Research Article

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Status of lead present in ground drinking water samples of Uttarakhand (Garhwal Region) in India.

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ABSTRACT

Lead is a naturally occurring metal found deep in the ground. It occurs in small amounts in ore, along with other elements such as silver, zinc, or copper. Even though it is found in small amounts, there is an abundant supply of lead throughout the earth. Because it is widespread, and easy to extract and work with, lead was used for hundreds of years in a wide variety of products found in and around homes, including paint and gasoline. Lead can get into our body in two ways — through breathing it in or by eating it. For example, lead can enter the body through eating or inhaling paint dust or chips. The soil, drinkable ground water around our home can pick up lead from sources such as exterior paint. Lead can also enter in drinking water through our plumbing. In drinking ground water samples of uttarakhand (garhwal region) the level of lead was estimated through ICP mass spectroscopy. The presences of lead in ground drinking water samples of uttarakhand were high as compared to BIS desirable and permissible limits. Both children and adults are vulnerable to the effects of lead. Young children under the age of 5 are particularly vulnerable, because their body, brain, and metabolism are still developing. Two-year-olds tend to have the highest blood level concentration, because they put many things into their mouth, including toys or other products that may contain lead. On the basis of present study we observed that due to the excess quantity of Pb, and others heavy metals in uttarkhand India, the human beings of that region are suffering with various diseases like gastrointestinal, speech disorder, Irritability aggressive behaviors temper tantrums, Sleep difficulties/ disturbances, Anorexia symptoms reflecting eating disorders loss of appetite/weight, behavior, Speech and Language Deficits, Cognitive Impairments and thyroid diseases etc.

Keywords: Lead, ground drinking water, ICP mass spectroscopy, BIS.

INTRODUCTION

Lead is a chemical element in the carbon group with symbol Pb (from Latin: *plumbum*). Lead is a soft and malleable metal, which is regarded as a heavy metal and poor metal [1]. Metallic lead has a bluish-white color after being freshly cut, but it soon tarnishes to a dull grayish color when exposed to air [2]. Lead has a shiny chrome-silver luster when it is melted into a liquid. It is also the heaviest non-radioactive element. Lead is a bright and silvery metal with a very slight shade of blue in a dry atmosphere [3]. Upon contact with air, it begins to tarnish by forming a complex mixture of compounds depending on the conditions. The color of the compounds can vary. The tarnish layer can contain significant amounts of carbonates and hydroxyl carbonates [4]. Its characteristic properties include high density, softness, ductility and malleability, poor electrical conductivity compared to other metals, high resistance to corrosion, and ability to react with organic chemicals[5].

Lead occurs naturally on earth exclusively in the form of four isotopes: lead-204, -206, -207, and -208 [6]. All four can be radioactive as the hypothetical alpha decay of any would be exothermic, but the lower half-life limit has been put only for lead-204: over 1.4×10^{17} years [7]. This effect is, however, so weak that natural lead poses no radiation hazard. Three isotopes are also found in three of the four major decay chains: lead-206, -207 and -208 are final decay products of uranium-238, uranium-235, and thorium-232, respectively [8]. Since the amounts of them in nature depend also on other elements' presence, the isotopic composition of natural lead varies by sample: in particular, the relative amount of lead-206 varies between 20.84% and 27.78%[9]. Lead-205 is the most stable radioisotope of lead, with a half-life of over 10^7 years. 47 nuclear isomers (long-lived excited nuclear states),

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corresponding to 24 lead isotopes, have been characterized [10]. The most long-lived isomer is lead-204m2 (half-life of about 1.1 hours).

Various traces of other metals change its properties significantly: the addition of small amounts of antimony or copper to lead increases the alloy's hardness and improves corrosion resistance from sulfuric acid [11]. Some other metals, such as cadmium, tin, and tellurium, also improve hardness and fight metal fatigue. Sodium and calcium also have this ability, but they reduce the alloy's chemical stability [12].

Metallic lead does occur in nature, but it is rare. Lead is usually found in ore with zinc, silver and (most abundantly) copper, and is extracted together with these metals. The main lead mineral is galena (PbS), which contains 86.6% lead by weight. Other common varieties are cerussite ($PbCO_3$) and anglesite ($PbSO_4$)[13]. Seawater contains trace amounts of lead (2-30 ppt). On average rivers contain between 3 and 30 ppb. Phytoplankton contains approximately 5-10 ppm lead (dry mass), freshwater fish approximately 0.5-1000 ppb, and oyster approximately 500 ppb. Under normal conditions lead does not react with water. However, when lead comes in contact with moist air reactivity with water increases. A small lead oxide layer forms at the surface of the metal [14]. When both oxygen and water are present, metallic lead is converted to lead hydroxide. As per various surveys and investigations conducted by organisations such as the 'Quality Council of India,' the presence of 'lead in water' has alarmed people and agencies across the country. Thirty three percent of over 370 samples of water from the top 26 cities of India tested positive for harmful content of lead [15]. Out of these, 31% of samples failed to adhere to the World Health Organization (WHO) standards of a lead content of less than 10 ppb (parts per billion), while 2% of the samples failed to meet even the lenient Indian norms of 50 ppb.

ENVIRONMENTAL LEVELS OF LEAD

Air

Concentrations of lead in air depend on a number of factors, including proximity to roads and point sources. Annual geometric mean concentrations measured at more than 100 stations across Canada declined steadily from 0.74 µg/m3 in 1973 to 0.10µg/m3 in 1989, reflecting the decrease in the use of lead additives in petrol[16][17]. Typical quarterly averages for urban areas without significant point sources in the United States of America (USA) in 1987 were in the range 0.1–0.3 µg/m3; in the vicinity of major point sources, such as lead smelters and battery plants, air levels typically ranged from 0.3 to 4.0 µg/m^3 [18]. An area remote from urban influences, varied between 0.1–0.3 and 0.3–9.0 ng/m^3 [19]. If an average concentration in air of 0.2 µg/m3 is assumed, the intake of lead from air can be calculated to range from 0.5 µg/day for an infant to 4 µg/day for an adult.

Water

With the decline in atmospheric emissions of lead since the introduction of legislation restricting its use in fuels, water has assumed new importance as the largest controllable source of lead exposure in India [20]. Lead is present in tap water to some extent as a result of its dissolution from natural sources, but primarily from household plumbing systems in which the pipes, solder, fittings or service connections to homes contain lead. Polyvinyl chloride (PVC) pipes also contain lead compounds that can be leached from them and result in high lead concentrations in drinking-water [21]. The amount of lead dissolved from the plumbing system depends on several factors, including the presence of chloride and dissolved oxygen, pH, temperature, water softness and standing time of the water, soft, acidic water being the most plumb solvent [22]. Although lead can be leached from lead piping indefinitely, it appears that the leaching of lead from soldered joints and brass taps decreases with time. Soldered connections in recently built homes fitted with copper piping can release enough lead (210–390 µg/l) to cause intoxication in children [23]. The level of lead in drinking-water may be reduced by corrosion control measures such as the addition of lime and the adjustment of the pH in the distribution system from <7 to 8–9[24][25]. Lead can also be released from flaking lead carbonate deposits on lead pipe and from iron sediment from old galvanized plumbing that has accumulated lead from lead sources such as plumbing and service connections, even when the water is no longer plumbosolvent.

Food

Prepared food contains small but significant amounts of lead. Lead content is increased when the water used for cooking or the cooking utensils contain lead or the food, especially if acidic, has been stored in lead-ceramic pottery ware or old lead cans. The intake of lead from lead-soldered cans is declining as the use of lead-free solders is becoming more widespread in the food processing industry [26].

Other routes of exposure

Soils and household dust are significant sources of lead exposure for small children [27], but the levels are highly variable, ranging from <5 µg/g to tens of milligrams per gram in contaminated areas. As lead is immobile, levels in contaminated soil will remain essentially unchanged unless action is taken to decontaminate them. The highest lead concentrations usually occur in surface soil at depths of 1–5 cm.

Lead in household dust will vary according to activities in the household, such as sanding old lead-based paint and, in some countries, recycling of industrial materials at the household level[28].

Estimated total exposure and relative contribution of drinking-water

More than 80% of the daily intake of lead is derived from the ingestion of food, dirt and dust. At 5 µg/ l, the average daily intake of lead from water forms a relatively small proportion of the total daily intake for children and adults, but a significant one for bottle-fed infants. Such estimates have a wide margin of error, as it is not known to what extent the general public flushes the system before using tap water; in addition, the stagnation time (and hence the lead levels) is highly variable[29].

KINETICS AND METABOLISM OF LEAD IN HUMANS

Adults absorb approximately 10% of the lead contained in food , but young children absorb 4–5 times as much lead from ingested soil and dust. In children it has been estimated to be close to 30% [30]. Absorption is increased when the dietary intakes of iron , calcium and phosphorus are low. Iron status is particularly important, as children from disadvantaged homes are more likely to suffer from anaemia, further increasing their absorption of lead.

The principal vehicle for the transport of lead from the intestine to the various body tissues is the red blood cell , in which lead is bound primarily to haemoglobin and has a special affinity for the beta, delta and, in particular, fetal gamma chains[31].Following its absorption, lead appears both in the soft tissue pool, consisting of blood, liver, lungs, spleen, kidneys and bone marrow, which is rapidly turned over, and is more slowly turned over from skeletal pool. The half-life of lead in blood and soft tissues is about 36–40 days for adults, so that blood lead concentrations reflect only the intake of the previous 3–5 weeks. In the skeletal pool, the half-life of lead is approximately 17–27 years [32]. In adults, some 80–95% of the total body burden of lead is found in the skeleton, as compared with about 73% in children . The biological half-life of lead may be considerably longer in children than in adults [33].Under conditions of extended chronic exposure, a steady-state distribution of lead between various organs and systems usually exists, and the blood lead concentration can therefore be used as a reasonably good indicator of exposure from all sources; the relationship between them is generally thought to be curvilinear in character.

Placental transfer of lead occurs in humans as early as week 12 of gestation, and uptake of lead by the fetus continues throughout development [34]. The concentration of lead in umbilical cord blood is 80–100% of the maternal blood lead level; the same applies to blood lead in the fetus . Inorganic lead is not metabolized in the body. Unabsorbed dietary lead is eliminated in the faeces, and lead that is absorbed but not retained is excreted unchanged via the kidneys or through the biliary tract . Metabolic balance studies in infants and young children indicated that, at intakes greater than 5 µg/kg of body weight per day, net retention of lead averaged 32% of intake, whereas retention was negative (i.e.excretion exceeded intake) at intakes less than 4 µg/kg body weight per day[35]. No increases in blood lead were observed in infants with low exposure to other sources of lead and mean dietary intakes of 3–4 µg/kg of body weight per day thus confirming the metabolic data.

Children's Vulnerability to Lead

Behavioral: Young children explore their surroundings by putting hands and other objects in their mouths, a primary route of lead exposure. Because the very young crawl and play on the floor, they are directly exposed to the areas where lead dust most heavily accumulates. Children with pica, a tendency to eat non-food items, are particularly vulnerable to lead poisoning, as they are likely to ingest lead if it is in paint chips, soil or other items the child eats [36].

Physiological: Relative to their size, children breathe more air, consume more food, and drink more water than adults. Lead found in air, water or food will therefore expose children more than adults. Added to that, children's bodies absorb greater proportions of lead than adult bodies. A toddler will absorb about 50% of ingested lead, whereas an adult will absorb about 10%. Children's brains and nervous systems are also more sensitive to the damaging effects of lead and may not be able to repair the damage caused. Children's organs are under development from the fetal stage through adolescence [37]. During his or her first years of life, a child's ability to metabolize, detoxify, and excrete toxins differs from that of an adult, making the child more susceptible to lead.

Developmental: Children have their whole lives ahead of them to develop health effects from lead exposure and to suffer the consequences of lead poisoning from their early years. In addition, children's systems can be permanently damaged if exposed to toxins such as lead during certain crucial periods of development [38].

Material and methods

Sampling & preservation

The water samples were drawn during monsoon (July-Sept) and non-monsoon (Nov-Jan). The ground water samples were collected from Haridwar, Vikasnagar, Mussoorie, Dehradun, Roorkee and Dakpathar regions of Uttarakhand, India by proper method from 10 places of each area. Water Samples from different location were collected in the plastic cane of 2.5 litre, about ½ litre water samples was taken from one hand pump in one location and these were mixed to get one sample from one location. In this way sample collected were analyzed in 2-3 days so no special preservation required .However samples in the cans were kept in the refrigerator.

Testing method

After collection of water samples, these were preserved to avoid further contamination. These samples were first filtered with whatmann's filter paper to remove un-dissolved material; after

Filtration different elements were determined in these samples by Inductive coupled plasma microscopy method. ICP mass spectroscopy has grown to be one of the most important techniques for elemental analysis because of its low detection limits for most elements. Its high degree of selectivity, in this application an ICP torch serves as an atomizer and ionizer. The sample introduction is accompanied by ultrasonic nebulizer. In this instrument positive metal ions produced in a conventional ICP torch, are sampled through a differently pumped interface linked to a quadruple mass spectrometer. The spectra produced in this way, which are remarkably simple compared with conventional ICP optical spectra, consist of a simple series of isotope peaks for each element. These spectra are used for qualitative and quantitative estimation of their amount in sample.

Results and Discussion:

Figure 1: Ground drinking water collected region in Uttarakhand (garhwal region), India.

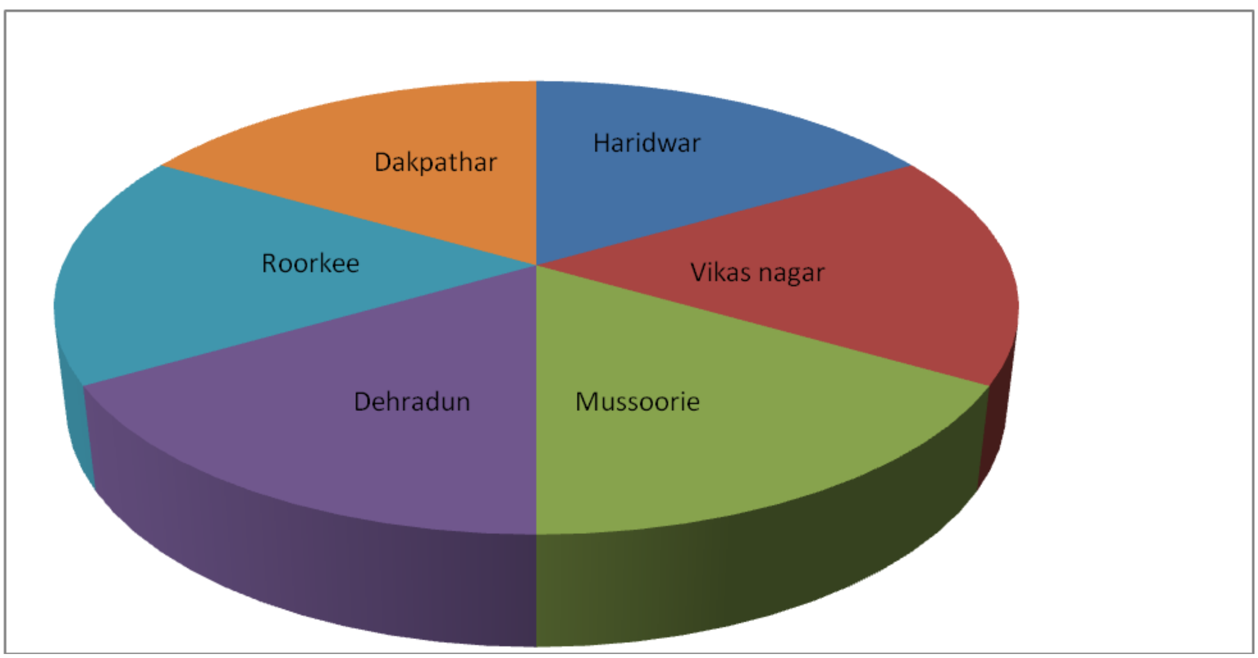


Figure 2: Lead concentrations (ppm) in ground drinking water samples of Uttarakhand, (garhwal region), India.

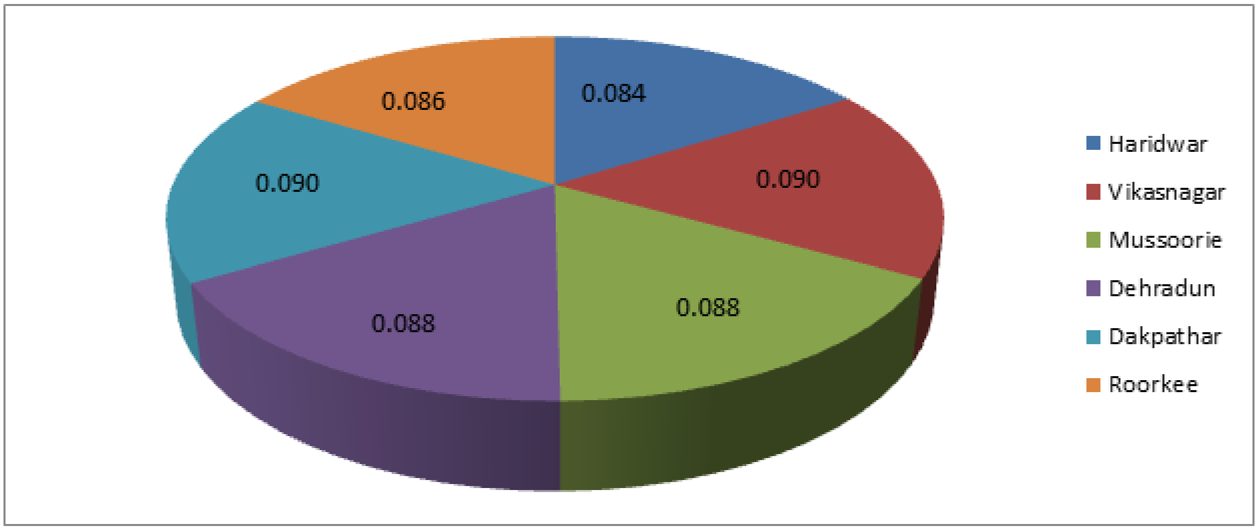
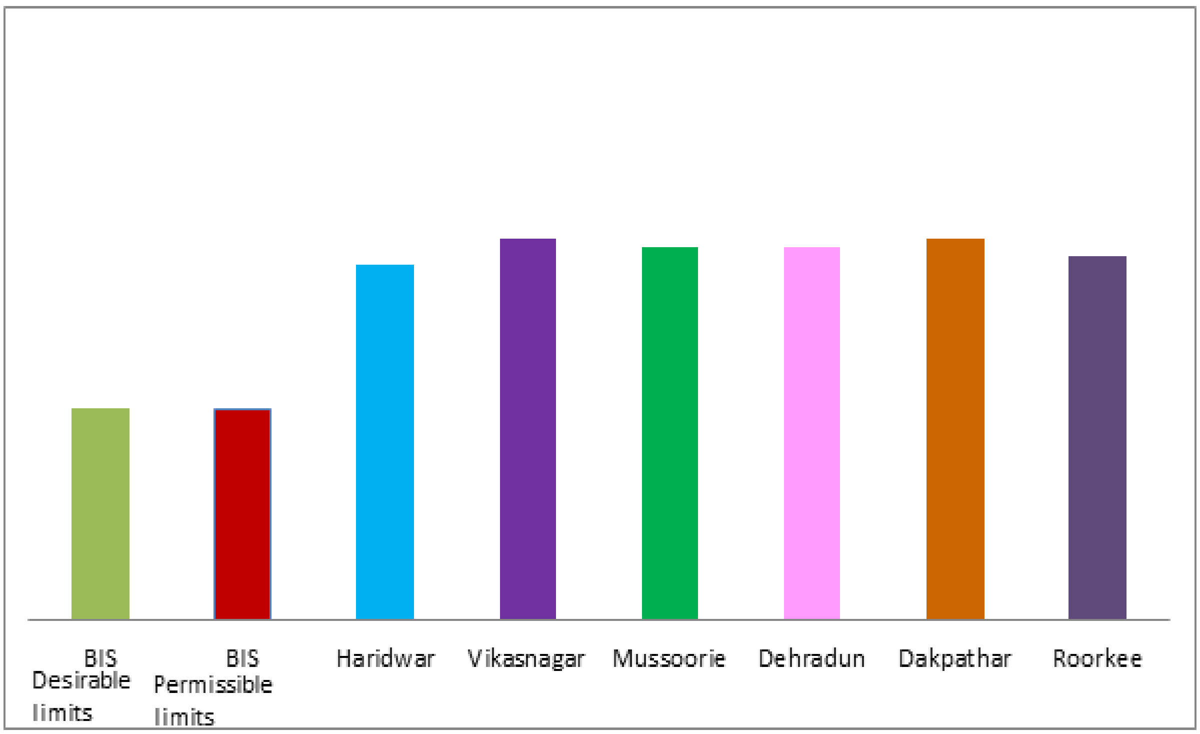


Figure 3: Lead concentrations (ppm) present in ground drinking water samples of Uttarakhand, (garhwal region), India with BIS levels.



The heavy metal lead analysis of the ground drinking water sample in our study showed that lead (Pb) content of all the six regions of Uttarakhand is higher than the BIS permissible limits. Therefore, the people living in these areas are prone to develop various ill effects of this heavy metal on long term exposure. These results are of concern as lead has been recognized for centuries as a cumulative general metabolic poison. It is neurotoxin and is responsible for the most common type of human metal toxicosis. Also, studies have linked lead exposures even at low levels with an increase in blood pressure as well as with reduced intelligence quotient in children and with attention. Exposure to lead can have a wide range of effects on a child's development and behavior. Blood lead levels less than 10 micrograms per deciliter (µg/dL) are associated with increased behavioral effects, delayed puberty, and decreases in hearing, cognitive performance, and postnatal growth or height. Some of these health effects are found even at low blood lead levels less than 5 µg/dL, including lower IQ scores, decreased academic achievement, and increases in both behavioral problems and attention-related behaviors. There is a wide range of lead-associated behavioral effects in the area of attention. Attention deficit hyperactivity disorder (ADHD) is one example on the more severe end of the spectrum.

Lead exposure has been linked to a number of health effects in adults. As a general rule, the more lead you have in your body, the more likely it is you'll have health problems. High blood lead levels greater than 15 µg/dL are associated with cardiovascular effects, nerve disorders, decreased kidney function, and fertility problems, including delayed conception and adverse effects on sperm and semen, such as lower sperm counts and motility.

Blood lead levels below10 µg/dL are associated with decreased kidney function and increases in blood pressure, hypertension, and incidence of essential tremor, a degenerative disorder of the central nervous system whose most recognizable feature is a tremor of the arms or hands during voluntary movements, such as eating and writing. There is also evidence showing that adults who have low levels of exposure to lead less than 5 µg/dL may have decreased kidney function.

Pregnant women need to be particularly careful about lead. Maternal blood lead levels less than 5 µg/dL are associated with reduced fetal growth. Because the effects of lead are different for everyone, more research needs to be done to fully understand the health effects.

A 2004 study, supported by NIEHS, also showed that lifetime lead exposure may increase the risk of developing cataracts, clouding of the eye lens resulting in partial loss of vision, which can be common in older people.

Most adults with elevated blood lead levels are exposed to lead at work. Those in occupations related to mining, ironwork or welding, construction, renovation and remodeling activities, smelters, firing ranges, the manufacture and disposal of car batteries, automobile radiator repair, metal shop work, and the manufacture of pottery or stained glass are particularly at risk for lead exposure.

Conclusion:

Heavy metal toxins contribute to a variety of adverse health effects. Heavy metal toxins that can impact human health and each toxin will produce different behavioral physiological and cognitive changes in an exposed individual. The present study gives an overview to show the how much quantity of element is present in mainly from Haridwar, Vikas-Nagar, Mussoorie, Dehradun, Roorkee and Dakpathar regions of Uttarakhand, India. The present study gives an overlook on quantity of lead present in uttarakhand region. It has been observed that due to industrial pollution, the lead metal and other heavy metals like Cd, &Cr are found on the higher side in Uttarakhand. On the basis of present study we observed that due to the excess quantity of Pb, and other heavy metals in uttarkhand, India, the human beings of that region are suffering with various diseases like gastrointestinal, speech disorder, Irritability, aggressive behavior and temper tantrums. Sleep difficulties/ disturbances, Anorexia, loss of weight, Speech and Language Deficits, Cognitive Impairments and thyroid diseases.

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