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Chemical Assessment of Lead in the Groundwater of Saharsa District, Bihar

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Abstract : Lead (Pb) is one of the seven metals of antiquity. It is established fact that excess of everything or anything is harmful and ultimately poisonous and so is for Lead also. It is believed that one of the main reasons for the fall of the Roman Empire was endemic lead poisoning due to over exposure to lead. Sweetening of wine with lead salts caused an endemic disease called 'lead colic'. Present paper reports the concentration of Lead (Pb) in the groundwater of Saharsa District, Bihar which is situated at latitude $25^0 35–26^0 28'$ N and longitude $86^0 18'– 86^0 51'$ E. All the ten community development blocks of Saharsa district have been selected as sampling sites and from each block two samples either from well or tube well, on the basis of availability of functioning well or tube-well have been collected for analysis. Thus all together twenty samples were collected for pre-monsoon (May-June) season and twenty samples were collected for post-monsoon (October-November) season in the year 20222 and analyzed. The analytical results of the elemental lead in the groundwater for pre and post monsoon seasons have been tabulated in Table-1. The Lead (Pb) concentration was found to be between 0.022 ppm to 0.243 ppm and 0.022 ppm to 0.228 ppm for the pre- and post-monsoon seasons respectively. The average value was between 0.022ppm to 0.232 ppm. The maximum allowable, limit as per WHO is 0.05 ppm and as per USPH the acceptable value is 0.100 ppm. Some of the values are within the limit and some of the values are higher than the prescribed limits.

(Keywords : Industrial Uses and Pollution Sources, Biochemical Effects Toxicology and Toxicity, Environmental Levels and Ecological Effects).

Introduction

Lead (Pb) is one of the seven metals of antiquity and was perhaps discovered by accidental dropping of galena (PbS) into a campfire. The average lead content of igneous rocks is about 15 ppm and hence it is categorized as a rare element. Fortunately it is concentrated as sulfide deposits in many parts of the world which is easily mined and smelted. In nature, lead occurs mainly as galena (PbS), although carbonate and chloride ores also exist. Ancient people used lead for ornaments, dishes, trays, as a core for bronze statues, as sinkers for fishing nets, etc. Greeks and Romans used lead extensively for sweetening the bitter taste of the food cooked in bronze pots, storing olive oil, preparing wine, etc. Incidentally, it is believed now that one of the main reasons for the fall of the Roman empire was endemic lead poisoning due to over exposure to Pb. Sweetening of wine with lead salts caused an endemic disease called 'lead colic".

Industrial Uses and Pollution Sources:

Lead is used in building construction, preparation of various alloys with Cu, Sn and Sb for use as accumulator plates in storage batteries, paints, pigments and varnishes, cable coatings, ammunition, etc. Lead arsenate is used as pesticide. Lead borate is used in plastic industries. Lead is used for making lead pipes, containers for corrosive liquids, and lead chambers. White lead, red lead and litharge are used in pigments and paints. Lead is used for preparing alloys like solder, pewter (for making utensils), woods metal, Rose metal, Lipowitz alloys, Newton metal, etc. These fusible alloys are used for making soft solders, electric fuses, safety plugs for automatic water sprinklers, etc. Organic forms of lead e.g., tetraalkyl leads are used as antiknocking additives to gasoline in internal combustion engines along with dichloroethane or dibromoethane as scavenging agents. In fact, the tetraalkyl lead accounts for 20% of lead used by mankind which accounts for the main environmental lead pollution problem. Street dusts and roadside soils on busy streets may contain Pb in the range of 1000 to 4000mg kg^{-1}. Apart from natural weathering processes, the main sources of lead pollution are mining and smelting of lead ores, emissions from automobile exhausts, effluent from storage battery industries, use of glazed earthenware-containers, lead pipes and lead pigments[1,2]. Hair dyes, eye-paints, canned foods, sea foods, painted toys, wicks in decorative candles, coloured pages in magazines, putty on the window frames, pewter ware etc., are the important sources of lead exposure.

Biochemical Effects Toxicology and Toxicity

Lead is considered as a general protoplasmic poison which is cumulative, slow-acting and subtle. It produces a variety of symptoms. Similar to other heavy metals, it has an affinity for sulphur. Although Pb exerts much of its activity through sulphydryl inhibition, it also interacts with carboxyl and phosphoryl groups. The major biochemical effect of lead (Pb) is its interference with heme synthesis and leading to hematological damage. Pb inhibits several important enzymes involved in the overall process of heme synthesis.Lead inactivates delta-aminolevulinic acid (ALA dehydrase) and thus obstructs its conversion to porphobilinogen (PBG), which is an important step in heme synthesis. It also impairs the activity of porphobilinogen decarboxylase. These effects lead to the disruption of the synthesis of haemoglobin and other respiratory pigments such as cytochromes which require heme. Further Pb obstructs the utilization of oxygen and glucose for the life-sustaining energy production. The interference with normal metabolic functions starts when the blood-lead level reaches about 0.3 ppm. When the blood-lead level reaches about 0.8 ppm, symptoms of anaemia will be observed due to the deficiency of haemoglobin. Higher levels of Pb in the blood can cause kidney dysfunction (leading to Fanconi syndrome) and brain damage because it is toxic to the central and peripheral nervous system[3].

One of the most insidious effects of inorganic lead is its ability to replace Ca in bones and accumulate there as a reservoir for long-term release. This lead is subsequently remobilized along with phosphates from the bones and exert toxic effects when transported to soft tissues. Air-borne lead of small particle size is readily absorbed through the lungs. On an average only about 10% of inorganic lead that is ingested is absorbed, and is distributed in the various tissues, liver, bones, kidneys and brain. About 90% of this lead is immobilised in bones. The bone-lead concentration goes on increasing and accumulating with age until it reaches toxic levels. Chronic exposure to lead causes weight loss, constipation and loss of teeth.

Organic lead, as tetraethyl lead and tetramethyl lead is even more acutely poisonous (10 to 100 times) than inorganic lead. Tetraethyl lead (TEL) is non-polar and lipophilic and hence is less soluble in water than inorganic lead. Inorganic lead is mainly absorbed by food or inhalation of particular lead whereas TEL is absorbed by inhalation of the volatile compound or by its dermal entry into the body. Inorganic lead mostly causes gastrointestinal and hematological disturbances whereas tetraethyl lead selectively attacks the central nervous system. Inorganic lead can bind to complexing agents such as calcium EDTA or to thiol groups but organic lead does not.

Organic lead compounds such as tetraethyl lead can penetrate the skin and absorb into the body tissues more rapidly as compared to inorganic lead compound. It is believed that the metabolism of tetraethyl lead involves sequential dealkylation process that forms triethyl lead, diethyl lead and then inorganic lead. It is the formation of triethyl lead from tetraethyl lead which accounts for the severe toxic effects of tetraethyl lead; further dealkylation renders this compound progressively more polar and less toxic. Brain is the target organ for tetraethyl lead. The organo-lead compounds, being lipophilic, and selectively localized in the central nervous systems and result in toxicity. The biochemical effects of tetraethyl lead include uncoupling of oxidative phosphorylation and inactivating and obstructing its conversion to porphobilinogen. Organo lead compounds are suspected to cause genetic modifications.

Environmental Levels and Ecological Effects:

The lead-levels of urban-dwellers may be as high as 200 mg. Owing to the continued use of leaded-gasoline, the blood-lead levels of population in major cities may vary between 2 to 35μg/dL. The World Health Organisation suggests a provisional tolerance of 7μg/kg body weight per day for adults. The degree of inorganic lead poisoning can be indicated by determining lead content in blood, hair and urine.

Leafy vegetables, potatoes and beans are likely to absorb more lead than fruiting crops like tomatoes, beats, etc. It is better not to grow carrots, turnips, beetroot and sprouts near highways where contamination by vehicular exhausts is more. The movements of lead into the vegetables grown in soil contaminated with lead can be controlled by adding large amounts of compost and maintaining the soil pH near 6 to 7.

Human activities have seriously upset the natural cycle of lead and urgent action is needed to prevent continuing and cumulative poisoning of the environment with lead[4]. Improved plant control in smelting operations and improving the automobile engine design are suggested so that lead-free gasoline can be used and at the same time emission of other pollutants like CO in the exhaust should be controlled by using suitable catalytic control devices. Immediate attention is imperative for controlling Pb pollution because in no other case the “normal levels” in humans are so close to the lowest prescribed safety levels.

Water quality parameters are getting monitored[5-31]across the globe to aware the people to use safe water for different purposes of domestic uses. Present paper describes the chemical assessment of Lead (Pb) contamination in the groundwater of Saharsa District, Bihar which is situated at latitude $25^{0}35^{'}$–$26^{0}28^{'}$ N and longitude $86^{0}18^{'}$ – $86^{0}51^{'}$ E.

Sampling Season: Samples were collected for two seasons namely pre-monsoon (May-June) and post-monsoon (October-November) seasons in the year 2022.

Sampling sites: All the ten community development blocks of Saharsa district have been selected as sampling sites and from each block two samples either from well or tube well, on the basis of availability of functioning well or tube-well, have been collected for analysis. Thus, all together twenty samples were collected. Descriptions of these samples are given in the Table-1

Results and Discussion

The analytical results of the elemental lead in the groundwater for pre and post monsoon seasons have been tabulated in the Table-1. The concentration of Lead (Pb) was found to be in between 0.022 ppm to 0.243 ppm and 0.022 ppm to 0.228 ppm for the pre-and post-monsoon seasons respectively. The average value was in between 0.022ppm to 0.232 ppm. Themaximum allowable, limit as per WHO is 0.05 ppm and as per USPH the acceptable value is 0.100 ppm. Some of the values are within the limit and some of the values are higher than these prescribe values.

Table-1
Lead concentration in the groundwater of Saharsa District (Bihar) for pre- and post-monsoon seasons and their average in the year 2022)

Sl. No.	Sampling site	Sample No.	Pb in ppm for pre-monsoon season	Pb in ppm for post-monsoon season	Average value of Pb in ppm for pre and post-monsoon	Maximum and Minimum values of Pb in ppm
1	Nauhatta	TW1	0.071	0.080	0.076	-
2	Nauhatta	TW2	0.033	0.056	0.044	-
3	Sattar Kataiya	W3	0.213	0.222	0.218	-
4	Sattar Kataiya	TW4	0.224	0.226	0.225	-
5	Mahishi	W5	0.231	0.228	0.230	-
6	Mahishi	W6	0.215	0.212	0.214	-
7	Kahra	TW7	0.047	0.040	0.044	-
8	Kahra	TW8	0.049	0.044	0.046	-
9	Sour Bazar	TW9	0.243	0.222	0.232	0.232 (max)
10	Sour Bazar	TW10	0.235	0.220	0.228	-
11	Patarghat	TW11	0.201	0.190	0.196	-
12	Patarghat	TW12	0.205	0.196	0.200	-
13	Sonvarsa	TW13	0.045	0.032	0.038	-
14	Sonvarsa	TW14	0.046	0.036	0.041	-
15	Simri Bakhtiyarpur	TW15	0.043	0.040	0.042	-
16	Simri Bakhtiyarpur	TW16	0.046	0.040	0.043	-
17	Salkhua	TW17	0.042	0.032	0.037	-
18	Salkhua	TW18	0.045	0.034	0.040	-
19	Banma Itahari	TW19	0.022	0.022	0.022	0.022 (min.)
20	Banma Itahari	TW20	0.025	0.024	0.024	-

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