JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Effect Of Heavy Metal Pollution On Total Microbial Count Ability Of Soil In Kanpur

Madhuri Yadav[1], Smriti Kamal[2] and Rajni Singh[3]

[1,2]Department of Zoology, D.B.S. College, CSJM University, Kanpur

[3]Department of Zoology, M.M.H. College, CCS University, Meerut

Corresponding author- Smriti Kamal

Abstract

Soil is one of the most important natural resource for human being and plants. Accumulation of heavy metal in the soil and plants have negative effect on physical and biochemical properties. The physiological and biochemical activities of microbes also effected by heavy metals. Microbes play an important role in environment by participation in biogeo-chemical cycles. They convert heavy metals in less toxic compounds and utilize them for plant growth. Recently environmental pollution has become a serious threat for whole world. This modern urbanization and industrialization expanded in all natural resources such as water, soil, air and expansion of chemical pesticides have been widely distributed and adversely affect the microbes and ecosystem. Some heavy metals like Cr, Pb, Hg, Cd, and As are harmful. If their concentration in soil crossed the appraisable limit then it will show toxic effects on all living organisms. They inhibit the growth of micro-organism by structure-deformation and interfere with biochemical cycle. Microbes are dynamic in nature and they are highly sensitive, if changes occurs in their surrounding like nutrients, temperature, pH and moisture. Soil health mainly determined by the presence of microbes. Increasing concentration of heavy metals badly affect the microbial diversity and their count. Heavy metals can be removed from polluted area by using of bioremediation technique. Microbes can be increased by using of maximum biological fertilizer and pesticide in agriculture. The case study of contaminated soil of Kanpur which is an example of both agricultural and industrial areas, show that Kanpur region are susceptible to industrial and highly urbanized areas.

Key Words- Soil, Heavy metal, microbial count, soil, pesticides

I. Introduction

Soil is natural resource of living beings. It is the basic element of food production and the carrier of economy (Lu and Li Cy 2010). Heavy metal are metallic element that have high density in soil comparison to water. Heavy metal like mercury, lead, chromium, cadmium and arsenic etc are harmful for ecosystem and some heavy metals like iron and nickel are essential for survival if they presence in low concentration (Misokiwie *et al.* 2015, Bakshi *et al.* 2018). The effects of excessive heavy metals exposure on plant development and physiological cycle includes reducing seed germination, limiting plant growth, shifting photosynthesis and adjusting enzymatic activities. They cause contamination of agricultural soil and crop by accumulation and magnification in different parts of plant, because of their non-biodegrable nature (Kachenko and Singh 2006).

Continuous release of heavy metals from anthropogenic sources, can easily penetrate in crops and food chain, and inhibits metabolic pathways and causes to metabolic diseases in living organism (Waalkes 2000, Satarug *et al.* 2023, Choi *et al.* 2012). Extent of soil pollution with heavy metals from various anthropogenic sources and subsequent uptake by crop depend upon several factors such as sources, soil type, frequency of application, organic matter content, seasonal variation major and minor nutrient of chemical pollutants.

Such type of pollution is irreversible process and it is hard to manage. Sources of heavy metal are mining, industrial production(smelters, oil refineries, petrochemical plants, pesticides production, chemical industry), untreated sewage sludge and diffuse sources such as metal piping, traffic and combustion by products from coal burning power stations. Rocks and soils are natural sources of heavy metals in the environment. Excess of heavy metals in the soil originate from many sources, which include atmospheric deposition, sewage irrigation, industrial soil waste and uses of pesticides and fertilizers(Zhang *et al.*2011). The fate of a heavy metal applied to soil depend largely on its persistence and solubility properties. Once applied to cropland, heavy metals may either be taken up by plants (Nair et *al.* 1993) or ingested by insects, animals and worms or micro-organisms in the soil or may move downword in the soil (Sujata and Chacko et *al.* 1992) and either dissolve in water and vaporize into atmosphere (Marcire 1992). It may also breakdown by chemical pathways and microbial into less toxic compounds (Samuel and Pillai 1989) rain or irrigation leached out of the root (Li and Migita 1992). Heavy metals like Cr, Pb, Hg, Cu, Ni, As and Zn are used by human activities as fossile fuels and fertilizers (Zanini et *al*. 1992). These heavy metals are persistent negative effect in soil after long lasting. They are absorbed by crops (Oladipo and Bodunde 1993) and afterwards enter the human food chain. Kanpur is industrial as well as agricultural city in Uttar Pradesh. The presence of high amount of heavy metals in some areas, that was analized by Sanghi and Sasi 2001. Resulting they promoted us to take up the monitoring of the agricultural soil, sludge soil and industrial soil where soil is most polluted by pollutants. We explored the possibility of presence of residues of some commonly found heavy metals in the soil sample of Kanpur, India. In this paper, we provide information about the level of heavy metals in agricultural soil, sludge and industrial soil in Kanpur and Near by District and blocks. Sources of heavy metals are given below in detail (Table- 1).

Table-1 Source of heavy metals

S.no.	Metal	Sources
1	Cr	Mining, industrial coolants, chromium manufacturing, leather tanning
2	Pb	Batteries, paints, e- waste, smelting operations, thermal power plant
3	Hg	Alkali plants, thermal power plants, fluorescent lamps
4	Cu	Electroplating, smelting operations
5	Ni	Battery industry, thermal power plants
6	As	Fuel burning
7	Zn	Electroplating

Heavy metal contamination in soil environment increases across the globe. They accumulate in the soil and plants, have negative influence on physiological activities such as photosynthesis, gaseous exchange, nutrient absorption, plant growth reduction and dry matter accumulation. Contaminated soil with heavy metals reduced the food quality and increase the risk and hazards to human beings and all other living organisms through direct ingestion or contact with contaminated soil. Heavy metal stress would tend to increase the tolerance of micro-organism. They also affect the presence of microbial communities and diversity (Zhao *et al.* 2019). The physiological and biochemical pathway of microorganisms can be altered by presence of heavy metals and they cause oxidative damage, affect the growth of soil microbes and denaturation of micro-organism and weak bioremediation of microbes (Gulser *et al.* 2008). The effect of heavy metals are given below in detail (Table-2).

Table-2 Effect of Heavy metals

S.No.	Heavy metal	Effect on Animal	Effects on plants	Effect on micro-organism
1.	Cr	Cause Asthma, eye irrigation and damage, respiratory problem, kidney damage	Reducing pigment and chlorosis in leaves	Affect metabolic activity of cells and disturbed oxidative balance
2.	Pb	Cause problem on bones, liver disease, skin cancer immunological and reproductive	Inhibit ATP production and root elongation	Inducing oxidative damage and denaturation of micro-organism
3.	Hg	Stomach pain, cough, Chest pain, insomnia, headache, and weight loss	Inhibit enzyme activity	Inhibit growth of actinomycetes, fungi and bacteria, and affected soil bacterial activity
4.	Cu	Liver damage, cramps, nausea and diarrhea	Plant growth, inhibit photosynthesis and	Disrupts bacterial cell membranes and generate

			metabolism	oxidative stress
5.	Ni	Lung fibrosis, cardiovascular disease and lungs cancer	Reduces seed germination and biomass accumulation	Decrease the acidic level
6.	As	Brain damage, diabetes and cancer	Reduction in shoot and root growth	Deactivation of enzyme
7.	Zn	Stomach pain, vomiting and nausea	Loss of production and grain nutrient content	Inhibit the growth

II. Materials and Methods

Kanpur District lies in the centre of Uttar Pradesh. The latitude of 26º27' N, 80º19' E longitude (Tripathi, 2013). Total fifteen soil samples were collected from different sites, of Kanpur district.

Soil Sample method

Contaminated soil Sample were collected from different sites of Kanpur region like industrial site, agricultural site and dumping sites. Samples from different location at each farm site were collected. At each sampling Slot 'V' Shaped cut was made up to 15cm depth to collect sample (Mhatre et *al.* 2022).

1. Measurement of Heavy metals in soil

Detection the effect of heavy metal on soil microbes in contaminated soil. Result of various research shows heavy metal affect the environment. In this study we find out the presence of heavy metals by like Cr, Pb, Hg, Cu, Ni, As and Zn by different detection methods such as spectrophotometer, Atomic absorption spectrophotometery and atomic fluorscence spectrometery (Sanghi and sasi 2001). The data analyzed during research were subjected to statistical analysis by the method of " Analysis of Variance" (ANOVA) technique (Fischer, 1927).

2. Analysis of Microbial count in Soil

A 20g soil sample were dissolved in 100 ml of sterile water and shaken for 10 minutes at 120 rpm (round per minutes) and used for dilution. Two aliquots of 0.1 ml of suitable dilution (10^{-6}) were separately poured and spread each on nutrient agar plates. The plate incubated at 30º C for 24 to 48 hour and observed for the formation of visible growth and colony forming units from each plate were counted (Sanghi and sasi 2001).

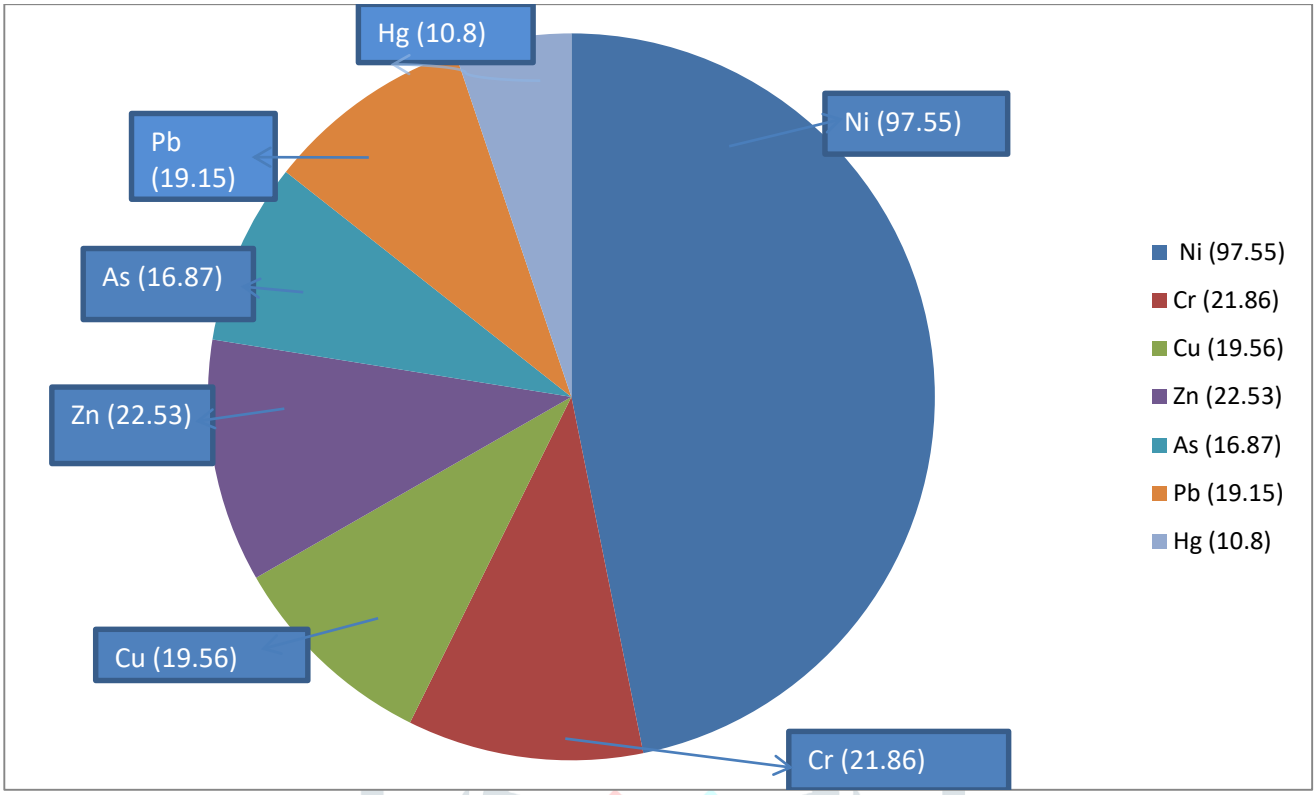
III. Result and Discussion

The total quantity of Cr, Pb, Hg, Cu, Ni, As and Zn metals present in agricultural soil sample were found at different range of ppm. Analysis of heavy metal in soil such as agricultural, industrial and dumping sites. Laboratory report shows the quantity of heavy metals for different parameters in contaminated soil. It helps to people to decide the gardening practices, land uses and other might help reduce contamination and improve the soil health. Large concentration of heavy metals in mg/kg were found and Result of this study are given below in table- 3(a, b and c).

Table-3: Heavy metal concentration in collected soil sample-

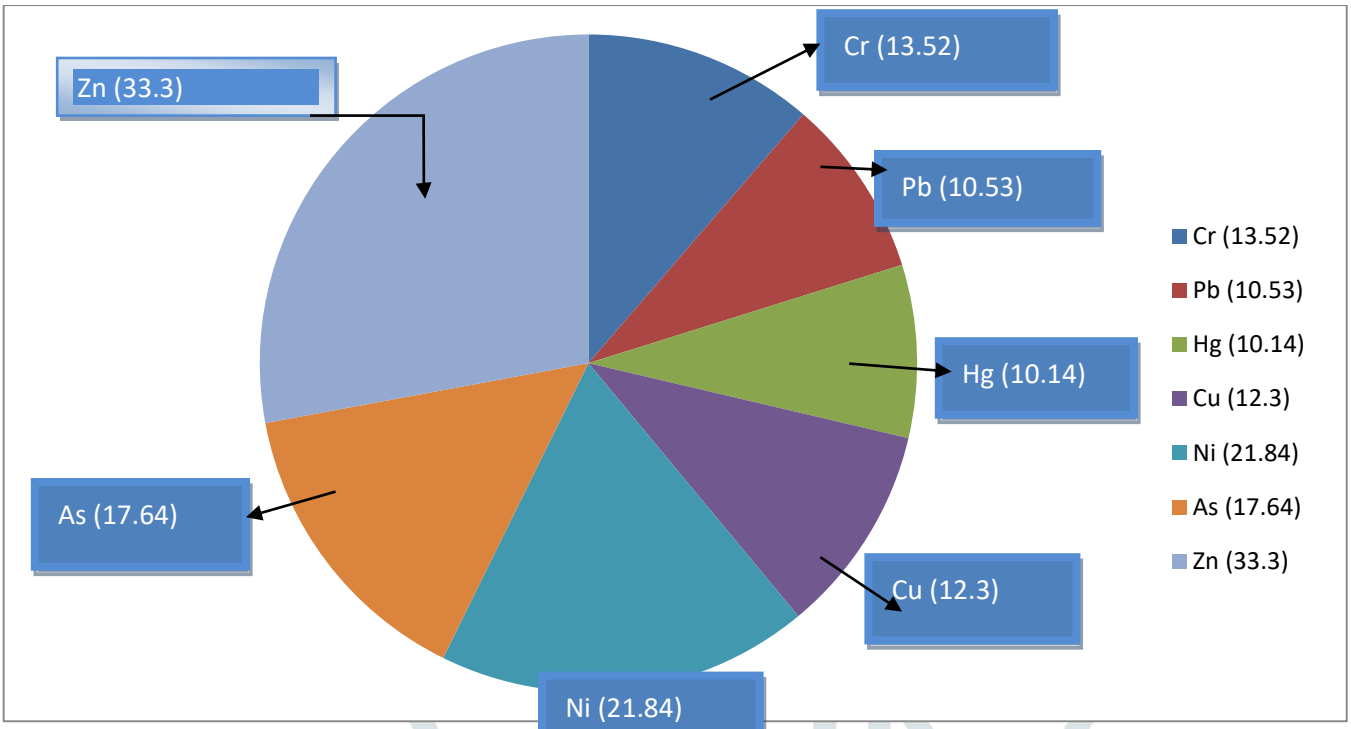
a) Mean Concentration of Heavy metals in mg/kg Industrial area soil sample

S. No.	Soil sample	Cr	Pb	Hg	Cu	Ni	As	Zn
1	**I**	22.0	20.5	4.0	13.04	145.50	15.60	22.03
2	**II**	25.20	24.0	10	14.85	20.0	10.60	15.08
3	**III**	20.1	23.08	16	15.98	41.50	11.24	18.42
4	**IV**	25.0	12.89	5.0	35.04	120.5	12.45	34.5
5	**V**	17.0	15.30	19.0	18.89	160.25	34.5	22.64
	Mean	21.86	19.15	10.8	19.56	97.55	16.87	22.53
	S.D.	3.95	4.86	10.8	8.91	63.07	10.03	7.34
	Range	17-25.20	12.89-24.0	4.0-19.0	13.04-35.04	20.0-160.25	10.60-34.5	15.08-34.5
	R.S.D.	18.09	25.41	61.20	45.55	64.65	59.46	32.57



b) Mean Concentration of Heavy metals in mg/kg Agricultural area soil sample

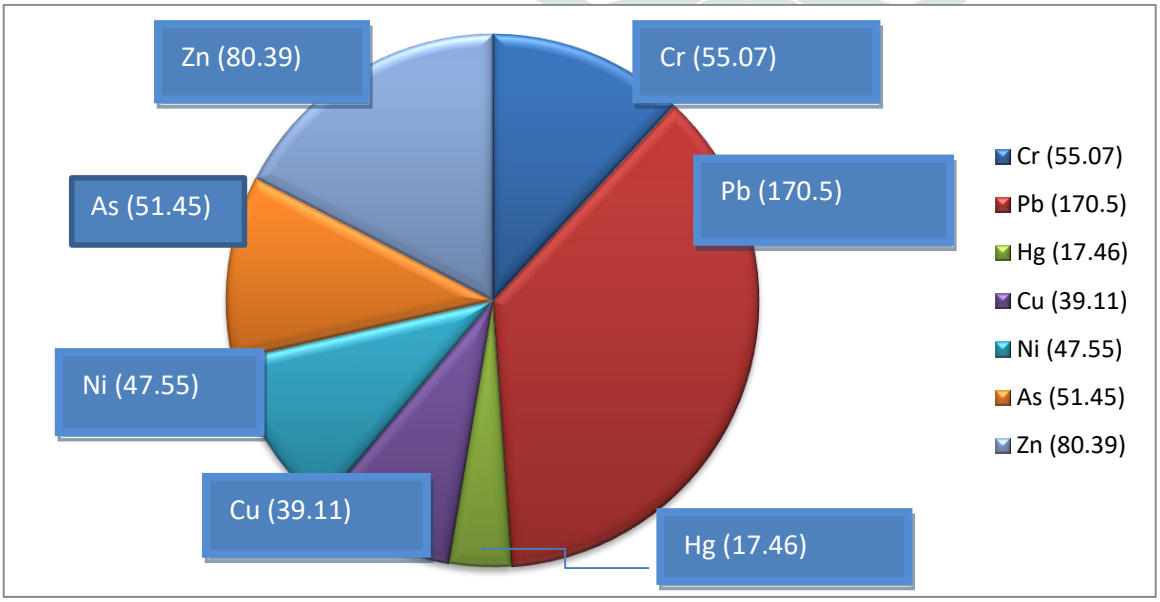
S. No.	Soil sample	Cr	Pb	Hg	Cu	Ni	As	Zn
1	I	12.30	4.64	10.48	10.22	28.5	15.60	56.7
2	II	18.10	5.09	2.02	8.72	26.4	12.30	21.47
3	III	9.12	10.08	16.42	10.24	23.08	33.45	14.07
4	IV	15.02	12.05	18.02	18.26	19.15	16.82	26.10
5	V	13.08	20.8	03.8	14.06	12.08	10.03	48.2
	Mean	13.52	10.53	10.14	12.3	21.84	17.64	33.30
	S.D.	3.32	6.56	7.20	3.87	6.50	9.23	18.24
	Range	9.12-18.10	4.64-20.8	2.02-18.02	8.72-18.26	12.08-28.5	10.03-33.45	14.07-56.7
	R.S.D.	24.54	62.29	71.00	31.46	29.76	52.32	54.77



c) Mean Concentration of Heavy metals in mg/kg sludge soil sample

S. No.	Soil sample	Cr	Pb	Hg	Cu	Ni	As	Zn
1	I	86.2	221.06	10.06	90.04	92.5	42.80	42.7
2	II	36.21	321.8	15.86	48.23	32.9	58.25	86.9
3	III	91.4	50.68	24.0	14.06	82.06	78.23	23.4
4	IV	25.08	190.08	12.11	23.86	16.05	32.65	19.06
5	V	36.5	68.90	25.30	13.36	14.86	45.32	14.36
	Mean	55.07	170.50	17.46	39.11	47.55	51.45	80.39
	S.D.	31.18	112.37	6.89	31.33	37.17	17.53	64.91
	Range	25.08-91.4	50.68-321.8	10.06-25.30	13.36-90.04	14.86-92.5	32.65-78.23	14.36-86.9
	R.S.D.	56.61	65.90	39.46	80.10	78.17	34.07	80.74

S.D.- Standard Deviation, R.S.D.- Relative Standard Deviation



Soil have a natural ability to hold the metals. The current input of metal contaminants might overload capacity. Where some metals less tightly bound to soil particle like mercury. Metals absorb by plants, which they might be toxic. Zinc and lead are more acidic in nature.

Agrobacterium, Xanthomonas, Pseudomonas, Rhizobium, fungal and nitrogen fixer are present in soil sample. There quantity were higher as compare to total number of bacteria present in metal contaminated soil samples. Heavy metals have high affinity to some biological molecules like enzyme activity. Resulting Heavy metasl inhibited the growth of bacteria (Chu et *al.* 2017). Oliveira et *al.* 2005 also observed the reduction of total microbial count in metal contaminated soil sample. Metal contaminated soil is also reduce the count of bacteria because higher concentration of heavy metals decreases the bacterial population. Such type of results by are given below (Table-4)

Table- 4. Total Microbial Count of collected Soil Sample(CFU/ml)

S.No.	Soil Sample	Xanthomonas	Psedomonas	Rhizobium	Fungal	Nitrogen fixer	Agrobacterium
1.	I	$3.2X10^6$	$1.6\ X10^5$	$0.4X10^4$	$7X10^5$	$7.2\ X\ 10^3$	$6.9X10^6$
2.	II	$2.8X10^6$	$3.23X10^5$	$5.7X10^6$	$8.2\ X10^5$	$5.2\ X\ 10^3$	$7.5X10^5$
3.	III	$0.4X10^6$	$1.2X10^6$	$8.3\ X10^5$	$3.5X\ 10^3$	$3.7\ X10^5$	$8.2X10^5$
4.	IV	$5.2X10^5$	$1.0X10^6$	$4.2X10^6$	$5.4X10^7$	$2.1\ X10^4$	$6.5X10^4$
5.	V	$4.5X10^5$	$5.6X10^3$	$2.01X10^4$	$6.2\ X10^5$	$4.2X10^5$	$4.2X10^3$

The mean concentration of Ni (97.55 mg/kg) is high, the standard deviation Ni (63.07) (R.S.D.-64.65%) in industrial soil, while Zn(33.3.) is high, the standard deviation Zn (18.24) (R.S.D.- 54.77%) in agricultural soil sample. Pb (170.50), standard deviation (112.37) (R.S.D.- 65.91) is higher in sludge. Remaining all metals are high in some concentration Cr (0.2- 77.6 mg/kg) are varied from sites to sites and locality to locality.

IV. Conclusion

The result of this study shows higher concentration of heavy metals such as Cu, Zn, Pb, Cr, As and Hg are present in contaminated soil of sampling sites. People uses maximum amount of chemical fertilizer in their agriculture and these chemical fertilizers have higher quantity of heavy metal. They affect the activity and growth of microbes which are present in soil. Heavy metal are toxic and non- biodegrable in nature. Microbes are more sensitive to environmental stress and they also affect directly and indirectly by these heavy metals in ecosystem . The uses of bioremediation technology would be conducive for development of ecology and sustainable agriculture. The case study of contaminated soil of Kanpur which is an example of both agricultural and industrial areas, show that Kanpur region are susceptible to industrial and highly urbanized areas. Case study of Kanpur district soil included- industrial, agricultural and dumping sites in which dumping site is highly contaminated sites and agricultural sites are least contaminated site.

Acknowledgement

I would like to express thanks for my supervisor Dr. Madhuri Yadav, Assistant Professor D.B.S. College, Kanpur Nagar, and also thankful for Agricultural department, Uttar Pradesh for providing necessary support and guidance.

Reference

1. Babkina, E.I. (1992) Pesticide monitoring in the soils of Russion Federation. Meteorologiya, Gidrologiya. 8, 116-120.
2. Choi, Y. HoH. Mukherjee, B. Miller, J. Park, S.K. (2012) Environmental Cadmium and Lead Exposures and hearing loss in U.S. Adults: The National Health Nutrition Examination Survey. 1999 – 2004. Environment Health Perspect. 120:1544-1550.
3. Fisher, RA. Statistical methods and scientific induction. Journal of the royal statistical society series 1927:17:69-78.
4. Kachenko, A.G. Singh, B. (2006)Heavy metals Contamination in vegetables grown in urban and metals smelter contaminated sites in Australia. Water Air Soil Pollution. 169,101-123.
5. Li, S. Migita, J. (1992) Pesticide runoff from paddy field and its impact on receiving water. Water Scie Technol, 25:69-79.
6. Miskowiec, P. Laptas, A. and Zieba, K. (2015) Soil pollution with heavy metals in Industrial and Agricultural Areas: A case study of Olkusz District. Journal of Elementology. 20(2): 353-362.

7. Maguire, R.J. (1992) Importance of Pesticide volatilization from the surface microlayer of natural waters after aerial spraying. Water scie Technol 25:111-116.
8. Nair, Dileepan, R., Burken, Joel, G. Licht, Louis A. Schnoor, Jerald, L. (1993) Mineralization and uptake of triazine pesticide in soil-plant systems. J Environ Eng 119:5:842-854.
9. Oladipo, M.O.A. Bodunde, J. O (1993) ICP- MS analysis of tomoto fruits grown on fertilizer amended soil. J Environ Sci Health, Part A: Environ Sci En 28:4:809-820.
10. Pillai, M.K.K. (1986) Pesticide pollution of soil, water and air in Delhi area, India. Sci Total Environ 55:321-328.
11. Sanghi, R. and Sasi, K.S. (2001) Analysing pesticide residues in winter vegetables from Kanpur. Indian J Environ Health In press.
12. Sujata, C.H. Chacko, J (1992) Organophosphorous pesticide adsorption variability in deserve estuarine sadiments. Toxicol Environ Chem 36:1-2:65-73.
13. Satarug, S., Baker, J.R., Urbonjapol, S., Elkins, M.H., Reilly, P.E.B., Williams, D.J., Moore, M.R. (2003) A global perspective on cadmium pollution and toxicity in non occupationally exposed population. Toxical. Lett. 137:65-83.
14. Tripathi, P.K.(2013) District ground Water brochure Kanpur Dehat District at Glace.
15. Verner, F., Ramsey, M.H., Helios, Rybicka, E., Jedrzedczyk, B.,(1996) Heavy metal contamination of Soil around a Pb- Zn smelter in Bukowno, Poland, Apple. Geochem., 11(1-2).
16. Waalkes, M.P. (2000) Cadmium carcinogenesis in review. J. Inorg. Biochem. 79:241-244.
17. WL Lu., CY Li.(2010) Influence of heavy metal Cadmium on the soil enzyme activity. Journal of Jilin Institute of Chemical Technolog. 27(3):24-26.
18. Zanini, E. Bonifacio, E. Cuttica, G.C. (1992) Heavy metals in soils near a steel making industry: a case study in a complex vally situation in Italy. J Environ Sci Health, Part A: Environ Sci Eng 27:8:2019-2036.