Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: **www.environmentaljournal.org**
2015 Volume 5, Issue 2: 90-100

Open Access **Research Article**

Effect of Treated Sewage Water on Soil Characteristics and Agricultural Produce of Chaka Block of Allahabad District

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Abstract:

The study was conducted in Chaka Block of Allahabad District, the project area has source of water from treated sludge irrigated water from Ganga Treatment Plant (60 MLD, Naini). The area is situated on the right bank of Yamuna River in South of Allahabad City, which is located at 25.8 N latitude and 81.5 E longitudes. Soil and water samples were collected at different intervals (November to March, days) depths (0-15, 15-30, 30-45, 45-60 cm, respectively) of soil columns. The analysis of the values in tables was done by the statically. Design (Two way analyses without replication). It was found that the higher concentration for the soil parameters were in the surface of the soil layer 0-15 cm and then decrease due to different depths of soil layer up to the 45-60 cm. It was observed that the sewage irrigated water at the farmer's field was taken during different intervals as though it was required for irrigating purpose in the farmer's field. The higher concentration for the heavy metals was found for Pb 0.43 mg/L, Cd 0.15 mg/L, Ni 0.21 mg/L. The values were found to be under the permissible limit according to guidelines.

Keyword: Agriculture, Heavy metals, Sewage water, Soil, Tube well

1.0 Introduction:

Protection of environment is the most vital issue today. Explosive population growth, rapid progress in science and technology, massive industrialization use of various chemicals in agriculture of most importantly the human activities are the factors threatening the very quality of life (Sharma, et al., 2000). The tremendous progress in every sphere of science and technology has lead ultimately to environmental impact resulting in extreme unhygienic conditions modifying our living environment. Environmental disturbances in the ecosystem against the backdrop of rapid population growth uncontrolled urbanization of unregulated industrialization is mainly reflected by changes in the chemical element concentration pattern. Environmental degradation by trace metal accumulation in eco-friendly systems caused by over exploitation of resource materials and human imposed interactions are the few unending problems encountered which threaten the very basic economy of a nation and individuals by affecting both the progress of the nation as well as the health of the human.

The problem of pollution as consequence of increased industrialization is now well-known phenomenon and is one of the most vital issues today. All over the globe, many workers have studied various types of pollutants and their effect on living systems in detail. Today, the world is facing both an environmental and developmental crises and both these crises seems to be intensifying and interacting to reinforce each other (Aery and Sarkar, 1991) presence of any pollutant in the environment influences not only abiotic but also biotic components, by causing certain changes in the functioning of their normal life systems (Mhatre, 1991).The biggest problem of environmental pollution on account of essential industrial growth is, in practical terms the problem of disposal of industrial waste, whether solid, liquid or gaseous. All the three types of wastes have the potentiality of ultimately polluting water. Polluted water in addition of other effects, directly affects soil, not only in industrial areas but also in agricultural fields, as well as the beds of rivers, creating secondary sources of pollution.

Out of the 112 elements in nature, about 80 are metals, most of which are found only in trace amounts in the biosphere and in biological materials. There are at least some twenty metals or metal like elements which do give rise to well organized toxic effects in man and his ecological associates (Fiber, *et al.,*1979) These elements include Arsenic, Antimony, Beryllium, Cobalt, Chromium, Lead, Manganese, Mercury, Molybdenum, Nickel and Tin. These metals have been known to be toxic to man for centuries, and their carcinogenic activities have also been reviewed. Among the different pollutants heavy metals have received escalating attention due to their possible injurious effects to man, animal and plants. Heavy metals are conventionally defined as elements with metallic properties such as ductility, conductivity, stability as cations, legend specificity etc. and atomic number greater than 20. The most common heavy metal contaminants are Cadmium, Chromium, Copper, Mercury, Lead, Zinc, Arsenic, Nickel and Vanadium. Heavy metals form the major group of toxic pollutants among the other pollutants, as these metals temper the harmony of the ecosystem .The accumulation of potentially toxic elements may vary from plant to plants and soil to soil. World Health organization (WHO) has recognized health hazards to these metals in food chain even at low concentration (WHO, 1984). Heavy metal ions such as Cu^{2+}, Zn^{2+}, Mn^{2+}, Fe^{2+}, Ni^{2+} and CO^{2+} are essential micronutrients for plant metabolism but when present in excess, these and other non-essential metals such as Cd^{2+}, Hg^{2+}, Ag^{2+} and Pb^{2+} can become extremely toxic (Williams, *et al.,* 2000).

Vegetables grown on sewage fed soils showed elevated content of some heavy metals, reduced crop yields have also been reported by farmers irrigating their field with sewage water over a period of time. Long term use of sewage effluents contaminated with heavy metals influence the soil microbial biomass, soil respiration, nitrification, potentially mineralizable nitrogen and dehydrogenises and phosphates' enzyme activities (Kizilkaya*et al.,* 2004). The application of city garbage and sludge contaminated with heavy metals to soil may affect the bioavailability of heavy metals (Jeevan Rao and Shantaram, 1994). In recent years research has been focused on accumulation of heavy metals in crop plants and naturally growing weeds. The process of metal uptake and accumulation of different plants depends on the available metals in soils, Solubility sequences and the plant species growing on these soils (Anderson, 1977) at high concentrations, these metals become toxic, as do the non-essential metals causing symptoms such as chlorosis and necrosis, stunting leaf discoloration and inhibition of root growth. Heavy metals enter plant mainly through the root system and may cause a morphological and physiological disturbance (Pahlsson, 1989) adverse cytological effect like chromosomal aberration and low mitotic index on *Allium sativum* has also been observed. Regular monitoring of the heavy metal content of sewage water industrial effluents underground water and soils is need of time. The present study addressing heavy metal concentrations in the sewage water and their accumulation in the sewage water and their accumulation in soli and plant species was undertaken with objectives, to study the effect of heavy metals (cadmium, lead, nickel) in treated sewage water and tube well water, to study the heavy metal toxicities by sewage water and tube well water on soil and to determine the heavy metal accumulation in crops (potato and radish) due to treated sewage water irrigation.

2.0 Materials and Methods:

2.1 Experimental Site:

The sites for the present investigation were selected at chaka block, Allahabad where farmers usually irrigated their fields with sewage water. All the facilities needed for the experimental procedures were readily available. The extraction/analysis for the selected samples was done in soil science laboratory of Forestry Department, AAI-DU, and Allahabad.

2.2 Climate of Allahabad:

Allahabad is located in south eastern part of Uttar Pradesh at an elevation of 78 meters from the Sea-level. The climate is basically sub-tropical with extreme of summer and winter. During summer the temperature raises up to 48 °C, whereas during the winter it is sometimes as low as 1.8 °C, occasionally frost is also seen. During summer, the southern extreme dry hot strong wind (loo) is common in feature. The average rainfall of Allahabad is about 50 cm, which is concentrated during the period of July to September. Occasional rains during winter may also be received.

2.3 Mechanical Analysis:

The mechanical analysis was done by "Bouyoucous hydrometer method" as described by Wright (1927).

Ingredients	Percentage
Sand	49%
Silt	25%
Clay	26%

Table 1: List of plant species which are chosen for chemical analysis

Botanical name	Common name	Plant part used
Raphanussativus	Radish	Root
Solanumtuberosum	potato	stem

2.4 Chemical Analysis:

2.4.1 Sampling and Analysis of Treated Sewage Water and Tube Well Water:

Composite waste water was collected from chaka block sewage channel carrying sewage mixed with untreated industrial effluents. The manual sampling from sewage surface was carried out by plastic bottle fastened by a rope. The container was rinsed twice with the sample to be examined before being finally filled. A 2000 ml of sewage sample was collected in polyethylene bottle reined with 20% HNO_3 followed by distilled water. Water samples from deep tube well were also collected. High grade plastic bottles of 2000 ml capacity were thoroughly cleaned and were rinsed with the water being sampled. The samples were collected after running the water for 15 minutes from the source so as to avoid error due to water contained within the pipes. For each samples background information regarding the area, location and depth of the well was recorded.A 100 ml portion of the thoroughly mixed sewage water sample was transferred to a 250 ml beaker. The 100 ml sewage water sample was evaporated to dryness on steam both and digested with 5 ml of perchloric acid (HClO4) and nitric acid (HNO_3) mixture (1 : 4) on hot plate to the lowest volume (15-20m1). Each digest was made up to 50 ml with the addition of double distilled water (APHA, 1975). Cd, Pb and Ni, were determined in the digest by AAS (Atomic Absorption spectrophotometer).

2.4.2 Soil Sampling and Analysis:

Before sowing of crops, representative soil samples were collected from field. The soil samples were collected at the depths (0-15 cm), (15- 30cm), (30-45 cm), (45 - 60 cm) with the help of a stainless steel tube auger. The representative soil samples were brought in polyethylene air tight bags to laboratory. The soil samples were dried at 40 °C for 48 hours in the hot oven and crushed to pass through a 2mm nylon sieve. A di-acid mixture was used to find out the heavy metals Cd, Pb, Cu in the soil. A known amount (5 gm) oven dry soil was weighed and transferred into 100 ml beaker to which 25 ml of concentrated HNO_3 and 5 ml of perchloric acid was added. [25 ml conc. HNO_3 and 5 ml of $HClO_4$ (5:1)].The mixture was placed on a hot plate 105 °C for one hour and then temperature was increased to 140 °C until the sample was completely dry. After cooling, the solution was mixed and filtered through what man No. 42 filter paper into a 50 ml volumetric flask. The digested samples were then analysed for Cd, Pb, and Ni on AAS (Atomic Absorption spectrophotometer) at IFFCO, Phulpur Allahabad.

2.4.3 Plant Sampling and Analysis:

Plant samples of different crops were collected from fields irrigated with treated sewage water, as well as with tube well water samples of Radish (*Raphanussatipuus*), potato (*Solonumtuborosum*), were collected at the time of harvest, plant samples were washed successively with the tap water, acidified water, distilled water and double distilled water. These samples then dried, first at room air temperature for several days and then in hot (60 + 5 °C) air oven for 48 hours. The dried plant parts were then crushed and powdered separately in mortar and pestle. The powdered plant samples were then put separately in well washed, dried and suitably tabled flasks and thee samples were then ready for digestion. The digestion mixture for biological sample was a di-acid mixture. The mixture comprised concentrated HNO_3 and $HCl0_4$. To one gram of plant material, 5 ml of concentration HNO_3 was added and kept overnight. Next day, 12 ml of diacid mixture (concentration HNO_3 +$HClO_4$ in the ratio 3:1) was added and digested on hot plate till white Reddish brown fumes of perchloric acid comes out. The plant samples slowly begin to dissolve and digest in di-acid mixture. After a few hours the plant sample dissolved completely in the digestion mixture and the solution was then evaporated until only about 2 ml was left in the flask. The digested samples were then transferred into small tubes and were sent for analysis using the Atomic absorption spectrophotometer (Jackson, 1967).

2.4.1 Atomic Absorption Spectrophotometer (AAS):
Atomic absorption spectroscopy is a relatively new technique, having been developed as an analytical tool in the late 1950's. AAS is widely used both for total elemental analysis and cation exchange analysis. The AAS phenomenon can be divided in to two major processes. The production of free atoms from the sample, and The absorption of radiation from an external source by these atoms. By this technique, the determination of test samples can be made in the presence of many other elements, and thus saves a great deal of time and eliminates several sources of error.

3.0 Result and Discussion:
The experimental results pertaining to the present investigation have been presented and discussed under following heads:

1. Concentration of heavy metals in treated sewage water and tube well water.
2. Accumulation of Cd, Pb, and Ni in sewage and tube well irrigated soils.
3. Cd, Pb and Ni concentration in potato and reddish when irrigated with treated sewage water and tube well water.
4. Concentration of heavy metals in treated sewage water and tube well water.

3.1 Cadmium:
The concentration of Cd was significantly higher in sewage contaminated water than the tube well water in tube well water Cd concentration varied from 0.0006 to 0.0002(mean 0.0004 mg l^{-1} water), But the concentration of Cd in sewage water ranged from 0.15 to 0.13(mean 0.14 mg $litre^{-1}$ water), In sewage water the values of mean concentration of Cd were 350 times than that of tube well water The sewage water near the discharge point contained appreciably high amount of Cd and gradually decreased as distance from the discharge point increased. Khan (2001) also reported that water in areas near to source of effluent discharge was more contaminated, as compared to the areas away from the sources. The increase in Cd concentration was also due to availability of different organic sources in sewage water. The mean total Cd concentration of tube-well water showed almost similar values.

3.2 Lead:
A wide range in concentration of Pb was found in sewage and tube well water Its concentration varied from, 0.43 to 0.35 mg l^{-1} (mean 0.39). In tube well water its concentration varied from.0.019 to 0.013 mg l^{-1} (mean 0.016). Thus, in sewage water the mean Pb concentration was 24.37 folds than its concentration in the tube well water.

3.3 Nickel:
Ni concentration varied from 0.0003 to 0.0001 mg l^{-1} (mean 0.0002). But concentration Ni in sewage water ranged from 0.21 to 0.17 mg 1^{-1} (mean 0.19). In sewage water the values of mean concentration of Pb were 950. Folds higher than that of tube well water. The heavy metals were significantly higher in sewage water as compared to that in tube well water. Mitra and Gupta (1999) also reported higher concentration of heavy metals in sewage water than that of tubewell water.

Table 2: Concentration of heavy metals (mgl-1) in sewage and tube well water

Sample	**Sewage water irrigated**			**Sample**	**Tubewell water irrigated**		
	Cd	**Pb**	**Ni**		**Cd**	**Pb**	**Ni**
SW_1	0.15	0.43	0.21	TW_1	0.0006	0.019	0.0003
SW_2	0.13	0.35	0.17	TW_2	0.0002	0.013	0.0001
Mean	0.14	0.39	0.19	Mean	0.0004	0.016	0.0002

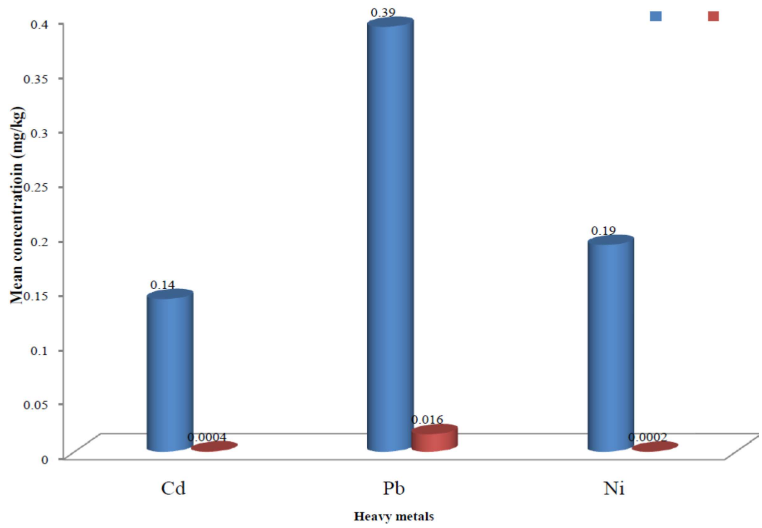

Fig. 1: Concentration of heavy metals in sewage and tube well water

3.4 Accumulation of Cd, Pb And Ni in Sewage and Tube Well Irrigated Soils:

The extent of contamination due to anthropogenic activity is generally judged by making comparisons of the metal contaminated soils with adjacent non polluted ones as there is no direct reference level due to wide variations in naturally occurring heavy metals in soils. The same criteria have been followed in present study to determine the distribution and extent of heavy metal pollution in sewage irrigated soil as compared to tub well irrigated soils. The data on Cd, Pb and Ni in soils is presented in table2. The concentration of these metals in the sewage and tube well irrigated soils at chaka block.

3.4.1 Cadmium:

Manifold increase in the Cd was found in sewage irrigated soils than tube well irrigated soils. In sewage fed soils of chaka block Cd content in 0-15.15-30,30-45 and 45-60 cm depth varied from 0.78 to 0.70 mg cd kg^{-1} soil (mean 0.74 mg Cd kg^{-1} soil), 0.62 to 0.20mg Cd Kg^{-1} soil (mean 0.41 mg Cd Kg^{-1} soil), 0.16 to 0.12 mg Cd Kg^{-1} soil(mean 0.14mg Cd Kg^{-1} soil), and 0.13 to 0.07 mg Cd Kg^{-1} soil (mean0.10mg Cd kg^{-1} soil). The mean values of Cd in tube well irrigated soils in the 0-15, 15-30 ,30-45, 45-60 cm depth respectively were 0.12, 0.10, 0.08, and 0.08 mg cd kg^{-1} soil in chaka block. The difference in Cd between sewage and tube well irrigated soils was restricted largely to the 0-15 and 15-30 cm soil depths and there was particularly no difference in Cd beyond 30 cm depth. In 0-15 and 15-30 cm soil depth, the respective Cd in sewage irrigated soils was 6.16 and 4.1 fold in chaka block over the tube well irrigated soils among the sewage irrigated soils, the mean Cd in the surface soils was in chaka block 0.74 mg Cd kg^{-1}. In 15-30 cm soil depth the order of accumulation of Cd was chaka block (0.41 mg kg soil).The maximum accumulation of Cd in soils may be due to the continuous use of sewage water for irrigation purposes for more than one decade and the site nearest to the sewage discharge point contained appreciably high amount of Cd and gradually decreased as distance from the discharge point increased. Brar an Arora (1995), Mitra and Gupta (1999) and Khurana*et al.,* (2004) also reported higher concentration of heavy metals in sewage irrigated. soils than soil irrigated with uncontaminated water. The Cd content of soils with continuous application of sewage water has been reported by many workers Jinds et al., (1997) have reported that in Australia the content of Cd increased from 0.36mg kg in unpolluted soils to 1.33mg kg in soils receiving heavy annual application of poultry manure. The decrease in Cd concentration with the depth had also been reported by Andersson and Nilsson (1972) and Singh and Kansal (1983).Tiller (1991) also surveyed the distribution of Cd and Pb in Australia and found that Cd in surface soil was associated with the geochemistry of parent materials, atmospheric fallout of urban origin and kind of organic and inorganic fertilizers applied.

Table 3: Depth wise distribution of cadmium (mg/kg) in sewage and tube well soils

Sample	Sewage irrigated				Sample	Tube well irrigated			
	0-15	15-30	30-45	45-60		0-15	15-30	30-45	45-60
S_1	0.78	0.62	0.16	0.13	S_1	0.14	0.12	0.08	0.09
S_2	0.70	0.20	0.12	0.7	S_2	0.10	0.08	0.08	0.07
Mean	0.74	0.41	0.14	0.10	Mean	0.12	0.10	0.08	0.08

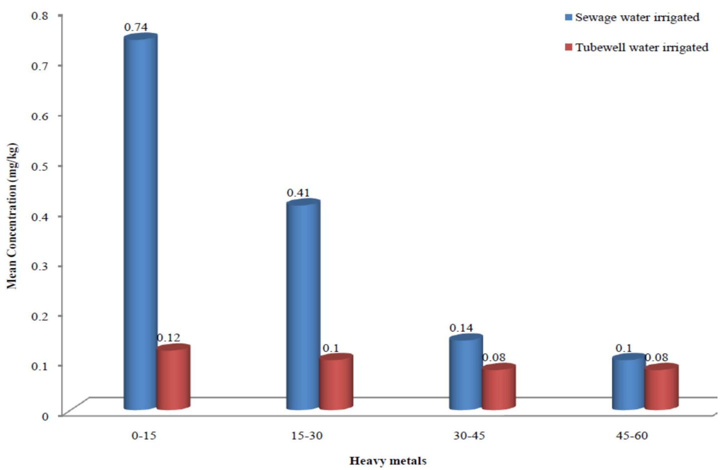

Fig. 2: Depth wise distribution of cadmium in sewage and tube well soils

3.4.2 Lead:

A perusal of the data in table indicated that the concentration of Pb was higher in sewage irrigated soils than in the tube well irrigated of chaka block at all the four depths (0-15, 15-30, 30-45 and 45-60cm). The amount of Pb in the Chaka block (4.10mg Pb Kg^{-1} soil). In 15-30 cm depth also the sewage fed soils contained Pb (2.10mg kg^{-1} soil). In chaka block, Allahabad. The concentration of Pb in the surface (0-15 cm) and subsurface soils (15-30 cm) respectively varied from 5.10 to 3.10 (mean 4.10) and 2.6 to 1.6 (mean 2.10 mg Pb kg^{-1} soil). The concentration of Pb decreased with depth in both tube well and sewage irrigated soils in Chaka block. The extent of lead built up in sewage irrigated soils was significant in both 0.-15 and 15-30 cm depth. This might be due to the fact that the concentration of heavy metals in sewage effluents emanating from different sources is manifolds higher than that of tube well water. A gradual decline in its concentration was recorded with increase in distance from the point of sewage discharge and down the profiles. The data further indicated the enrichment of Pb due to the discharge of sewage water and sludge mostly in the surface layer with very little mobility down the profile. Datta *et al.,* (2000) reported that the soils of IARI farm receiving sewage water of mostly domestic origin for more than three decades has only marginally increased the concentration Pb from 1.2 to 1.6 mg kg^{-1} soil.

Table 4: Depth wise distribution of lead (mg/kg) in sewage and tube well soils

Sample	**Sewage irrigated**				**Sample**	**Tube well irrigated**			
	0-15	**15-30**	**30-45**	**45-60**		**0-15**	**15-30**	**30-45**	**45-60**
S_1	5.1	2.6	0.50	0.30	S_1	1.074	0.70	0.59	0.27
S_2	3.1	1.6	0.42	0.22	S_2	1.00	0.58	0.35	0.15
Mean	4.10	2.10	0.46	0.26	Mean	1.02	0.64	0.47	0.22

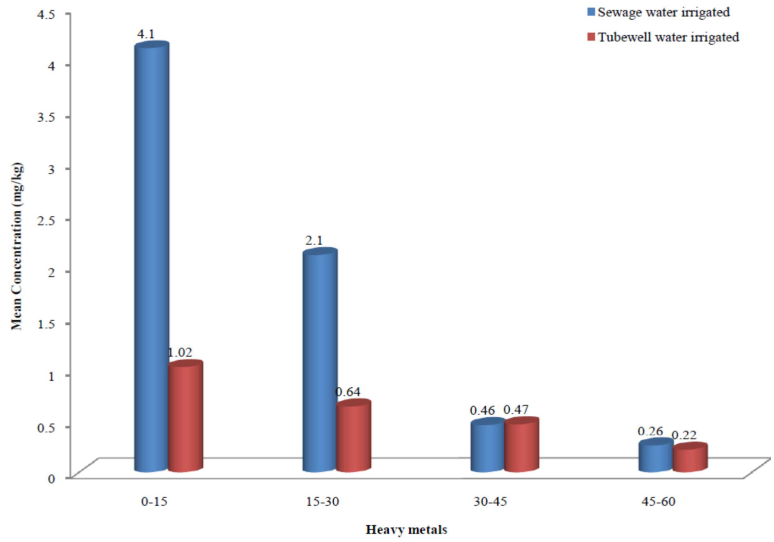

Fig. 3: Depth wise distribution of lead in sewage and tube well soils

3.4.3 Nickel:

The data on Ni content of different depths in soils of chaka block is presented in table. In sewage irrigated surface soils of chaka block, it varied from 2.31 to 1.57mg Ni kg^{-1} soil with the mean value of 1.94mg Ni kg^{-1} soil and in tube well irrigated surface soils it varied from 0.56 to 0.42mg Ni kg^{-1} soil with mean value of 0.49mg Ni kg^{-1} .Thus the mean value of Ni in 0-15cm soil layer was 3.96 fold in sewage irrigated soil over the tube well irrigated soils. In other the two soil depths i.e. 30-45 and 45-60 cm the differences were not of much significance. As has been stated above for Cd and Pb the concentration of Ni also decreases with the depth in both tubes well and sewage irrigated soils. The elevated levels of Ni sewage irrigated compared to tube well irrigated soils was due to the addition of this metal through the sewage water which contained up to 0.19 mg Ni 1-1 in chaka block. Since the sampled soils were receiving such waters for a long period, therefore it has lead to continuous build up Ni in the soils. The mean nickel concentration (0.19 mg Ni kg soil) in sewage irrigated soils of chaka block.

The Ni decreased progressively with soil depth and increase in distance from the point of sewage discharge. Organic matter has been reported to bind various heavy metals (Singer and Navrot1976;) and is responsible for their accumulation and movement in soils depending on nature of organic matter. Thus, it may be concluded from the present study that the application of waste waters has resulted in appreciable accumulation of Cd, Pb and Ni in soil most of the accumulation of these metals was restricted up to 30 cm depth. The continuous cultivation of these lands for food and fooder crops, result in greater uptake of metals by crops, resulting in health hazard to animals and human beings.

Table 5: Depth wise distribution of nickel (mg/kg) in sewage and tube well soils

Sample	**Sewage irrigated**				**Sample**	**Tube well irrigated**			
	0-15	**15-30**	**30-45**	**45-60**		**0-15**	**15-30**	**30-45**	**45-60**
S_1	2.31	0.50	0.12	0.06	S_1	0.56	0.20	0.08	0.05
S_2	1.57	0.30	0.10	0.02	S_2	0.42	0.18	0.04	0.03
Mean	1.94	0.40	0.11	0.04	Mean	0.49	0.19	0.06	0.04

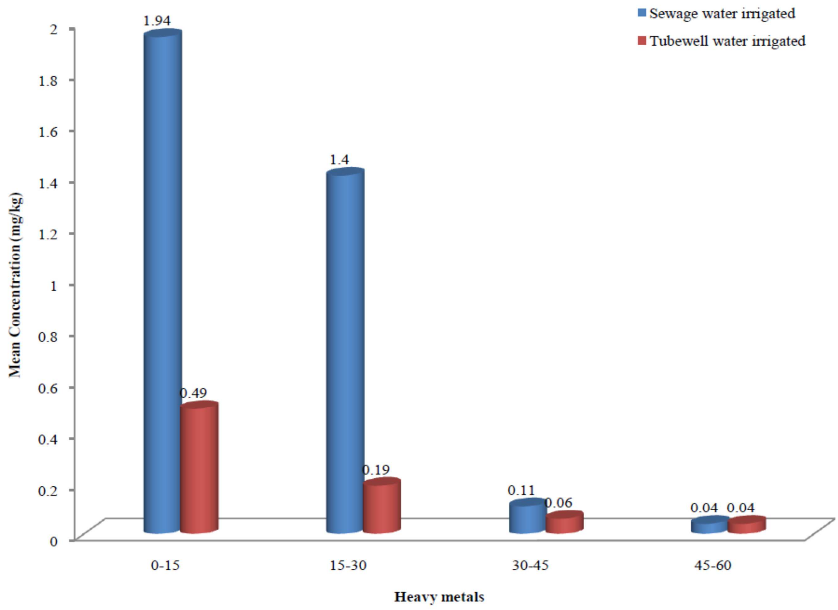

Fig. 4: Depth wise distribution of nickel (mg/kg) in sewage and tube well soils

3.5 Cd, Pb and Ni Content in Potato and Reddish Grown on Sewage and Tube Well Irrigated Soils:

Crops are one of the principal sinks for accumulation of the heavy metals and these metal contaminated edible portions act as poisons for human being and other living organisms. This is a matter of serious concern as vegetables, being prolific accumulators of heavy metals provide easy entry into food chain to these dreaded metals. The heavy metal accumulation by plant roots collected from the field receiving by sewage water in chaka block and from the adjoining field irrigated by tube well water is presented in table4

3.5.1 Cadmium:

Cadmium content of the plant samples exhibited a wide range of variations in chaka block, In plants collected from tube well irrigated soils the Cd content varied from 1.10 to 0.57 (mean 0.835 mg kg^{-1} dry matter),. But Sewage irrigation increased the accumulation of Cd in different crop species. It varied from 1.491 to 1.159 (mean 1.325 mg kg^{-1} dry matter), In sewage irrigated crops the values of mean content of Cd were 1.58, times than the tube well irrigated plants . The results showed that sewage water led to the buildup of heavy metals in crop plants grown in that soil. However, Cd concentration in plants grown in tube well irrigated soils shows almost similar values.

Chitdeshwari et al., (2002) reported that increased levels of sewage water increased the uptake of heavy metals including Cd and Cr in amaranthus crop. The greater accumulation of pb in roots of crops were observed. Breckle and Kahle (1992) demonstrated that Pb is captured in the root applets and hence, its translocation to the shoot was restricted.

3.5.2 Lead:

A wide range in plant concentration of Pb was found in sewage and tub well irrigated soils. In sewage irrigated plants, It concentration varied from, 0.88 to 2.28 mg kg^{-1} dry matter (mean 6.60). In tube well irrigated plants its concentration varied from 2.10 to 0.64 mg kg^{-1} dry matter (1.37). Thus, in sewage irrigated soils the mean Pb concentration of plants was 4.81 folds than its content in the tube well irrigated soils. Brar*et al.,* (2000) also reported higher accumulation of metals in tubers of potato grown on sewage irrigated soils as compared to those grown on tube well water irrigated soils. On comparison of heavy metal concentration with respect to initial concentration, the concentration was below the critical concentration range which is 25 —85 [.ig/g for Pb (Maniacal and Beckett, 1985), indicating safe background levels.

3.5.3 Nickel:

A substantial increase in mean Ni concentration of plants from 1.50 mg kg in tube well irrigated soils of chaka block to 4.78 mg kg^{-1} in sewage irrigated soils was observed. This may be due the fact that sewage water contains munical, domestic and hospital wastes. The wastes of these sources contain lot of Ni .Tiwana et al., (1987) also observed a nickel concentration varying from 1.0 to 3.0 μg^{-1} in waste water from electroplating industries of ludhiana city. Anderson and Nilsson (1976) reported that the use of sludge had elevated the level of Ni, Cd, Zn and Cu in soils as well as the crops. Similar findings have earlier been observed by Singh and Kansal (1983). However, due to genetically characteristics, plant species and even varieties differed in their susceptibility and tolerance to Nickel. The preceding results indicated that heavy metal enriched sources affected the soil and plant metal concentration directly by serving as a source of trace metals and indirectly by altering the soil chemistry. Therefore irrigating agricultural fields by sewage water, the chemical composition of sewage water especially heavy metal concentration should be tested properly as sewage water contain higher concentration of potentially toxic elements, therefore the accumulation of heavy metals, in soils and their subsequent uptake by plants is a major concern for soil, plant, animal and human health.

Table 6: Heavy metals concentration in potato and reddish grown on sewage and tube well irrigated soils

Sample	Sewage water irrigated			Sample	Tube well water irrigated		
	Cd	Pb	Ni		Cd	Pb	Ni
SW_1	1.491	8.88	6.14	TW_1	1.10	2.10	1.42
SW_2	1.159	2.28	3.42	TW_2	0.57	0.64	1.58
Mean	1.325	6.60	4.78	Mean	0.835	1.37	1.50

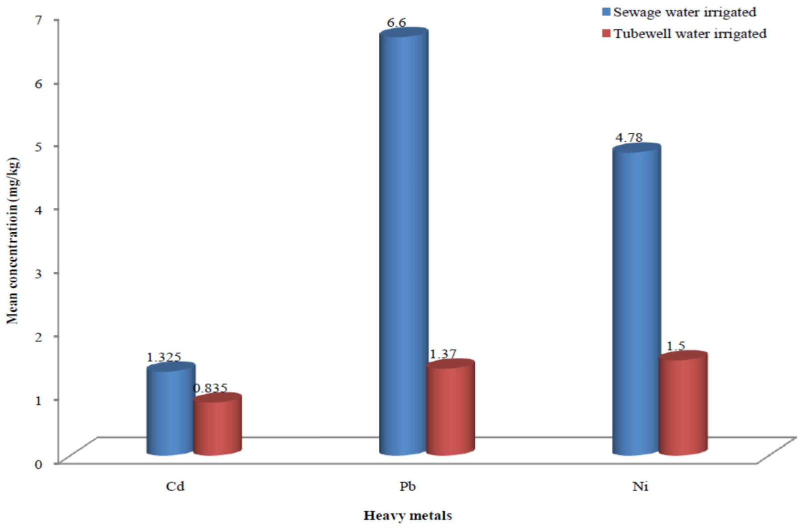

Fig. 5: Heavy metals concentration in potato and reddish grown on sewage and tube well irrigated soils

4.0 Conclusion:

An investigation was undertaken to study the heavy metal concentration in sewage water collected from Chaka block in Allahabad city and its accumulation on soil and crop plants. Results of the investigation revealed that sewage water was polluted with Cd, Pb, and Ni due to the disposal of house hold, commercial and hospital wastes in the sewage drain. The concentration of heavy metals was significantly higher in sewage water than tubewell water. The overall mean concentration of Pb, Cd, and Ni sewage water were 562.5, 24.09, 900, times higher over their respective concentration in tube well water. The Cd, Pb and Ni concentration in sewage water were above the permissible limits for their disposal on agricultural .land. The mean total Cd, Pb, and Ni concentration in tube well water. The concentration of Cd, Pb and Ni was significantly higher in all sewage irrigated soils at all the four depths (0-15cm 15-30cm, 30-45cm and 45-60cm. The maximum accumulation of heavy metals in soils of chaka block is due to the continuous use of sewage water for irrigation purposes for more than one decade.

Cadmium, lead and Nickel concentration are higher at the surface horizons and it decreases sharply with depth in both tube well aria sewage irrigated soils in the three sites. The extent of heavy metal built up in sewage irrigated soils was significant in both 0-15 cm and 15-30 cm depth. A gradual decline in its concentration was recorded with increase in distance from the point of sewage discharge and down the profile. The data further indicated that the enrichment of heavy metals due to the discharge of sewage water and sludge mostly in the surface layer with very little mobility down the profile.

Vegetables commonly grown in the sewage and non-sewage irrigated area, are radish, potato, etc. The higher concentration of Pb, Cd and Ni, were observed in the roots of all crops grown in sewage irrigated soils compared to that of crops grown on tube well irrigated soils. The mean concentration of Cd, Pb, and Ni in crops grown on sewage irrigated soils were 1.41 is higher than on tube well water irrigated soils. Therefore, the sewage water irrigation has a great potential to contaminate the soil which may lead to the accumulation of heavy metals in crop plants and may cause harmful effect, on human beings, animals and plants. The results of this study, therefore, indicate that long term and indiscriminate application of sewage water which contains heavy metals may cause accumulation of heavy metals in surface and sub-surface soils and the buildup of heavy metals on soil profile may prove harmful not only to plants, but also to consumers of the harvested crops.

1) It is suggested that efficiency of sewage water treatment plants should be increased which will reduce the toxic heavy metal load in the environment.

2) Metal tolerant species (i.e. hyper accumulator plant/weeds grasses etc.) should be selected and alternatively grown with crops and vegetables to eliminate or least, reduce to some extent, the metal concentration in the soil.

3) Practices of irrigating the agricultural lands with sewage water for long periods should be ceased.

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