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Full Length Research Paper

The solid and liquid waste of uttarakhand state carries heavy metals above permissible limit

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The aim of this study was to estimate the heavy metals and their level in the solid and liquid (municipality waste and industrial effluent) waste in Uttarakhand state of India. It is the part of my research on *in situ* bioremediation. 62 samples from 32 cities of Uttarakhand were collected according to standard method of APHA in triplicate. The heavy metals viz. Zinc (Zn), Manganese (Mn), Nickel (Ni), Copper (Cu), Chromium (Cr), Cadmium (Cd), Lead (Pb) and Cobalt (Co) were reported in the waste samples. Mercury and Arsenic were not detected in any set of sample. The metal Zinc was measured in maximum extent in all the samples. The metals Zn, Mg, Ni, Cu, Cr, Cd, Pb and Co were measured minimum 0.45mg/l, 0.28mg/l, 0.021mg/l, 0.005mg/l, 0.018mg/l, 0.001mg/l and 0.002mg/l and maximum 11.9mg/l, 55.5 mg/l, 7.6 mg/l, 6.503 mg/l, 8.56 mg/l, 8.56 mg/l, 8.56 mg/l and 0.905 mg/l respectively. The heavy metals in waste can pose serious health problems in human also. It is recommended that periodic analytical testing of heavy metal should be carried out for maximum permissible level. Primary treatment is required for the quality of the waste/effluent.

Keywords: Heavy Metal Toxicity, ICP-MS, e-waste, Effluents, Permissible limit.

INTRODUCTION

The waste contaminates the soil. The solid waste includes garbage, domestic refuse and discarded solid materials such as those from commercial, industrial and agricultural operations. They contain increasing amounts of paper, cardboards, plastics, glass, old construction material, packaging material and toxic or otherwise hazardous substances (Knaebel et al., 1994). The e-waste contains some very serious contaminants such as lead, cadmium, beryllium and brominates flame retardants (Dogbevi, 2007; Pinto 2009). Liquid waste, wastewater, fats, oils or grease or used oil have various contaminants including soil particles and other sediment, heavy metals, organic compounds, animal waste. It may be originated from various sites and by different uses (Massoud and Ahmad 2005). Industrial wastes will be as varied as the industries that generate the wastes.

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Municipal waste-water also contains a variety of inorganic substances from domestic and industrial sources, including a number of potentially toxic elements such as arsenic, cadmium, chromium, copper, lead, mercury, zinc etc (Ferrari et al., 1999).

Some human activities have resulted in the accumulation of metals in the environment. Both soil and aqueous effluents have been contaminated with heavy metals as the result of numerous industrial activities, including mining, smelting, jewellery, automobile battery production, vehicle emission and landfilling of industrial waste and fly ash from incineration process. This contamination of the environment poses serious health threats to humans and animals, as these heavy metals tend to persist in the environment indefinitely.

This kind of contamination presents a challenge, as the presence of heavy metals in soils and aqueous effluents leads to serious problems because they cannot be biodegraded. In this case, the metal ion can only be converted to the base metal, methylated, precipitated,

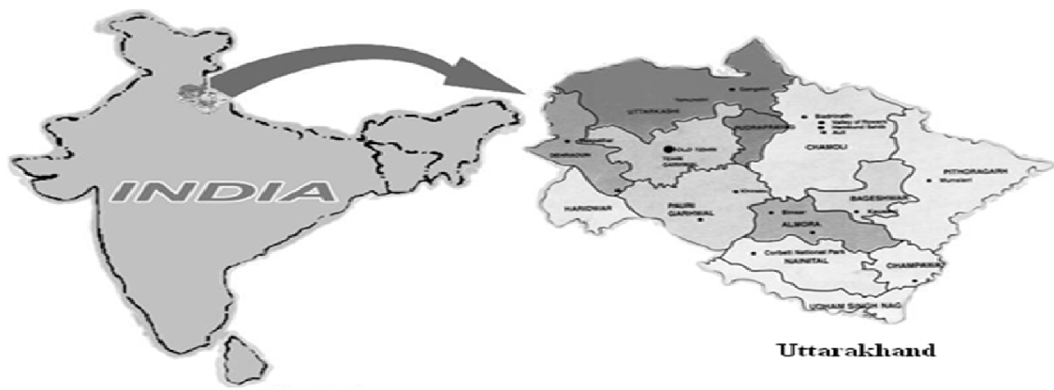

Figure 1. Location of Uttarakhand

volatilized or complexed with an organic ligand. The development of technologies involving many of the processes listed above has been the subject of a host of basic and more applied projects. The more common heavy metals (HMs) associated with anthropogenic activities include lead, cadmium, copper, chromium, nickel, iron, mercury and zinc. Methods of treating the contaminated effluents currently consist of chemical precipitation, solvent extraction, dialysis, electrolytic extraction, cementation, reverse osmosis, evaporative methods, ion-exchange resins, carbon adsorption and dilution (European Union, 2002).

Several metals are essential for biological systems and must be present in a certain concentration range. Too low concentrations lead to a decrease in metabolic activity. At too high concentrations these metals lead to toxicity. Nonessential metals are tolerated at very low concentrations and inhibit metabolic activity at higher concentrations. The many uses of heavy metals in several applications lead to their wide distribution in soil, silt, waste and waste water. Such pollution of the environment by toxic metals and radionuclide arises as a result of many human activities, largely industrial, although such sources as agriculture and sewage disposal also contribute. Heavy metal contamination can be a consequence of industrial activities that eliminate residues in the soil that in long term promote their accumulation. The majority of the sources are originated by human actions like metal manufacture and mining industries with storage, disposal and transportation problems (Glick, 2003). Among the metals found more frequently there are Cd, Pb, Co, Cu, Hg, Ni, Si and Zn. For Cd, Pb, Cu and Zn, their toxicity increases as follows: Pb < Zn < Cu < Cd, depending on countless abiotic and biotic factors (Zenker et al., 2005).

The discharge of wastewater containing high concentrations of heavy metals to receiving water bodies has serious adverse environmental effects. Their occurrence and accumulation in the environment is a result of direct or indirect human activities, such as rapid industrialization, urbanization and anthropogenic sources (EPA, 1998; 2000; Hussein et al., 2005; Gardea et al., 2005). Metals when present in our body are capable of causing serious health problems, by interfering with, our normal body functions. Some of these metals are useful to the body in low concentrations like arsenic, copper, iron and nickel but are toxic at high concentrations. Other metals like aluminum, beryllium, cadmium, lead and mercury have no biological functions and are highly toxic disrupting bodily functions to a large extent. They disrupt bodily functions by accumulating in vital organs and glands in the human body such as in the heart, brain, kidney, bone and liver.

They also displace vital nutritional minerals from their proper place in the body to provide biological functions e.g., lead or cadmium displaces calcium in an enzyme reaction disrupting the enzyme reaction to a large extent (European Union, 2002). Cr (VI) is toxic, carcinogenic and mutagenic to animals as well as humans and is associated with decreased plant growth and changes in plant morphology. They cause physical discomforts, diseases and disorders and sometimes life threatening illness including irreversible damage to vital body system (Malik, 2004; Ozer and Pirincci, 2006).

MATERIALS AND METHODS

Sampling Sites And Sample Collection

The solid and liquid wastes were collected from 32 different sites of Uttarakhand (Figure 1) especially from municipality and industrial area. The sites were identified for sample collection and given a definite code (Table 1). The method of sample (solid and liquid waste) collection was followed of APHA 1998. The solid waste samples were collected in polythene bags of capacity 1 kg and carried to laboratory in well packed box sealed in ice to avoid the contamination. The area covered 1 m^2 in depth of 25 cm. The liquid wastes was collected in pre-rinsed

Table 1. Name of sampling site with code

S.No.	Sampling Site	Code	S.No.	Sampling Site	Code
1	Pauri	PA	17	Joshimath	JM
2	Lansdown	LD	18	Ukhimath	UM
3	Kotdwara	KD	19	Srinagar	SN
4	Rudraprayag	RG	20	Uttarkhashi	UK
5	Devprayag	DP	21	Purola	PL
6	Almora	AM	22	Mussorie	MR
7	Lohaghat	LG	23	Dhanolti	DN
8	Ranikhet	RT	24	Chamba	CB
9	Nainital	NL	25	New Tehri	NT
10	Haldwani	HD	26	Badshahithaul	BT
11	Pantnagar	PN	27	Chakrata	CR
12	Rudrapur	RP	28	Dakpathar	DK
13	Tanakpur	TP	29	Dehradun	DD
14	Kashipur	KR	30	Haridwar	HR
15	Corbett National Park	CP	31	Rishikesh	RK
16	Roorkee	RR	32	Lakshar	LS

clean one liter polythene bottle having double stopper facility to its full capacity without entrapping air bubbles inside it.

Preparation Of Leachate

The leachate from solid waste was prepared according to the method described by French Standard method (Ferrari et al., 1999, Srivastava et al., 2005 and Savitha et al., 2010). For leachate preparation; 100 g of solid waste was added to 1000 ml of distilled water, which was kept on a rotary shaker at 180 rpm at 30 $\pm 1^{0}$C for 24 hr for continuous shaking. The suspension was first course filtered muslin cloth and then by Whatman filters paper No. 42. To remove the fine suspended particles, it was centrifuged at 3000 rpm for 15 min and the supernatant was used for heavy metal analysis.

Heavy Metal Analysis

The filtrate of solid and liquid waste was used to analyze the heavy metal concentrations by Inductive Coupled Plasma-Mass Spectroscopy (ICP-MS) using AR grade chemicals and high grade reference (Ashok et al., 2010).

Analysis Of Data

The data (Tables 2,3,4,6) were statistically analyzed by using one way analysis of variance (ANOVA) at p = 0.05 (Snedecor and Cochran 1982; SAS 2001). All statistical analyses were performed with Statistical Analysis System programs SPSS 10.0 for Windows 2003 XP.

RESULTS

The eight metals viz. zinc (Zn), manganese (Mn), nickel (Ni), copper (Cu), chromium (Cr), cadmium (Cd), lead (Pb) and cobalt (Co) were measured in the solid and liquid waste. Mercury (Hg) and arsenic (As) were not detected in any set of sample. Zinc found in high extent among the samples analyzed although it was nil in 19 samples i.e. 15 solid samples PA, RG, NL, PN, RP, CP, UM, SN, UK, PL, DN, CB, NT, BT, LS and 4 liquid samples LG, JM, PL and CR. Zinc was recorded minimum (0.45mg/l) at Almora (solid) and maximum (11.9mg/l) at Roorkee (liquid).

Manganese was nil in 25 samples i.e. 11 solid samples- RG, AM, RT, PN, RP, TP, CP, UM, SN, DN, LS and 14 liquid samples- LD, AM, LG, RT, HD, PN, RP, CP, JM, UM, UK, PL, DN and CR. Manganese was minimum (0.28mg/l) at Purola (solid) and maximum (55.5 mg/l) at Kashipur (liquid). Nickel found nil in 33 samples i.e. 5 solid samples of AM, TP, JM, CR, RR and 26 liquid samples of PA, LD, KD, RG, DP, AM, RT, NL, RP, CP, JM, UM, SN, UK, PL, MR, CB, NT, BT, CR, DK, DD, HR, RK and LS. Ni was minimum (0.021mg/l) at Danolti (solid) and maximum (7.6 mg/l) at Musoorie (solid). The copper was not detected in the 32 samples (26 solid samples of PA, LD, KD, RG, DP, NL, HD, PN, TP, KR, CP, JM, UM, SN, UK, PL, MR, CB, NT, BT, DK, DD, HR, RH, LS and RR and 6 liquid samples of LG, RP, TP, KR, CP and DK). Copper was minimum (0.005mg/l) at Dhanolti (liquid) and maximum (6.503 mg/l) Lansdwon (liquid). Chromium found nil in 26 samples i.e. 12 solid samples of LD, RT, NL, TP, CP, JM, SN, UK, PL, CB, NT, BT and 14 liquid samples of LD, RG, DP, AM, LG, NL, RP, UM, UK, PL, DN, NT, DK and RR. Chromium was minimum (0.018mg/l) at Lakshar (solid) and maximum (8.56 mg/l) at Haridwar (liquid).

Table 2. Total Metals Analysis in Solid and Liquid wastes (mg/l)

S. No	City	Waste	Zn	Mn	Ni	Cu	Cr	Cd	Pb	Hg	Co	As
1	**PA**	Solid	nil	12.50	0.85	nil	0.09	nil	nil	nil	0.230	nil
		Liquid	4.560	15.90	nil	1.09	0.03	0.007	0.830	nil	nil	nil
2	**LD**	Solid	4.905	3.678	0.875	nil	nil	0.215	nil	nil	0.35	nil
		Liquid	5.680	nil	nil	6.503	nil	2.380	nil	nil	nil	nil
3	**KD**	Solid	6.458	11.90	5.95	nil	0.45	nil	nil	nil	0.430	nil
		Liquid	5.435	12.40	nil	3.78	0.76	0.100	0.322	nil	nil	nil
4	**RG**	Solid	nil	nil	6.50	nil	0.32	nil	nil	nil	0.450	nil
		Liquid	4.550	9.87	nil	1.65	nil	0.012	0.025	nil	nil	nil
5	**DP**	Solid	3.455	4.58	3.30	nil	0.05	nil	nil	nil	0.230	nil
		Liquid	4.350	8.90	nil	0.79	nil	0.015	0.054	nil	nil	nil
6	**AM**	Solid	4.567	nil	nil	0.452	3.456	0.005	nil	nil	nil	nil
		Liquid	0.45	nil	nil	0.580	nil	0.086	0.02	nil	nil	nil
7	**LG**	Solid	2.505	1.560	2.456	0.580	0.450	nil	nil	nil	nil	nil
		Liquid	nil	nil	2.350	nil	nil	nil	0.568	nil	nil	nil
8	**RT**	Solid	5.89	nil	0.785	3.568	nil	nil	0.05	nil	nil	nil
		Liquid	2.36	nil	nil	1.456	0.067	0.043	nil	nil	nil	nil
9	**NL**	Solid	nil	9.50	1.29	nil	nil	nil	nil	nil	0.089	nil
		Liquid	2.320	4.60	nil	0.110	nil	0.008	0.010	nil	nil	nil
10	**HD**	Solid	2.305	5.45	1.95	nil	0.560	nil	nil	nil	0.087	nil
		Liquid	4.550	nil	nil	0.320	0.870	0.010	0.120	nil	nil	nil
11	**PN**	Solid	nil	nil	0.345	nil	2.650	nil	0.785	nil	nil	nil
		Liquid	8.905	nil	0.125	0.645	0.128	0.760	nil	nil	0.50	nil
12	**RP**	Solid	nil	nil	2.872	0.325	0.785	nil	0.896	nil	nil	nil
		Liquid	4.680	nil	nil	nil	nil	nil	0.325	nil	nil	nil
13	**TP**	Solid	4.580	nil	nil	nil	nil	0.234	0.456	nil	nil	nil
		Liquid	2.456	3.245	3.456	nil	0.981	0.680	nil	nil	nil	nil
14	**KR**	Solid	5.860	35.50	6.50	nil	3.12	nil	nil	nil	0.205	nil
		Liquid	8.780	55.50	1.35	nil	2.15	0.605	0.564	nil	0.260	nil
15	**CP**	Solid	nil	nil	0.654	nil	nil	nil	0.765	nil	0.25	nil
		Liquid	4.891	nil	nil	nil	6.40	0.505	nil	nil	nil	nil
16	**JM**	Solid	6.780	2.543	nil	nil	nil	nil	nil	nil	nil	nil
		Liquid	nil	nil	nil	0.783	0.532	0.543	0.543	nil	nil	nil
17	**UM**	Solid	nil	nil	4.50	nil	0.32	nil	nil	nil	nil	nil
		Liquid	4.550	nil	nil	1.05	nil	0.015	0.035	nil	0.350	nil
18	**SN**	Solid	nil	nil	0.78	nil	nil	nil	nil	nil	0.120	nil
		Liquid	6.980	10.65	nil	0.45	0.07	0.002	0.230	nil	nil	nil
19	**UK**	Solid	nil	0.980	0.03	nil	nil	nil	nil	nil	0.002	nil
		Liquid	3.120	nil	nil	0.065	nil	0.003	0.013	nil	nil	nil
20	**PL**	Solid	nil	0.280	0.033	nil	nil	nil	nil	nil	0.002	nil
		Liquid	nil	nil	nil	0.065	nil	0.003	nil	nil	nil	nil
21	**MR**	Solid	8.455	12.97	7.60	nil	0.56	nil	nil	nil	0.905	nil
		Liquid	8.120	34.80	nil	5.95	1.05	0.210	0.202	nil	nil	nil
22	**DN**	Solid	nil	nil	0.021	0.052	0.050	nil	0.003	nil	nil	nil
		Liquid	1.68	nil	0.022	0.005	nil	nil	nil	nil	nil	nil
23	**CB**	Solid	nil	3.60	0.40	nil	nil	nil	nil	nil	0.079	nil
		Liquid	6.840	6.50	nil	0.89	0.098	0.003	0.101	nil	nil	nil
24	**NT**	Solid	nil	1.50	0.06	nil	nil	nil	nil	nil	0.045	nil
		Liquid	5.989	7.80	nil	0.015	nil	0.001	0.010	nil	nil	nil
25	**BT**	Solid	nil	8.95	0.76	nil	nil	nil	nil	nil	0.040	nil
		Liquid	0.760	4.76	nil	2.08	0.054	0.004	0.150	nil	nil	nil
26	**CR**	Solid	0.890	5.560	nil	1.65	1.98	nil	nil	nil	nil	nil
		Liquid	nil	nil	nil	2.087	0.98	2.56	nil	nil	nil	nil
27	**DK**	Solid	3.257	11.85	2.58	nil	0.605	nil	nil	nil	nil	nil
		Liquid	5.505	8.85	nil	nil	nil	0.012	0.025	nil	nil	nil
28	**DD**	Solid	7.908	30.20	5.50	nil	3.34	nil	nil	nil	0.605	nil
		Liquid	9.980	45.75	nil	4.78	1.85	0.405	0.560	nil	nil	nil
29	**HR**	Solid	7.830	10.90	5.30	nil	2.09	nil	nil	nil	0.550	nil
		Liquid	8.227	20.50	nil	3.90	8.56	0.523	0.858	nil	nil	nil
30	**RK**	Solid	7.980	11.45	2.60	nil	0.96	nil	nil	nil	0.420	nil
		Liquid	8.500	13.67	nil	1.80	1.45	0.020	0.865	nil	nil	nil

Table 2. Cont.

31	**LS**	Solid	nil	nil	0.65	nil	0.018	nil	nil	nil	0.076	nil
		Liquid	3.450	3.07	nil	0.078	0.020	0.005	0.011	nil	nil	nil
32	**RR**	Solid	8.90	20.55	nil	nil	3.45	nil	nil	nil	nil	nil
		Liquid	11.9	45.75	5.30	4.78	nil	0.405	0.56	nil	0.15	nil

*Leachate was used to test. #Data depicted in the table is the average of three samples.

Cadmium found not measured in 32 samples i.e. 29 solid samples of PA, KD, RG, DP, LG, RT, NL, HD, PN, RP, KR, CP, JM, SN, UK, PL, MR, DN, CB, NT, BT, CR, DK, DD, HR, RH, LS, RR cities and 3 liquid samples of LG, RP and DN. Cadmium was minimum (0.001mg/l) at New Tehri (liquid) and maximum (8.56 mg/l) at Chakrata (liquid). Lead was found nil in 35 samples (26 solid samples of PA, LD, KD, RG, DP, AM, LG, NL, HD, KR, JM, UM, SN, UK, PL, MR, CB, NT, BT, CR, DK, DD, HR, RH, LS, RR and 9 liquid samples of LD, RT, PN, TP, CP, PL, DN, CR). Lead was recorded minimum (0.003mg/l) at Dhanolti (solid) and maximum (8.56 mg/l) at Rudrapur (solid). Cobalt was nil in 40 samples i.e. 12 solid and 28 liquid out of 64 samples. Cobalt was measured minimum (0.002mg/l) UK (solid) and maximum (0.905 mg/l) MR (solid).

The total metal analysis was done for river water and it was found that water sample of YY had no metals although Zn was found in all water samples except BG, MR and YY. Copper (Cu) was detected in Alaknanda at Rudraprayag (0.52mg/l) and Yamuna at Dakpathar (0.004mg/l) only. Cadmium (Cd) was found in Ganga at Hardwar (0.012mg/l) and Yamuna at Dakpathar (0.011mg/l), nickel (Ni) in Ganga at Hardwar (0.01mg/l) and lead (Pb) in Ganga at Hardwar (0.08mg/l) and Yamuna at Dakpathar (0.53mg/l). Mn, Hg, Co and As were not detected in any sample (Table 2).

DISCUSSION

The elements viz. Zn, Mn, Ni, Cu, Cr, Cd, Pb and Co were observed in the waste samples. According to ICMR (1996) the zinc is an essential element in human metabolism. It changes the verge taste at about 5 mg/l and imparts caustic taste to water. Manganese is essential as a cofactor in enzyme systems and metabolism processes. It is reported (ICMR, 1996; WHO, 2001) that the excess of Mn causes change in appetite and reduction in metabolism of iron to form hemoglobin. It imparts undesirable taste and stains plumbing fixtures and laundry. The nickel observed 0.021 mg/l to 7.6 mg/l in the waste samples, whereas the desirable limit is 0.20 mg/l for crop production, it reduced toxicity at neutral or alkaline pH (Pratt, 1972).

The short-term overexposure to nickel (USEPA, 2000) is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage and skin irritation. The EPA does not currently regulate nickel levels in drinking water. Nickel can accumulate in aquatic life, but its presence is not magnified along food chains (USEPA, 2000). The copper was observed 0.005mg/l - 6.503 mg/l which exceeded the permissible limit for crop production and is toxic to a number of plants (Pratt, 1972). Copper in the natural water also results in higher concentration due to pollution. According to ICMR, (1996) it imparts biting taste but essential element in human metabolism. The deficiency of Cu results in nutritional anemia in infants and large amount of Cu may result in liver damage, cause CNS irritation and depression.

The chromium was found 0.018 mg/l - 8.56 mg/l in the waste samples, which showed beyond the limit (0.10 mg/l). It is not generally recognized as an essential growth element. Pratt, (1972) reported that the conservative limits recommended due to lack of knowledge on its toxicity to plants. According to Bandyopadhyay and Biswas, (1998) the chromium is one of the toxic heavy metals and because of its wide application; there is urgent need to remove the chromium compounds from various polluting streams. Sharma and Forster, (1993) observed two forms of chromium; trivalent and hexavalent, which are found in industrial wastewater. The hexavalent form Cr (IV) is more toxic to human than the trivalent form. Baisakh and Patnaik, (2002) observed in the animal experiments that acutely toxic doses of Cr (III) fall in range of g/kg of body weight. Dietary intake of Cr (IV) in mg/l levels produces chronic toxicity causing erosion of gastrointestinal tract and kidney lesions.

The cadmium was recorded 0.001mg/l - 8.56 mg/l in the waste samples. In the environments, cadmium is reported toxic to animals and microorganisms. According to National Academy of Sciences (1972), the cadmium is toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans. USEPA, (2000) reported that cadmium accumulates especially in the kidneys leading to dysfunction of the kidney with increased secretion of proteins in urine. Intake of cadmium is generally based on diet, particular vegetables and corn products.

The lead was recorded 0.003mg/l - 8.56 mg/l in the samples. The permissible limit of lead is 5 mg/l. According to Pratt and NAS, (1972) lead can inhibit plant cell growth at very high concentrations. USEPA, (2000) reported that Lead influences the nervous system,

Table 3.: Limits of Heavy Metals in Drinking Water as BIS Specification and APHA Guidelines

S. No.	Parameter/ Characteristics	Unit	Standard Desirable Limit	Limit Permissible Limit
1.	Arsenic	mg/l	0.05	NR*
2.	Aluminium	mg/l	0.03	0.2
3.	Calcium	mg/l	75	200
4.	Cadmium	mg/l	0.01	NR
5.	Chromium	mg/l	0.05	NR
6.	Copper	mg/l	0.05	1.5
7.	Iron	mg/l	0.3	1.0
8.	Magnesium	mg/l	30	100
9.	Manganese	mg/l	0.10	0.30
10.	Lead	mg/l	0.05	NR
11.	Zinc	mg/l	5	15

*NR: No Relaxation

Table 4. Maximum conc. Level for Heavy Metal conc. in Air, Soil and Water (UNEPA)

Heavy Metal	Max Conc. in Air (mg/m^3)	Max Conc. in Sludge Soil (mg/kg)	Max Conc. in Drinking Water (mg/l)	Max Conc. in Aquatic Life (mg/l)
Cd	0.1-0.2	85	0.005	0.008
Pb	__	420	0.001	0.0058
Zn	1.5	7500	5.00	0.0766
Hg	__	<1	0.002	0.05
Ca	.5	Tolerable	50	Tolerable>50
Ag	0.01	__	00	0.1
As	__	__	0.01	__

(Adapted from USEPA, 1992; Washington Code, 1992)

slowing down the nerve response and also influences learning abilities and behavior. Children are exposed to lead right form their birth, as children in the embryonic stage receive lead from the mothers through the blood (WHO, 2004).

The cobalt was observed 0.002mg/l - 0.905 mg/l in the samples. The threshold limit of cobalt is 0.05 mg/l. Pratt, (1972) observed that cobalt is toxic to the plant especially tomato at 0.1 mg/l in nutrient solution, it tends to be inactivated by neutral and alkaline soils. According to Glick (2003), heavy metal contamination can be a consequence of industrial activities that eliminate residues in the soil that in long terms, promote their accumulation. Zenker et al., (2005) reported that the majority of the sources are originated by human actions like metal manufacture and mining industries with storage, disposal and transportation problems.

Analysis of a polluted environment with heavy metals from other sources such as Cu and Zn in animal manures (Christie and Beattie, 1989), run-off from timber treatment plants (Bardgett et al., 1994), past applications of Cu-containing fungicides (Zelles et al., 1994) and analysis of soils in the vicinity of metal-contaminated army disposal sites (Kuperman and Carreiro, 1997) confirm that a decrease in the microbial biomass occurs at a relatively modest, and sometimes even at a low (Dehlin et al., 1997) metal loading (Ghorbani et al., 2002). Metals when present in our body are capable of causing serious health problems, by interfering with, our normal body functions (Ray and Ray, 2009). Some of these metals are useful to the body in low concentrations like arsenic, copper, iron and nickel but are toxic at high concentrations. Other metals like aluminum, beryllium, cadmium, lead and mercury have no biological functions and are highly toxic disrupting bodily functions to a large extent. They disrupt bodily functions by accumulating in

Table 5: Effluent Discharge Standards (BIS)

Aluminium	mg/l	5
Arsenic	mg/l	0.1
Beryllium	mg/l	0.1
Boron	mg/l	0.75
Cadmium	mg/l	0.01
Cobalt	mg/l	0.05
Copper	mg/l	0.5
Iron	mg/l	2.0
Lead	mg/l	0.05
Lithium	mg/l	2.5
Manganese	mg/l	0.2
Mercury	mg/l	0.005
Molybdenum	mg/l	0.01
Nickel	mg/l	0.1
Selenium	mg/l	0.02
Sodium	mg/l	200
Total Chromium	mg/l	0.05
Vanadium	mg/l	0.1
Zinc	mg/l	2

Table 6: Threshold Levels of Trace Elements for Crop Production (mg/l)

S. No.	Element	Symbol	Limit	Remarks
1	Arsenic	As	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
2	Cadmium	Cd	0.01	Toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
3	Cobalt	Co	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
4	Chromium	Cr	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
5	Copper	Cu	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/l in nutrient solutions.
6	Fluoride	F	1.0	Inactivated by neutral and alkaline soils.
7	Manganese	Mn	0.20	Toxic to a number of crops at few-tenths to a few mg/l, but usually only in acid soils.
8	Nickel	Ni	0.20	Toxic to a number of plants at 0.5 mg/l to 1.0 mg/l; reduced toxicity at neutral or alkaline pH.
9	Lead	Pb	5.0	Can inhibit plant cell growth at very high concentrations.
10	Zinc	Zn	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at pH > 6.0 and in fine textured or organic soils.

Source: Adapted from National Academy of Sciences (1972) and Pratt (1972).

vital organs and glands in the human body such as in the liver, bone, kidney, heart, brain. They also displace vital nutritional minerals from their proper place in the body to provide biological functions e.g. lead or cadmium displaces calcium in an enzyme reaction disrupting the enzyme reactions to a large extent. As their impact in the body, is at such basic levels that they are the casual factors in multiple health problems. Leonard et al., (2004) reported that the metal causes genotoxicity as they affect the DNA and immunotoxicity as they are major irritants tothe body. The genomic instability by these metals induces cancer.

Heavy metals pollution such as copper, cadmium, lead, mercury, arsenic and chromium has been classified as a priority pollutant by the Department of Environment. Continuous monitoring of heavy metals level in the environment is very important since it cannot be degraded and becoming public health problem when increased above acceptance level. Health problem due to heavy metals pollution include nausea, vomiting, bone complications, nervous system impairments and even death become a major problem throughout many countries when metal ions concentration in the environment exceeded the admissible limits (McCluggage, 1991). Due to that, various treatment technologies had been searched to reduce the concentration of heavy metals in the environment. Sawyer and McCarty, (1979) reported that the heavy metal include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag) chromium (Cr), copper (Cu) iron (Fe) and the platinum group elements. USEPA, (2000) defined the pollutant that any substance in the environment, which causes objectionable effects, impairing the welfare of the environment, reducing the quality of life and may eventually cause death is known as pollutant. Such a substance has to be present in the environment beyond a set or tolerance limit, which could be either a desirable or acceptable limit.

Living organisms require varying amounts of heavy metals. Some metals viz. iron, cobalt, copper, manganese, molybdenum and zinc are required by humans. Excessive levels can be damaging to the organism. Other heavy metals such as mercury, plutonium and lead are toxic metals that have no known vital or beneficial effect on organisms and their accumulation over time in the bodies of animals can cause serious illness (Leonard, 2004). Nies (1999) observed that the metals may present in the earth's crust only in very low amounts or the ion of the particular heavy metal may not be soluble. Many investigators (Garbarino et al., 1995; INECAR, 2000; European Union, 2002) observed that the metals are leached out and in sloppy areas and carried by acid water downstream or run-off to the sea.

CONCLUSION

Study reveals the heavy metals present above the permissible limit in the waste (solid and liquid). The minimum Zinc content was recorded 0.45mg/l in solid waste of Almora city and the maximum (11.9mg/l) in the liquid sample of Roorkee city, which was beyond the limit.The waste having metal beyond maximum permissible level, should not dispose into the dustbins/gutters/municipality waste dumps.

The heavy metals are toxic for crops; they reduce the crop yields and cause diseases in the plants. Periodic analytical testing of heavy metal must be carried out for maximum permissible level to ensure that the pollutant removed is not introduced back. Properly channeled drain with equalizing pipes to ensure regularized and monitored flow of liquid waste onto the dump sites will help keep the heavy metal free environment. There should be public education on the economic as well as the environmental importance of heavy metals and their toxic effects. There should be laws that will prevent the disposal of electronic waste.

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