Nil | 0.07 | 0.01 |
| NSW-2 | 0-15 | 0.57 | 0.45 | 11.13 | 5.34 | 0.02 | Nil | 0.05 | 0.02 |
| | 15-30 | 0.29 | 0.68 | 10.82 | 5.17 | 0.01 | Nil | 0.05 | 0.02 |
| Mean sewage | 0-15 | 1.51 | 2.45 | 18.65 | 12.57 | 0.04 | Nil | 0.19 | 0.09 |
| | 15-30 | 1.29 | 2.12 | 17.76 | 10.73 | 0.03 | Nil | 0.18 | 0.07 |
| Mean non-sewage | 0-15 | 0.58 | 0.61 | 9.74 | 5.12 | 0.02 | Nil | 0.07 | 0.02 |
| | 15-30 | 0.31 | 0.51 | 9.23 | 4.59 | 0.02 | Nil | 0.06 | 0.02 |

*SW - Sewage water, NSW - Non-sewage water*

**Table 6. DTPA extractable micro-nutrients and heavy metals of sewage and non-sewage water irrigated soils of peri-urban area of Jind**

| Location | Depth (cm) | Zn | Cu | Fe | Mn | Cd | Cr | Pb | Co |
|---|---|---|---|---|---|---|---|---|---|
| | | (mg kg$^{-1}$) | | | | | | | |
| SW-1 | 0-15 | 4.86 | 3.67 | 21.51 | 13.68 | 0.06 | Nil | 0.20 | 0.21 |
| | 15-30 | 4.50 | 2.64 | 18.38 | 10.86 | 0.03 | Nil | 0.14 | 0.15 |
| SW-2 | 0-15 | 4.00 | 2.98 | 17.34 | 11.31 | 0.04 | Nil | 0.15 | 0.13 |
| | 15-30 | 3.27 | 2.68 | 16.96 | 9.48 | 0.03 | Nil | 0.12 | 0.09 |
| NSW-1 | 0-15 | 2.23 | 1.26 | 10.50 | 5.72 | 0.02 | Nil | 0.06 | 0.04 |
| | 15-30 | 2.01 | 1.15 | 8.86 | 4.81 | 0.01 | Nil | 0.02 | 0.02 |
| NSW-2 | 0-15 | 2.45 | 1.27 | 9.25 | 5.90 | 0.01 | Nil | 0.07 | 0.05 |
| | 15-30 | 1.63 | 1.13 | 8.06 | 4.06 | 0.01 | Nil | 0.03 | 0.02 |
| Mean sewage | 0-15 | 4.43 | 3.33 | 19.43 | 12.50 | 0.05 | Nil | 0.18 | 0.17 |
| | 15-30 | 3.89 | 2.66 | 17.67 | 10.17 | 0.03 | Nil | 0.13 | 0.12 |
| Mean non-sewage | 0-15 | 2.34 | 1.27 | 9.88 | 5.81 | 0.02 | Nil | 0.07 | 0.05 |
| | 15-30 | 1.82 | 1.14 | 8.46 | 4.44 | 0.01 | Nil | 0.03 | 0.02 |

*SW - Sewage water, NSW - Non-sewage water*

## 4. CONCLUSION

The above study describes that, in Kaithal, Narwana and Jind was found to be improving soil properties due to application of sewage water irrigation. Sewage water contains a high amount of N, P, and K. So, the application of sewage water reduces the cost of fertilizer to provide a better growth conditions for the crop. Sewage water has a high amount of micronutrients like Zn, Cu, Fe and Mn, but all these nutrients are present below the permissible limit. If sewage water present in a high amount than toxic heavy metals like Cd, Cr, Pb and Co had adverse effect on the crops. To avoid this type of problem regular monitoring of the field is done and use mixed water that is a combination of both sewage and non-sewage water.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Singh H, Alam Md. S, Singh AK, Pratap T, Ingle SR, Maurya JK, Devrajand, Dahiya DS. Effect of sewage and industrial effluents application on soil physical properties and nutrient uptake by plants in Karnal (Haryana), India. International Journal of Chemical Studies. 2018;6(3):156-160.
2. Sushil, Garhwal RS, Dinesh, Singh R. Effect of sewage water on physical properties of cultivated soils of Peri-urban Areas of Haryana. Journal of Pharmacognosy and Phytochemistry. SP1. 2019;128-131.
3. Gleick PH. Water resources. In Encyclopedia of climate and weather, (By schneidered SH), Oxford University Press, New York. 1996;2:817-823.
4. Howard P. USGS- Science for a changing world: Earth's water distribution; 2009.
   Available:http://ga.water.usgs.gov/edu/waterdistribution.html
   (Retrieved on 26-01-2010)
5. Begum A, Harikrishna S, Khan I. Chemical composition of rain water in south Bangalore, Karnataka. Rasayan journal of Chemistry. 2008;1(4):856-861.
6. Kumar R, Singh RD, Sharma KD. Water resources of India. Current Science. 2005;89(5):794-811.
7. Jaramillo M, Restrepo I. Wastewater reuse in agriculture: A review about its limitations and benefits. Sustainability. 2017;9(10): 1734.
8. Srikanth R, Khanam A, Rao V. Cadmium levels in the urine of male sludge farmers in India. Journal of Toxicology and Environmental Health. 1994;43:1-6.
9. Minhas PS. Wastewater use for sustainable agriculture – Indian perspective. Proc. Inter. Conf. on soil water and environmental quality – Issues and strategies. New Delhi. 2005;84-90.
10. Rattan RK, Datta SP, Chhonkar PK, Suribabu K, Singh AK. Long term impact of irrigation with sewage effluents on heavy metal content in soils, crops and ground water – A case study. Agriculture, Ecosystems and Envionment. 2005;109: 310-322.
11. Yadav RK, Chaturvedi RK, Dubey SK, Joshi PK, Minhas PS. Potentials and

hazards associated with sewage irrigation in Haryana. Indian Journal of Agricultural Science. 2003;73:249-255.
12. Asano T, Levine AD. Wastewater reclamation, recycling and reuse: Past, present, and future. Water Science and Technology. 1996;33(10-11):1-14.
13. Subbiah, Ashija. Available nitrogen in soil. In practiced Agricultural Chemistry by Kanwar JS, Chopra SL, Chand S and Co., New Delhi. 1956;100-107.
14. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bioca-rboante. Circ U.S. Dep. Agric. 1954;939.
15. Millar RH, Keeney DR. Method of soil analysis. Part-II American Society of Agronomy, Madison Wiscosin, USA; 1982.
16. Jackson ML. Soil chemical analysis. Prentic Hall (India) Pvt. Ltd. New Delhi; 1973.
17. Sheoran OP, Tonk DS, Kaushik LS, Hasija RC, Pannu RS. Statistical software package for agricultural research workers. Recent Advances in Information Theory, Statistics & Computer Applications by D.S. Hooda& R.C. Hasija, Department of Mathematics Statistics, CCS HAU, Hisar. 1998;139-143.
18. Datta SP, Biswas DR, Saharan N, Ghosh SK, Rattan SR. Effect of long-term application of sewage effluents on organic carbon, bio-available phosphorus, potas-sium and heavy metal status of soils and content of heavy metals in crops grown thereon. Journal of the Indian Society of Soil Science. 2000;48(4):836-739.
19. Gwenzi W, Munondo R. Long-term impacts of pasture irrigation with treated sewage effluent on nutrient status of a sandy soil in Zimbabwe. Nutrient Cycling in Agroecosystems. 2008;82(2):197-207.
20. Rattan RK, Datta SP, Singh AK, Chonkar PK, Suribau K. Effect of long-term application of sewage effluents on available nutrients and available water status in soil under Keshopur effluent irrigation scheme in Delhi. Journal of Water Management. 2001;9:21-26.
21. Patel KP, Pandya RR, Maliwal GL, Patel KC, Ramani VP, George V. Heavy metal content of different effluents and their relative availability in soils irrigated with effluent water around major industrial cities of Gujarat. Journal of the Indian Society of Soil Science. 2004;52(1):89-94.
22. Suhag V, Jha A, Suhag A. Sewage irrigation: An environmental challenge. Annals of Biology. 2008;24(2):125-129.
23. Oman AM. Long term effect of irrigation with the treated sewage effluent on some soil properties for date palms in Al Hassa, Saudi Arabia. Proceedings of the 19th World Congress of Soil Science: Soil solutions for a changing world, Brisbane, Australia, 1-6 August 2010. Symposium 3.5.1 Heavy Metal Contaminated Soils. 2010;169-172.
24. Prakash UHB, Parama VR, Rashmi I, Munavere A. Heavy metals contamination in the soils of peri-urban Banglore irrigated with sewage and industrial effluents. Journal of Soils and Crops. 2010;20(1):10-15.
25. 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.
26. Zan NR, Datta SP, Rattan RK, Dwivedi BS, Meena MC. Prediction of the solubility of zinc, copper, nickel, cadmium, and lead in metal contaminated soils. Environmental Monitoring and Assessment. 2013;185(12): 10015-10025.
27. Tandi NK, Nyamangara J, Bangira C. Environmental and potential health effects of growing leafy vegetables on soil irrigated using sewage sludge and effluent: A case of Zn and Cu. Journal of Environmental Science and Health, Part B. 2004;39(3):461-471.
28. Kabata-Pendias A. Trace metals in soils in Poland—Occurrence and behaviour. Soil Science. 1992;140:53-70.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://sdiarticle4.com/review-history/51828*