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Impact of heavy metals (Chromium and Nickel) on the health of residents of Jagadhri city due to intake of contaminated underground water

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ABSTRACT

Disposal of Industrial waste is the major problem and responsible for soil & water pollution. Accumulation of water of different places creates adverse impact on all the living organism and environment. Industrial sludge is more dangerous than Industrial solid waste. These pollutants affect and alter the chemical and biological properties of soil and water. As a result hazardous chemicals and metal ions can enter into the human food chain from the soil or water, disturb the bio-chemical processes and finally lead to serious effects on living organisms. These industrial discharges, various pollutants from pulp and paper mills, sugar mills, distilleries, metal processing industries, starch mills, tanneries, textiles, fertilizers and pharmaceuticals pollute the water, air and soil. Yamuna Nagar and Jagadhri are the two twin cities in Haryana. Yamuna Nagar is the second biggest industrial city in Haryana. All the industries discharge their solid as well as liquid waste on land and in water bodies without recommended treatment and pollute the soil, water and air. Jagadhri is famous for metal and industries steel processing and there are more than 800 units of metal industries. All these industries discharge there solid and liquid waste on the land and in water. The hand pump water of Jagadhri and Yamuna Nagar colonies where the sludge of paper mill, sugar mill and metal industries are used for land filling is seriously polluted due to seepage effect of various contaminants from these wastes. The physico-chemical parameters of the underground water samples, from the colonies where solid industrial waste used for land filling, had been analyzed and compared with standard permissible values supplied by WHO and ICMR for drinking water. The values of all the parameters are beyond the permissible limits. This chronically polluted water containing chemicals and metal ions causes problems to health and leads to severe diseases in the cities. The diseases due to metal ions (Cr& Ni) contamination are liver necrosis, nephritis and irritation of the gastrointestinal mucosa. Hexavalent chromium can produce cutaneous and nasal mucous-membrane ulcers, dermatitis and cancer. Nickel induces embryo toxic and nephrotoxic effects, allergic reactions and contact dermatitis. Nickel sensitization may also cause conjunctivitis, eosinophilic pneumonitis, and asthma. Nickel is a potential human carcinogen resulting into lungs and nasopharyngeal cancers. Therefore assessing the concentration level of these metals and their health impact on the residents of these cities is very necessary.

Keywords: Eosinophilic pneumonitis, nephrotoxic, homochromatosis, percutaneous, dermopathological.

INTRODUCTION

Heavy metals can create adverse effects on the environment and human health due to their bioavailability and toxicity in various environmental components. During the last three decades,

number of studies has been carried out to assess the fate and behavior of various heavy metals in the environment as well as their environment effects [1]. Diffuse pollution of the environment by heavy metals is a major environmental problem world-wide. An important input pathway is the underground and surface water. The risk of heavy metal contamination is pronounced in the water bodies and soil. Many cases of particularly severe metal pollution in water have been reported in various industrial cities. Nickel and Arsenic contamination was found in water supply of Orissa and West Bengal. The highest values were from Haryana and Punjab highest median (3.2µg/g). High mean concentrations were found in Haryana, Chandigarh and Punjab. A great concern has been expressed about the role and fate of toxic metals derived from industries in the environment in many countries as it causes toxicity and threat to human life and the environment. Jagadhari is famous for metal industries and there are more than 800 units of metal industries. All these industries discharge their solid and liquid waste[2] on the land without any recommended treatment. These wastes are used for filling due to increasing urbanization which will have serious threat on groundwater due to seepage of various metal ions contamination from these wastes. The underground water of various colonies in Jagadhari has been chronically polluted. Physico-chemical parameters of hand pump water of various pollution infested colonies around Jagadhari have been investigated and compared with standard and permissible values as reported by W.H.O.[3]. The presence of various metals in waste water like Fe,Cr,Ni,Pb, Cu used in metal processing industries were also analyzed.

It is assumed from animal studies that absorption rate for water-borne hexavalent chromium is at least 9 times that for trivalent chromium and that approximately 10% of elevated waterborne chromium is usually hexavalent. Chromium is an essential nutrient for plant and animal metabolisms (glucose metabolism, amino acid synthesis). When it present in higher amount it can create ferias diseases like nausea, skin ulcer and lung cancer.

The daily intake of chromium would be in range 1.2-12.6µg through water for the ranges in the mean values reported in the present study. Though nickel is insoluble salts are readily soluble in water and hence water contamination by nickel is common. Level up to 1 mg/l in surface waters are reported though the levels are generally lower, e.g., 5 - 20 µg/1 (NRC-NAS, 1977). Underground water supplies in USSR have been found to contain nickel at levels upto 0.13 mg/1. In Finland nickel content of underground water was found to be 2 - 10µg/1.

MATERIALS AND METHODS

All the chemicals used in the study were of analytical grades. All glass wares and sample containers were thoroughly cleaned and rinsed with distilled water. Standard methods for the examination of hand pumps water of different colonies [4] were adopted as reference. Samples were collected at regular intervals from various strategic points. The various parameters like pH, alkalinity, total hardness, permanent hardness, temporary hardness, total solids, dissolved solids, suspended solids, dissolved oxygen, bio-chemical oxygen demand, and chemical oxygen demand and chloride contents were studied using the standard methods for the examination of water[5] and waste water. Concentrations of both metals, i.e. Cr and Ni, were analyzed by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

The sample of hand pump were collected from various colonies where solid industrial waste/sludge of metal industries used for land filling, in order to analyze the seepage effect of contaminated water. The analytical result showed heavy load of various pollutants. In most potable water the pH observed was less than seven. The pH was observed in hand pump water of various colonies was in the range of 5.74 to 7.23 ppm. The high value of total hardness 284 to 1902 ppm has been reported that shows the hand pump water of these colonies has higher contents of inorganic acids [6], bases, salts etc. and hence the water is unfit for human consumption. The value of phenolphthalein acidity in the polluted zone is higher than the permissible limit up to 92 ppm (table-4) which makes the water acidic which is not recommended for drinking. Due to seepage effect of various contaminants from industrial waste the concentration of DO depletes. It was recorded in the range 4.4 and 7.4 ppm. The value of COD was observed in the range to 182 to 812 ppm in different samples shows that maximum contamination in drinking water is due to chemical load. Toxic effects of non biotic component also affect the health. The presence of metals[7] in the potable water is a subject of serious concern due to the toxic properties of these metals, Fe, Ni, Cd, Mg, Cr, Hg, Pb, etc. (table- 1 & 2)

This may seriously affect the health of people, and cause fatal diseases [8] like cancer, minamata, lead poisoning, arsenical, neurological disorder etc. Prolonged accumulation of Iron in the body may result in homochromatosis due to which tissues are damaged. Colour of some hand pump water of various colonies like Durga Garden, Jaisco Colony, Mukherjee Nagar in Jagadhri is light yellow due to the presence of excess of Iron.

Chromium metabolism is tilled undefined. Deficiency disease or symptoms include impaired glucose tolerance secondary to paraenteral nutrition. Estimated safe and adequate daily dietary intake for adequate daily dietary intake for adults is 0.04-0.2mg/day (NRC-NAS, 1980). The observed biological effects of chromium must therefore be due to some complexes form. Biologically active chromium compounds have been synthesized from chromium, nicotinic acid and glutathione. Both synthetic and biologically active extracts bind tightly to insulin and can be dissociated from insulin at low pH. Hexavalent chromium at 10mg/kg of body weight can induce liver necrosis, nephritis and depth in man lower doses will cause irritation of the gastrointestinal mucosa. Hexavalent chromium can produce cutaneous and nasal mucous-membrane ulcers and dermatitis [9] by skin contact. Chromium has been proved to be carcinogenic in man and animals. Increased risk of lung cancers for workers who are exposed to high levels of chromium is reported. Digestive tract cancers, prostate cancers and maxillary sinus cancers have also been reported in workers. Because the hexa form is carcinogenic and there is no safe threshold, no safe level for hexavalent chromium can be recommended. Drinking water containing above 50µg/1 of hexavalent chromium is to be discarded (WHO, 1987). Chromium was reported up to 8.71 ppm (table-3) in underground water samples and 17.89 ppm (table-1) in samples of waste water. Since chromium compounds are increasingly present in products used in daily life, chromium eczemas are often observed in the general population. Chromium containing steel, metal pins used for internal fixation of broken bones and bullets retained in the body also occur (WHO, 1988).

Because of the carcinogenic properties of nickel no safe level can be recommended for nickel in water. The body burden of nickel in healthy adults average 0.5 mg (7.3µg/kg body weight for a 70 kg person). Oral intake of nickel average 170 µg/day of which approximately 5% is absorbed (8.5 µg/day). Inhalation of nickel average 0.4µg/day for urban dwellers and 0.2 µg/day for rural dwellers, of which 35% is retained (0.007 to 0.014 µg/day). This assessment of nickel metabolism involves the assumption that 70% of absorbed nickel is promptly excreted by the kidneys and the remaining 30% is deposited in the tissues with a mean retention time of 200 days. Percutaneous absorption of nickel is important in view of the dermopathological effects (Contact dermatitis) in the context of nickel sensitivity. Nickel was reported up to 2.98 ppm (table-3) in underground water samples and 2.98 ppm (table-1) samples of waste water. Absorbed nickel is transported via blood bound to albumin. There is little evidence of accumulation of nickel by tissues. Presumably there must be an as yet unelucidated mechanism in the animal body to control excessive intake, absorption and accumulation of nickel. The reactivity and protein binding properties of nickel compounds are related to their surface properties and crystalline nature. The numerous industrial uses of nickel in addition to production and refining suggest that many workers can be exposed to nickel in their occupations. Similarly the general population is exposed to nickel-plated objects used in day to day life [10] apart from intake through water and food.

Nickel induces embryotoxic and nephrotoxic effects, allergic reactions and contact dermatitis. Nickel alloy and nickel compounds are among the most common causes of allergic contact dermatitis.

Table-1: Analysis of metal ions by atomic absorption spectrophotometer of effulent of distillery, paper mill, steel industry and brass mill

Effluent Samples	Zinc λ= 213.9nm	Cadmium λ = 228.8 nm	Lead λ =283.3 nm	Nickel λ =232 nm	Copper λ=324.8 nm	Chromium λ =358 nm
Distillery	9.16ppm	16.310ppm	Nil	5.775ppm	Nil	0.0777ppm
Paper Mill	9.26ppm	16.10ppm	Nil	6.725ppm	Nil	0.2301ppm
Steel Mill	17.15ppm	9.490ppm	Nil	13.285ppm	10.40ppm	17.892ppm
Brass Mill	22.94ppm	Nil	Nil	7.3ppm	14.275ppm	10.533ppm

Table-2: Physico-chemical analysis of metal ions of water of ganda nala after mixing of the effluents

Effluent Mixing Site	Zinc λ= 213.9nm	Cadmium λ = 228.8 nm	Lead λ =283.3 nm	Nickel λ =232 nm	Copper λ=324.8 nm	Chromium λ =358 nm
Distillery	Nil	8.21ppm	Nil	0.7625ppm	4.250ppm	0.0150ppm
Paper Mill	7.59ppm	7.162ppm	Nil	0.78ppm	7.3ppm	Nil
Steel Mill	3.05ppm	18.506ppm	Nil	4.275ppm	2.75ppm	12.396ppm
Brass Mill	8.10ppm	12.297ppm	Nil	1.4325ppm	1.325ppm	4.316ppm

Water contaminated with heavy metals [11] causes high infant mortally rates and endemic diarrheal, malarial, Jaundices, cancer, dermatitis and intestinal diseases, reported in Jagadhri. Every year many water borne diseases spread in the city due to intake of highly contaminated water. In the colonies like Mukherjee Park, Durga Garden, Jaisco Colony, the underground water is also highly contaminated due to leakage of water pipes. Hence the underground water of these colonies is severely polluted due to the seepage effect, leakage of pipe lines, dumping of solid

industrial [12] and municipal waste. Because it contains highly toxic substances, metal ions and bacteria. So necessary steps must be taken to save the health of residents of Jagadhri.

Table-3: Physico-chemical analysis of metal ions of water of pollution infested zone

Metal ions	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Mean
Zinc λ= 213.9nm	4.8	4.7	3.6	4.1	3.9	6.1	7.34	5.89	4.36	5.7	5.049
Cadmium λ = 228.8 nm	0.011	0.012	0.008	0.007	0.007	0.013	0.089	0.071	0.01	0.008	0.0235
Lead λ =283.3 nm	Nil	Nil	nil	Nil	nil	Nil	nil	nil	nil	nil	Nil
Nickel λ =232 nm	1.51	1.49	0.98	0.87	0.87	1.37	2.15	1.78	0.56	2.98	1.456
Copper λ=324.8 nm	1.8	1.7	0.32	0.41	0.38	1.11	3.67	2.71	0.92	0.81	1.383
Chromium λ =358 nm	8.71	7.67	6.8	5.3	7.15	5.14	6.64	5.12	4.98	5.4	6.291

All the values are in ppm

Table-4: Physico- chemical studies of hand pump water of the colonies where solid industrial waste used for land filling

S. No	Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	pH	7.1	7.23	7.12	6.43	7.23	5.74	5.78	6.92	6.21	6.02
2	Temperature	18.1	18.2	18.1	18.2	18.1	17.9	18	18.4	18.4	18
3	Methyl orange alkalinity	44	64	74	30	42	92	94	76	58	84
4	Phenolphthalein acidity	42	55	53	24	64	82	78	49	92	62
5	CO_2	28.98	42.84	29.18	31.23	26.12	4214	38.72	38.6	34.24	52.42
6	Total solids	642	736	730	892	810	1080	1270	1002	1023	990
7	Total dissolved solids	214	492	484	672	662	850	940	692	762	748
8	Total suspended solids	428	244	246	220	148	230	330	310	261	242
9	Cl^-content	34.78	32.64	28.42	18.46	16.38	54.48	42.34	58.22	24.85	28.21
10	Total hardness	284	530	640	420	460	1038	1078	920	680	1902
11	Permanent hardness	104	360	432	328	186	678	638	638	338	982
12	Temporary hardness	180	170	208	102	274	360	440	282	342	420
13	Ca^{2+} hardness	180	260	280	320	270	430	390	410	260	320
14	Mg^{2+} hardness	80	180	490	210	120	320	280	510	420	270
15	DO	5.6	6	6.2	5.9	7.4	6.6	4.4	4.9	5.1	5.2
16	BOD	182.5	92.4	128.4	64.2	48.4	1320	472.2	382.4	292.6	284.2
17	COD	266	182	322	346	490	668	812	486	336	732
18	Sulphate content	2.04	0.68	5.42	5.62	4.24	6.27	8.56	7.83	5.54	7.28
19	Total fungal count	Nil	Nil	Nil	Nil	Nil	2	Nil	3	Nil	Nil
20	Total coliform(MPN)	38	40	22	47	52	154	92	160	106	112
21	Total bacterial count	14	24	8	31	34	98	74	114	87	85

All the values are in ppm except pH, temperature and conductance

CONCLUSION

The results indicate that the metal industrial waste is raising the level of toxic metal in soil and water bodies. The enhanced concentration of these to metal may be attributed to various metal industries located in Jagadhri and these are making the life of residence difficult. From the

present investigation it may be concluded that besides industrial activates are also responsible for the elevated level of heavy metals in the city and shifting of these industrial unit in the city's outer area can only be an effective measure to control the pollution level in the city. The present study further suggested that if release of metal ion, complexes is not controlled in near future, these may lead to serious consequences due to pollution problem in the city of Jagadhri. The only way is to take stringent action against polluting metal industries and develop awareness. These aspects should be given priority.

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