Vol. 48, No. 3, pp 277–285, 2020
Indian Journal of Soil Conservation

# Spatial distribution and correlation characteristics of heavy metals in sewage and tube well water irrigated peri-urban areas of Haryana

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ARTICLE INFO

***Article history:***
Received : Augusts, 2020
Revised : December, 2020
Accepted : December, 2020

***Key words:***
DTPA
GPS
Heavy metals
Physico−chemical properties
Spatial distribution

## ABSTRACT

A study on “spatial distribution and correlation characteristics of heavy metals in peri−urban areas of Haryana, India” was conducted during 2018−19 in sewage and tube well water irrigated areas of Mohindergarh and Narnaul cities of Haryana. In this study soil samples were collected using Global Positioning System (GPS) by following random sampling method and analyzed for physico−chemical properties and DTPA extractable heavy metals (Zn, Cu, Cd, Cr, Pb, Ni and Co). In soil, chemical properties like electrical conductivity (EC), organic carbon (OC) and cation exchange capacity (CEC) found to be higher in sewage irrigated soils compared to tube well irrigated whereas pH and $CaCO_3$ higher in tube well irrigated than sewage irrigated soils of the study area and DTPA extractable Zn content was higher followed by Cu > Pb > Ni > Cr > Co > Cd in sewage irrigated soils than tube well irrigated soils and found within the permissible limit.

## 1. INTRODUCTION

Rapid industrialization and chaotic urbanization have majorly contributed the elevated levels of pollutants in the urban environment of India (Khillare *et al.*, 2004). Heavy metal contamination of agricultural soils can pose long−term environmental problems. Soil−to−crop transfer of heavy metals is the major pathway of human exposure to heavy metals. The demand for food supply continues to grow with an increase in population growth, which in turn has led to increased use of pesticides, fertilizers, manures, composts and so on as well as the use of wastewater for irrigation (Hua *et al.,* 2018). Food crops grown in heavy metal contaminated soil can uptake and accumulate metals in quantities high enough to affect food quality and safety (Muchuweti *et al.,* 2006). Heavy metals belong to a group of elements with the characteristics of higher density, generally greater than 5g $cm^{-3}$ and atomic weight more than calcium (Sun *et al.,* 2019). Heavy metals such as Pb, Cd, Cu and Zn have been reported to be released into the atmosphere during different operations of the road transport (Sharma and Prasade, 2010; Zhang *et al.*, 2012). Chemical and metallurgical industries are the most important sources of heavy metals in soils (Jantschi *et al*., 2008). The contamination of environment by Cr has become a major concern and its toxicity to plants depends on its valence state as Cr (VI) being highly toxic and more mobile than Cr (III). Parween *et al.* (2011) reported that these metals present in the soil as in the form of inorganic compounds or they may remain bonded with organic matter, clays or as oxides. Due to agro−climatic conditions, anthropogenic activities, presence and distribution of heavy metals is inevitable, therefore, their assimilation in soil is very likely. Hence, accumulation may create a health alarm as well as the consumers of different food crops, consumed directly to meet the food needs (Chahal *et al.,* 2016).

In the semi−arid regions, factors which create the situations to use sewage effluent for crop production on the account of scarcity of good quality water for irrigation and high cost of fertilizers (Zhang *et al.,* 2018). The accumulation of heavy metals in land, water bodies and the plants growing in the sewage takes place due to the un−scientific disposal of large quantity of untreated effluent (Singh *et al.,* 2004). Due to indiscriminate use of sewage, clogging of soil pores takes place resulting in decreased permeability. Sewage was found to create the unhygienic conditions as it produces toxic gases due to lack of aeration (Hunshyal *et al.,* 2003). The quality of irrigation water available to farmers and others will play an important role on the type of plants that can be grown, the productivity of the plants, water infiltration and other soil physical conditions. The irrigation with waste water is known to contribute significantly to the heavy metals content of soil (Mapanda *et al.,* 2005; Nan *et al.,* 2002). The long−term irrigation with sewage water can bring the changes in the soil quality and trace element inputs are continued over long periods (Zhang *et al.,* 2008). Though the sewage water contains low levels of the heavy metals (Pb, Cd and Cr), the soil and plant samples showed higher content due to their accumulation (Gupta *et al.,* 2010). The major sinks for heavy metals released into the environment by above mentioned anthropogenic activities are soils and most metals do not undergo microbial or chemical degradation and their total concentration in soils persists for a long time after their introduction, and unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action. Thus, keeping in view the above facts, the present study was carried out.

## 2. MATERIALS AND METHODS

The study of spatial distribution of heavy metals was carried out in peri−urban areas of Mohindergarh and Narnaul cities of Haryana, India. Mohindergarh city is situated at 28.2710°N latitudes and 76.1494°E longitudes at an altitude of 262 m above the mean sea level and the Narnaul city is situated at 28.0658°N latitudes and 76.10 15°E longitudes at an altitude of 318 m above the mean sea level. Soil samples were collected using GPS by following random sampling method and analyzed for physico−chemical properties and DTPA extractable heavy metals (Zn, Cu, Cd, Cr, Pb, Ni and Co). Soil samples were processed and passed through 2 mm sieve. The soil samples were analyzed for soil reaction (pH) and electrical conductivity (EC) in (1:2) soil: water suspension ratios by (Jackson, 1973). Organic carbon (OC) content was estimated by wet oxidation method (Walkley and Black, 1934), calcium carbonate by rapid titration method (Puri, 1949), soil texture by International pipette method (Piper, 1950) and cation exchange capacity (CEC) by ammonium acetate method (Hesse, 1971). DTPA extractable Pb, Cr, Cd, Co and Ni contents were estimated by Lindsay and Norvell (1978) with the help of AAS (Model−Z−Xpress 8000).

## 3. RESULTS AND DISCUSSION

### Physico−chemical Properties of Soils

The data on pH of surface soil samples of irrigated with sewage water of Mohindergarh city ranged from 7.62 to 8.29 with an average pH of 7.96 and those surface soil samples irrigated with tube well water ranged from 8.13 to 9.01 with the mean of 8.63. Similarly in Narnaul city, soil pH values of surface soil irrigated with sewage water was ranged from 7.60 to 8.28 with the mean of 7.91 and those surface soil irrigated with tube well water ranged from 8.08 to 8.85 with an average of 8.49 (Table 1). The soil reaction of sewage and tube well irrigated soils of Mohindergarh city and Narnaul city was neutral to highly alkaline nature. Factors like leaching action of water, soil nature and mechanical composition of sewage water attributed the variation in soil pH. During the present study pH was more in tube well water irrigated soils compared to sewage irrigated soils. Lower pH was found in waste water irrigated soils but the higher EC, probably, due to the higher salt content in the waste water. The basic pH of the soil reduces the solubility of micro−nutrients, especially Fe, Zn, Cu and Mn. Irrigation with waste water decreased soil pH, reason might be due to the decomposition of organic matter and production of organic acid in soils irrigated with wastewater (Vaseghi *et al.,* 2005). Parth *et al*. (2011) reported the similar results of soil pH ranging from 5.7−8.9 and is found to be acidic to near neutral and alkaline in

**Table: 1**
**Physico−chemical properties of Mohindergarh and Narnaul soil in surface layer (0−15 cm)**

| Soil Properties | Mohindergarh | | Narnaul | |
|---|---|---|---|---|
| | Sewage irrigated | Tube well irrigated | Sewage irrigated | Tube well irrigated |
| pH (1:2) | 7.62−8.29<br>(7.96)* | 8.13−9.01<br>(8.63) | 7.60−8.28<br>(7.91) | 8.08−8.85<br>(8.49) |
| EC (dS m$^{-1}$) | 0.34−0.77<br>(0.49) | 0.25−0.41<br>(0.32) | 0.48−0.84<br>(0.62) | 0.29−0.69<br>(0.45) |
| Organic carbon (%) | 0.45−1.62<br>(0.96) | 0.32−0.57<br>(0.49) | 0.59−1.62<br>(0.99) | 0.21−0.81<br>(0.56) |
| CEC (cmol kg$^{-1}$) | 7.54−12.73<br>(9.92) | 6.27−10.97<br>(8.20) | 14.21−23.96<br>(19.12) | 12.16−22.41<br>(15.16) |
| $CaCO_3$ (%) | 0.00−0.54<br>(0.24) | 0.28−1.25<br>(0.69) | 0.13−1.28<br>(0.69) | 0.70−2.88<br>(1.87) |
| Sand (%) | 80−93<br>(88.09) | 87−93<br>(90.18) | 49−86<br>(78.58) | 45−87<br>(74.83) |
| Silt (%) | 2.0−9.0<br>(4.64) | 2.0−7.0<br>(4.09) | 2.0−28<br>(8.17) | 3.0−31<br>(11.42) |
| Clay (%) | 5.0−12.0<br>(7.27) | 4.0−7.0<br>(5.73) | 6.0−23<br>(13.25) | 7.0−24<br>(13.75) |

**Parentheses − Mean value*

nature. The solubility and mobility of the heavy metals significantly affected by the soil pH, as most of the metals are soluble in acidic range compared to neutral or slightly alkaline range. The concentration of soluble salts (EC) of sewage irrigated soil samples of Mohindergarh city was non−saline, ranged from 0.34 to 0.77 dS $m^{-1}$ with the mean of 0.49 dS $m^{-1}$ (Table 1) and those tube well irrigated soil samples of the same city ranged from 0.25 to 0.41 dS $m^{-1}$ with the overall EC of 0.32 dS $m^{-1}$. Similarly in Narnaul city EC of sewage irrigated surface soil was non−saline, ranged from 0.48 to 0.84 dS $m^{-1}$ with an average EC of 0.62 dS $m^{-1}$ and that tube well irrigated soil varied from 0.29 to 0.69 dS $m^{-1}$ with an average EC of 0.45 dS $m^{-1}$.

During present study the EC was found to be more in sewage irrigated surface soil and falls within the safe limits of EC, the higher concentrations of cations such as K and Na in waste water lead to an increase in EC (Khaskhoussy *et al.*, 2013). Mollahoseini (2013) reported that the irrigation of soils with sewage water increased the EC of soil and though EC was less than 4 dS $m^{-1}$ in the present study, it may pose problem on prolonged use particularly in ill−drained soils. Sewage water irrigation resulted in significant increase in EC of the surface soils. In comparison with groundwater, EC is greater with sewage water because of higher salt concentrations.

The OC content of sewage irrigated surface soil of Mohindergarh city was medium to high, ranged from 0.45% to 1.62% with an average OC of 0.96% and those soil irrigated with tube well water ranged from 0.32 to 0.57 % with an average OC of 0.49 % (Table 1). Similarly organic carbon content of Narnaul city in sewage water irrigated soil was ranged from 0.59% to 1.62% with an average of 0.99% and in tube well irrigated soil the OC content ranged from 0.21% to 0.81% with an average OC of 0.56%. Soil's ability to retain and immobilize the heavy metals depends upon the soil organic matter content which plays an important role not in forming the complexes with these heavy metals, but also retaining them in an exchangeable form. OC sources in the cultivated soil include crop residues, animal manure and human waste, cover crops, green manure and organic fertilizer etc. The high content of OC in soil may be due to addition of organic compounds either naturally or artificially and their subsequent decomposition. The present study revealed that irrigation with sewage water decreased of soil pH and increased the OC compared to groundwater. OC content is high in most of soils irrigated with sewage water which might be due to very high organic load of sewage water (Singh *et al.*, 2012) and also due to rapid to the rapid decomposition of organic compounds of sewage effluents. During the present study, OC was more in sewage irrigated soils. The possible reason for decrease in soil pH and increase in OC may be due to decomposition of organic matter and the production of organic acids in soils irrigated with wastewater (Khai *et al.,* 2008). The data on calcium carbonate ($CaCO_3$) content of sewage irrigated soil samples of Mohindergarh city varied from nil to 0.54% with an average of 0.24% and in those soils irrigated with tube well water calcium carbonate ranged from 0.28% to 1.25% with an average of 0.69%. However, in Narnaul city, calcium carbonate content of sewage water irrigated soil ranged from 0.13% to 1.28% with an average of 0.69% and tube well irrigated soil ranged from 0.70% to 2.88% with an average of 1.87% (Table 1). The findings indicate that some of soil samples were free from the calcium carbonate content and few samples have low calcium carbonate content as soils were non−calcareous in nature. The similar findings of calcium carbonate content in Ethiopia were reported by Yerima *et al.* (2013).

Sewage irrigated soil of Mohindergarh city had composition of sand (88.09%), silt (4.64%), clay (7.87%) and classified as sandy loam and those tube well irrigated soils had composition of 90.13%, 4.09%, 5.73% (sand, silt and clay) and classified as sandy loam. Similarly soil texture of sewage irrigated soil of Narnaul city had composition of sand (78.58%), silt (8.17%), clay (13.25%) and classified as sandy those tube well irrigated soils had composition of 74.83%,11.42%, 13.75% (sand, silt and clay) and classified as sandy (Table 1). Jangir *et al.* (2019) got the similar results in accordance with present study and reported that texture of Panchkula soils was loamy to loamy sand. The soil texture was governed by the type of parent materials from which the soils had developed. Meuser *et al.* (2011) reported the similar results and stated that soils were generally dominated by sand sized particles ranged from 82.9% to 88.3% whereas clay and silt varied from 2.8% to 4.7% and 8.8% to 12.5%, respectively. The CEC [cmol ($p^+$) $kg^{-1}$] of sewage irrigated soil of Mohindergarh city ranged from 7.54 to 12.73 with an average of 9.92 and tube well irrigated soils varied from 6.27 to 10.97 with an average of 8.20. Whereas in Narnaul city, sewage irrigated soils had CEC ranged from 14.21 to 23.96 with an average of 19.12 and tube well irrigated soil samples varied from 12.16 to 22.41 with an average of 15.16 (Table 1). The results are in concurrent with the findings of Adrover *et al.* (2012) also reported that treated waste water irrigated soil had CEC [cmol ($p^+$) $kg^{-1}$] of 15.3 compared to non−wastewater irrigated soil with CEC of 17.2 cmol $kg^{-1}$. Yerima *et al.* (2013) also reported the similar outcomes which are in nearer to the findings of present study. The possible reason maybe a varying mineralogical site probably dominated by 2:1 clay minerals of the smectite or vermiculite group.

## DTPA Extractable Zn, Cu, Cd, Cr, Pb, Ni and Co Content

The DTPA extractable Zn of sewage irrigated soil of Mohindergarh city, ranged from 0.94 to 1.88 mg $kg^{-1}$ with an average of 1.46 mg $kg^{-1}$ and tube well water irrigated soil ranged from 0.75 to 1.08 mg kg$^{-1}$ with an average of 0.90 mg kg$^{-1}$ (Table 2). Similarly in Narnaul city, Zn of sewage irrigated soil ranged from 1.11 to 2.88 mg kg$^{-1}$ with an average of 1.62 mg kg$^{-1}$ and tube well irrigated soil varied from 0.61 to 1.09 mg kg$^{-1}$ with an average of 0.85 mg kg$^{-1}$. The DTPA extractable–Zn in both the cities was sufficient in amount as compared to that of their critical limit (*i.e.* <0.6 mg kg$^{-1}$ means as deficient; > 0.6 mg kg$^{-1}$ means as sufficient). The overall range of Zn (mg kg$^{-1}$) in sewage irrigated soils ranged 0.94 to 2.88 and in tube well irrigated soils, ranged from 0.61 to 1.09; this change in extractable Zn is due to higher Zn content in sewage water. Soil irrigated with wastewater caused increase Zn but it caused a decrease of soil pH (Vaseghi *et al.,* 2005). The DTPA extractable Cu of sewage irrigated soil of Mohindergarh city, ranged from 0.37 to 1.38 mg kg$^{-1}$ with an average of 0.93 mg kg$^{-1}$ and tubewell water irrigated soil ranged from 0.23 to 1.27 mg kg$^{-1}$ with an average of 0.68 mg kg$^{-1}$. Similarly in Narnaul city, Cu of sewage water irrigated ranged from 0.98 to 1.94 mg kg$^{-1}$ with an average of 1.53 mg kg$^{-1}$ and tube well water irrigated soil ranged from 0.31 to 0.85 mg kg$^{-1}$ with an average of 0.65 mg kg$^{-1}$ (Table 2). The DTPA extractable–Cu in both cities was sufficient in amount as compared to that of their critical limit (*i.e.* <0.2 mg kg$^{-1}$ means as deficient; > 0.6 mg kg$^{-1}$ means as sufficient). The overall range of Cu (mg kg$^{-1}$) in sewage irrigated soils was 0.37 to 1.94 and in tube well irrigated soils, range was 0.30–0.85. Vaseghi *et al.* (2005) reported that 7 years application of wastewater had no significant effect on the Cu content in the soil and it was stabilized by the clay minerals, organic matter and Fe, Al and Mn oxides in soil.

The DTPA extractable Cd of sewage irrigated soil of Mohindergarh city, ranged from 0.01 to 0.06 mg kg$^{-1}$ with an average of 0.03 mg kg$^{-1}$, while tube well irrigated soil ranged from nil to 0.04 mg kg$^{-1}$ with an average of 0.02 mg kg$^{-1}$. Similarly, in Narnaul city, Cd of sewage irrigated soil ranged from 0.02 to 0.14 mg kg$^{-1}$ with an average of 0.06 mg kg$^{-1}$, on the other hand tube well irrigated soil ranged from nil to 0.08 mg kg$^{-1}$ with an average of 0.04 mg kg$^{-1}$ (Table 2). The overall range of soluble Cd in sewage and tube well water irrigated soils of the study area was found to be 0.01 to 0.14 and 0.00 to 0.08, respectively. Results of the present investigation revealed that soil irrigated with wastewater increased of cadmium content compared to tube well irrigated. This is in line with findings of Mapanda *et al.* (2005). Untreated industrial effluents upon their application build up Cd content in the soil (Chary *et al.,* 2008). The DTPA extractable Cr of sewage irrigated soil of Mohindergarh city, varied from 0.20 to 0.26 mg kg$^{-1}$ with an average of 0.23 mg kg$^{-1}$, on the other hand tube well irrigated surface soil ranged from 0.12 to 0.23 mg kg$^{-1}$ with an average of 0.18 mg kg$^{-1}$ (Table 2). Similarly, soluble Cr content of sewage irrigated soil of Narnaul city ranged from 0.20 to 0.34 mg kg$^{-1}$ with an average of 0.28 mg kg$^{-1}$, but tube well irrigated soil ranged from 0.14 to 0.29 mg kg$^{-1}$ with an average of 0.22 mg kg$^{-1}$. The overall range of soluble Cr in sewage and tube well water irrigated soils of the study area was found to be 0.20 to 0.34 and 0.12 to 0.29 mg kg$^{-1}$, respectively. Etim and Onianwa (2013) got the similar findings in accordance with the present study and reported that the lead and chromium levels at the industrial area and effluent channels were found to be slightly higher compared with other metals *viz.,* Cu, Ni and Cd. The DTPA extractable Pb of sewage irrigated soil of Mohindergarh city, ranged from 0.38 to 0.89 mg kg$^{-1}$ with an average of 0.64 mg kg$^{-1}$ and in tube well water irrigated soil ranged from 0.28 to 0.52 mg kg$^{-1}$ with the average of 0.36 mg kg$^{-1}$ (Table 2). Similarly, in Narnaul city, Pb of sewage irrigated soil ranged of 0.43 to 0.90 mg kg$^{-1}$ with an average of 0.66 mg kg$^{-1}$, while tube well irrigated soil samples ranged from 0.19 to 0.52 mg kg$^{-1}$ with an average of 0.35 mg kg$^{-1}$. The overall range of soluble Pb (mg kg$^{-1}$) in sewage and tube well water irrigated soils of the study area was found to be 0.38 to 0.90 and 0.19 to 0.52 mg kg$^{-1}$, respectively. While studying sampling sites of Romania, Suciu *et al.* (2008) also got the similar results with the present study. Jagtap *et al.* (2010) recorded that Pb (84.77 mg kg$^{-1}$ to 134.19 mg kg$^{-1}$), in irrigated soils of urban waste waters Solapur, Maharashtra (India).

**Table: 2**
**Soluble concentrations of heavy metals content in surface layer (0–15 cm)**

| Location | | DTPA extractable heavy metals (mg kg$^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Zn | Cu | Cd | Cr | Pb | Ni | Co |
| Mohindergarh | Sewage irrigated | 0.94–1.88<br>(1.46)* | 0.37–1.38<br>(0.93) | 0.01–0.06<br>(0.03) | 0.20–0.26<br>(0.23) | 0.38–0.89<br>(0.64) | 0.23–0.33<br>(0.28) | 0.10–0.17<br>(0.13) |
| | Tube well irrigated | 0.75–1.08<br>(0.90) | 0.23–1.27<br>(0.68) | 0.00–0.04<br>(0.02) | 0.12–0.23<br>(0.18) | 0.28–0.52<br>(0.36) | 0.16–0.30<br>(0.22) | 0.06–0.18<br>(0.11) |
| Narnaul | Sewage irrigated | 1.11–2.88<br>(1.62) | 0.98–1.94<br>(1.53) | 0.02–0.14<br>(0.06) | 0.20–0.34<br>(0.28) | 0.43–0.90<br>(0.66) | 0.22–0.45<br>(0.33) | 0.11–0.19<br>(0.14) |
| | Tube well irrigated | 0.61–1.09<br>(0.85) | 0.31–0.85<br>(0.65) | 0.00–0.08<br>(0.04) | 0.14–0.29<br>(0.22) | 0.19–0.52<br>(0.35) | 0.13–0.34<br>(0.21) | 0.05–0.15<br>(0.10) |

**Parentheses – Mean value*

The DTPA extractable Ni of sewage irrigated soil of Mohindergarh city, ranged from 0.23 to 0.33 mg kg$^{-1}$ with an average of 0.28 mg kg$^{-1}$, while tube well irrigated soil ranged from 0.16 to 0.30 mg kg$^{-1}$ with an average of 0.22 mg kg$^{-1}$ (Table 2). Similarly, in Narnaul city, Ni of sewage irrigated soil ranged from 0.22 to 0.45 mg kg$^{-1}$ with an average of 0.33 mg kg$^{-1}$, while in tube well irrigated soil ranged from 0.13 to 0.34 mg kg$^{-1}$ with an average of 0.21 mg kg$^{-1}$. The DTPA extractable–Ni in both cities was sufficient in amount in sewage irrigated soil but deficient in tube well irrigated soil as compared to that of their critical limit (*i.e.* <0.2 mg kg$^{-1}$ means as deficient; >0.2 mg kg$^{-1}$ means as sufficient). The overall range of soluble Ni in sewage and tube well water irrigated soils of the study area was found to be 0.22 to 0.45 and 0.13 to 0.34 mg kg$^{-1}$, respectively. Irrigation with waste water increased Ni content in sewage irrigated soil compared to tube well irrigated soil. This is in line with findings of Mapanda *et al.* (2005) and Jagtap *et al.* (2010). The DTPA extractable Co of sewage irrigated soil of Mohindergarh city, ranged from 0.10 to 0.17 mg kg$^{-1}$ with an average of 0.13 mg kg$^{-1}$, on the other hand tube well irrigated soil varied from 0.06 to 0.18 mg kg$^{-1}$ with the average of 0.11 mg kg$^{-1}$ (Table 2). Similarly, in Narnaul city, the DTPA extractable Co in sewage irrigated soil ranged from 0.11 to 0.19 mg kg$^{-1}$ with an average of 0.14 mg kg$^{-1}$, but tube well irrigated soil ranged from 0.05 to 0.15 mg kg$^{-1}$ with an average of 0.10 mg kg$^{-1}$. The DTPA extractable–Co in both cities was deficient in amount as compared to that of their critical limit (*i.e.* <0.2 mg kg$^{-1}$ means as deficient; >0.2 mg kg$^{-1}$ means as sufficient). The overall range of soluble Co in sewage and tube well water irrigated soils of the study area was found to be 0.10 to 0.19 and 0.05 to 0.18 mg kg$^{-1}$, respectively. Jagtap *et al.* (2010) reported that application of wastewater for irrigation for a period of 47 years caused the total and available Co content to increase significantly in soil.

## Correlation Matrix

With the help of Pearson's correlation coefficient, the relationship between different physico–chemical properties with micro–nutrients and heavy metals contents in soil were determined. Results revealed that negative correlation between pH and all heavy metals, significant positive correlation between pH and CEC (r = 0.328*), (Table 3) whereas, EC showed positive significant correlation with CEC (r = 0.706*) and clay (r = 628*). Clay showed positive significant correlation with EC (r = 0.628*), OC (r = 0.426**), CEC (r = 0.820**) and silt content (r = 0.617*). Zinc had positive significant correlation with OC (r = 514*), CEC (r = 0.474*), clay content (r = 423*) and Cu (r = 0.465**). Among heavy metals, Cd had positive significant correlation with Zn (r = 0.569**) and Cu (r = 0.716*). Cobalt had positive and significant correlation with silt content (r = 0.620*), Cu (r = 0.727*), Cr (r = 0.784**), Pb (r

**Table: 3**

**Pearson's correlation coefficients (r) between physico–chemical properties and heavy metal contents in sewage irrigated surface soils of Mohindergarh city**

| Variable | pH | EC | OC | $CaCO_3$ | CEC | Sand | Silt | Clay | Zn | Cu | Cd | Cr | Pb | Ni | Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | | | |
| EC | 0.192 | 1 | | | | | | | | | | | | | |
| OC | 0.208 | 0.289 | 1 | | | | | | | | | | | | |
| $CaCO_3$ | 0.299 | −0.022 | −.002 | 1 | | | | | | | | | | | |
| CEC | 0.328* | 0.706* | 0.024 | 0.125 | 1 | | | | | | | | | | |
| Sand | −0.301 | −0.513 | −0.192 | −0.574 | −0.708* | 1 | | | | | | | | | |
| Silt | 0.097 | 0.293 | 0.376 | 0.292 | 0.451 | −0.898** | 1 | | | | | | | | |
| Clay | 0.442 | 0.628* | 0.426** | −0.136 | 0.820** | −0.901** | 0.617* | 1 | | | | | | | |
| Zn | −0.185 | 0.244 | 0.514* | −0.220 | 0.474* | 0.352 | −0.209 | 0.423* | 1 | | | | | | |
| Cu | −0.019 | 0.111 | 0.068 | 0.168 | 0.083 | −0.002 | 0.203 | 0.196 | 0.465** | 1 | | | | | |
| Cd | −0.097 | −0.066 | 0.072 | 0.121 | 0.006 | −0.202 | −0.070 | −0.292 | 0.569** | 0.716* | 1 | | | | |
| Cr | −0.132 | 0.160 | −0.119 | 0.246 | 0.272 | −0.273 | 0.480 | 0.014 | 0.080 | 0.857** | 0.502 | 1 | | | |
| Pb | −0.251 | 0.519 | 0.251 | −0.515 | −0.514 | −0.568 | −0.496 | −0.526 | −0.318 | −0.228 | −0.195 | −0.153 | 1 | | |
| Ni | −0.267 | 0.555 | 0.177 | 0.458 | 0.464 | −0.835** | 0.851** | 0.652* | −0.198 | 0.360 | 0.036 | 0.450 | −0.534 | 1 | |
| Co | −0.041 | 0.491 | 0.225 | 0.487 | 0.505 | −0.532 | 0.620* | 0.338 | 0.115 | 0.727* | 0.293 | 0.784** | 0.671* | 0.659* | 1 |

**Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level*

= 0.671*) and Ni (r = 0.659*). Results in Table 4 revealed that OC had significant positive correlation with EC (r = 0.661*) and Co (r = 0.614*). Soil pH has non−significant correlation with Cu (r = −0.313), Cr (r = −0.236), Pb (r = −0.372), Ni (r = −0.176) and Co (r = −0.101).

However, negative correlation was found between pH and heavy metals. CEC had significant correlation with EC (r = 0.833**), OC (r = 0.415**) and clay content (r = 0.877**). OC had significant correlation with clay (r = 0.367*) and Cd (r = 0.481**). Positive significant correlation was found among Co with Cd (r = 0.648*) and Cr (r = 0.770**). Non−significant correlation was found between $CaCO_3$ and sand (r = −0.717**) (Table 5). Positive and significant correlation of pH with $CaCO_3$ (r = 0.335*), CEC (r = 0.540*) and clay content (r = 0.456*). Clay content showed positive significant correlation with EC (r = 0.419*), $CaCO_3$ (r = 0.723**), CEC (r = 0.811**), silt (r = 0.721**) and non−significant with sand (r = −0.890**). OC showed positive and significant correlation with Zn (r = 0.524**) and Cu (r = 0.435**). Cr had significant correlation with Zn (r = 0.727**), Ni with Cd (r = 0.714**) and Co with Cu (r = 0.766**) (Table 6).

The negative correlation between pH and all heavy metals may be due to their precipitation as hydroxides and carbonates subsequently making them immobile and unavailable to the plants. Similar, results were obtained by Shinde (2007). Zn availability was found significant positively correlated with OC (r = 0.514*). This might be due to the formation of soluble Zn−organic complexes on the clay surface. Similar results were also reported by Venkatesh *et al.* (2003). DTPA−extractable heavy metals did not reveal any significant relationship with soil pH and EC. Pati and Mukhopadhya (2011) also recorded no relationship of soil pH with DTPA− extractable heavy metals. This shows that distributions of available cationic heavy metals in these soils were not influenced by pH and EC. Co showed positive and significant correlation with silt content (r = 0.620*), Cu (r = 0.727*), Cr (r = 0.784**), Pb (r = 0.671*) and Ni (r = 0.659*). Several earlier studies had reported that pH had negative correlation with micro−nutrients in some calcareous alkaline soils (Chahal *et al.*, 2014; Sharma and Prasade, 2010). OC had significant correlation with Cd (r = 0.481**), suggests that organic matter had adsorption effects on these metals.

## 4. CONCLUSIONS

The concentrations of heavy metals (Zn, Cu, Cd, Cr, Pb, Ni and Co) in sewage and tube well water irrigated soil samples were found within the permissible limits. The mean DTPA extractable Zn, Cu, Cd, Cr, Pb, Ni and Co concentration (mg $kg^{-1}$) in sewage and tube well irrigated soils of Mohindergarh was found as 1.46, 0.93, 0.03, 0.23, 0.64, 0.28 and 0.13 and 0.90, 0.48, 0.02, 0.18, 0.36, 0.22 and 0.11,

**Table: 4**
**Pearson's correlation coefficients (r) between physico−chemical properties and heavy metal contents in tube well water irrigated surface soils of Mohindergarh city**

| Variable | pH | EC | OC | $CaCO_3$ | CEC | Sand | Silt | Clay | Zn | Cu | Cd | Cr | Pb | Ni | Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | | | |
| EC | −0.187 | 1 | | | | | | | | | | | | | |
| OC | −0.151 | 0.661* | 1 | | | | | | | | | | | | |
| $CaCO_3$ | 0.536 | −0.024 | −0.340 | 1 | | | | | | | | | | | |
| CEC | −0.046 | 0.015 | 0.189 | −0.235 | 1 | | | | | | | | | | |
| Sand | −0.492 | −0.079 | 0.029 | −0.316 | −0.739** | 1 | | | | | | | | | |
| Silt | 0.346 | 0.170 | −0.055 | 0.482 | 0.632* | −0.835** | 1 | | | | | | | | |
| Clay | 0.376 | −0.112 | 0.030 | −0.148 | −0.395 | −0.565 | 0.018 | 1 | | | | | | | |
| Zn | 0.017 | −0.087 | 0.090 | −0.199 | 0.411 | 0.081 | −0.033 | −0.098 | 1 | | | | | | |
| Cu | −0.313 | −0.017 | 0.418 | −0.307 | −0.481 | −0.346 | 0.328 | 0.138 | 0.114 | 1 | | | | | |
| Cd | 0.853** | 0.149 | 0.160 | 0.243 | −0.035 | −0.437 | 0.318 | 0.318 | −0.008 | −0.239 | 1 | | | | |
| Cr | −0.236 | −0.373 | 0.058 | −0.606* | −0.167 | 0.113 | −0.401 | 0.396 | 0.073 | 0.509 | −0.153 | 1 | | | |
| Pb | −0.372 | −0.157 | 0.099 | ?0.113 | 0.100 | 0.163 | −0.076 | −0.183 | 0.438 | 0.493 | −0.470 | 0.380 | 1 | | |
| Ni | 0.176 | 0.057 | 0.010 | 0.337 | 0.486 | 0.290 | −0.004 | −0.521 | −0.236 | −0.510 | 0.103 | −0.754** | −0.379 | 1 | |
| Co | −0.101 | 0.534 | 0.614* | 0.269 | 0.103 | 0.088 | 0.144 | −0.376 | 0.235 | 0.329 | −0.006 | −0.125 | 0.466 | −0.028 | 1 |

**Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level*

**Table: 5**
**Pearson's correlation coefficients (r) between physico−chemical properties and heavy metal contents in sewage irrigated surface soils of Narnaul city**

| Variable | pH | EC | OC | $CaCO_3$ | CEC | Sand | Silt | Clay | Zn | Cu | Cd | Cr | Pb | Ni | Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | | | |
| EC | 0.197 | 1 | | | | | | | | | | | | | |
| OC | 0.201 | 0.268 | 1 | | | | | | | | | | | | |
| $CaCO_3$ | 0.327 | 0.357 | −195 | 1 | | | | | | | | | | | |
| CEC | 0.546 | 0.83?3** | 0.415** | 0.013 | 1 | | | | | | | | | | |
| Sand | −0.233 | −0.647* | 0.298 | −0.717** | −0.711** | 1 | | | | | | | | | |
| Silt | 0.016 | 0.225 | 0.125 | 0.474 | 0.294 | −0.825** | 1 | | | | | | | | |
| Clay | 0.379 | 0.847** | 0.367* | 0.018 | 0.877** | −0.761** | 0.261 | 1 | | | | | | | |
| Zn | −0.185 | 0.056 | 0.026 | −0.109 | 0.272 | 0.001 | 0.043 | 0.047 | 1 | | | | | | |
| Cu | −0.171 | 0.292 | 0.104 | −0.014 | 0.352 | −0.201 | 0.546 | 0.283 | 0.184 | 1 | | | | | |
| Cd | −0.308 | 0.150 | 0.481** | −0.333 | 0.313 | −0.067 | 0.042 | −0.162 | 0.311 | 0.461 | 1 | | | | |
| Cr | −0.041 | 0.456 | 0.060 | −0.490 | −0.422 | 0.491 | 0.258 | −0.543 | −0.157 | 0.027 | 0.244 | 1 | | | |
| Pb | −0.136 | −0.391 | 0.292 | −0.535 | −0.421 | 0.461 | −0.299 | 0.244 | 0.378 | −0.027 | 0.426 | 0.323 | 1 | | |
| Ni | −0.109 | 0.523 | −0.311 | 0.084 | 0.194 | −0.219 | 0.002 | 0.372 | 0.535 | 0.098 | 0.513 | −0.037 | 0.338 | 1 | |
| Co | −0.070 | −0.388 | 0.037 | −0.437 | −0.486 | 0.428 | −0.212 | 0.487 | 0.345 | 0.261 | 0.648* | 0.770** | 0.564 | 0.310 | 1 |

**Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level*

**Table: 6**
**Pearson's correlation coefficients (r) between physico−chemical properties and heavy metal contents in tube well water irrigated surface soils of Narnaul city**

| Variable | pH | EC | OC | $CaCO_3$ | CEC | Sand | Silt | Clay | Zn | Cu | Cd | Cr | Pb | Ni | Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | | | |
| EC | 0.562 | 1 | | | | | | | | | | | | | |
| OC | 0.194 | 0.266 | 1 | | | | | | | | | | | | |
| $CaCO_3$ | 0.335* | 0.035 | −0.083 | 1 | | | | | | | | | | | |
| CEC | 0.540* | 0.580* | 0.229 | 0.550 | 1 | | | | | | | | | | |
| Sand | −0.176 | −0.331 | 0.200 | −0.713** | −0.623* | 1 | | | | | | | | | |
| Silt | 0.133 | 0.239 | −0.176 | 0.627 | 0.435 | −0.958** | 1 | | | | | | | | |
| Clay | 0.456* | 0.419* | −0.202 | 0.723** | 0.811** | −0.890** | 0.721** | 1 | | | | | | | |
| Zn | 0.241 | 0.318 | 0.524** | 0.284 | 0.450 | −0.216 | 0.113 | 0.340* | 1 | | | | | | |
| Cu | 0.265 | 0.193 | 0.435** | 0.337 | 0.458 | −0.110 | −0.003 | 0.270 | 0.279 | 1 | | | | | |
| Cd | 0.051 | −0.054 | 0.268 | 0.388 | 0.194 | −0.315 | 0.425 | 0.085 | 0.450 | 0.171 | 1 | | | | |
| Cr | 0.003 | 0.002 | 0.283 | 0.133 | 0.263 | −0.020 | −0.134 | 0.259 | 0.727** | 0.088 | 0.037 | 1 | | | |
| Pb | 0.268 | 0.058 | 0.340 | −0.212 | 0.093 | −0.161 | 0.250 | −0.008 | 0.425 | 0.176 | 0.431 | 0.264 | 1 | | |
| Ni | 0.186 | 0.283 | 0.260 | 0.127 | 0.040 | −0.061 | 0.209 | −0.184 | 0.232 | 0.359 | 0.714** | −0.328 | 0.347 | 1 | |
| Co | 0.209 | 0.128 | 0.513 | 0.215 | 0.405 | 0.204 | −0.318 | 0.013 | 0.477 | 0.766** | 0.380 | 0.225 | 0.065 | 0.421 | 1 |

**Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level*

respectively. The mean soluble extractable Zn, Cu, Cd, Cr, Pb, Ni and Co content (mg $kg^{-1}$) in sewage and tube well irrigated soils of Narnaul was found as 1.62, 1.53, 0.06, 0.28, 0.66, 0.33 and 0.14 and 0.85, 0.65, 0.04, 0.22, 0.35, 0.21 and 0.1, respectively. The present investigation is very useful to estimate the metal contamination and risk associated in agricultural soil. It would be useful for the better soil health and environment.

## ACKNOWLEDGMENTS

The authors are very thankful to the Head, Department of Soil Science, CCS HAU, Hisar, Haryana (India) for providing facilities and constant support for carrying out the research work.

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