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Barium: Presence in Environment and Health Effects

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ABSTRACT

Heavy metals have high atomic weight and density. These are used in multiple applications. It includes domestic, agricultural, industrial and medical applications. Due to all these uses, wide distribution of heavy metals is also there in environment in the form of waste. It also has potential health effects. Some of these heavy metals are considered as carcinogens. Barium is an alkaline earth metal which is present in food and water naturally. In this paper we will discuss about barium, its distribution, exposure and possible health effects.

***Key words**: Heavy metals, Environment, Barium, Human Health*

Introduction

In last few years heavy metal contamination in environment is increasing. Pollution in environment is due to mining, foundries etc and other industrial activities which are metal based. Heavy metals are generally found in earth's crust but these contaminate environment due to various anthropogenic activities. Metals are generally defined on the basis of their physical properties in solid state. Some physical properties are: High Reflectivity, which is responsible for characteristic metallic lustre, High Electrical Conductivity, which decreases with increasing temperature, High thermal conductivity. Barium is an alkaline earth metal. It is the sixteenth most abundant element on earth. It is found mainly in barite and witherite ores. In drinking water and food, it is present naturally. The amount present is low as, barium sulphate and barium carbonate does not mix with water very well. Toxicity of Barium compounds depend on their solubility. Free ions of Barium can get absorbed in lung or gastrointestinal tract, but barium sulphate is unabsorbed. After absorption, it accumulates in bone and also in pigmented parts of eye. In experimental animals, acute exposure of Barium salts shows a number of disorders which include renal intoxication, hypertension and cardiac malfunction. Kidney is observed as most sensitive target organ in rats and mice, exposed to Barium Chloride in drinking water. No carcinogenic activity in rats and mice is observed through Barium exposure.

Physical and Chemical Properties

Barium is heaviest of stable alkaline earth metals. Its atomic weight is 137.3 and atomic number is 56. It is silver white soft metal with a melting point of 725 Degree Celsius. It oxidizes readily in presence of moist air and also it reacts with water or with diluted acids under evaluation of hydrogen gas. The compounds of Barium are colorless divalent positive ions. Although in carbonate and sulphate form the water solubility is less but in acetate, chloride, hydroxide, and nitrate form, the solubility in water is

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higher. Solubility in acids is relatively higher.

Methods of Analysis

Atomic absorption spectroscopy (AAS), Inductively Coupled plasma atomic emission spectrometry (ICP-AES) and Inductive Coupled plasma mass spectroscopy (ICP-MS) are some analytical procedures which are used to determine the barium and its compounds in air, water, geological and biological materials. By these methods low level of barium can also be determined. For example, by ICP-MS, detection limits for analysis of urine is 1 microgram per Litre (Komaromy-Hiller *et al.,* 2000) and in water is 0.001 microgram per Litre (Rosborg *et al.,* 2003). There are some other techniques also which involves the less sensitive methods are X-Ray fluorescence spectroscopy and neutron activation analysis and the less commonly used methods are scintillation spectroscopy, and spectrography (ATSDR, 1992). Generally, analytical procedures measure the total barium ion present, not the barium compounds.

Production and Uses

The leading producers of mineral Barite ($BaSO_4$) are China followed by India and Morocco. Barium occurs mainly as Barite. The total production in 2002 was approximately 6 metric tons. For manufacturing of Barium chemicals, the barite is reduced to much more reactive barium sulphide through sintering with charcoal in high temperature. It can be mined in small amounts of witherite ($BaCO_3$).

In last few years, Barite sold in crushed and ground form is used as weighing agent in oil and gas well drilling mud. Barium is used in manufacturing alloys, glass, cement, ceramics, lubricating oils additives, pharmaceuticals, electronics, fine chemicals etc. In addition these are used for root canal fillings. These have toxicological significance so these are used in insecticides, Rodenticide etc.

Exposure

It constitutes approximately 0.04% of earth's crust and its presence is quite high in environment. It enters in environment through anthropogenic activities i.e. weathering of rocks and minerals. Some manmade activities like emissions from industries due to mining, refining, manufacturing etc. also contribute in increasing barium content in environment. It is released in environment during burning of coal, fossil fuels and waste. During environmental and industrial activities, barium got discharged in water also. Deposition in soils is due to human activities and disposal due to fly ash (WHO, 1990). There are some compounds of barium like barium sulphate which are insoluble in water, but under few acidic conditions these become soluble. These compounds then mix in groundwater. In previous studies, it has been noted that plants near waste water sites have high quantity of barium as compared to plants on other sites. Barium interfered with sulphate and calcium nutrition as well as had depressing effect on potassium concentrations in leaves. Soils show a high concentration of barium but a very low amount is taken by plants hence a low transfer to animals. In respiratory tract all soluble forms are absorbed in all segments. Alkaline earth metals accumulate in the skeleton. As we know approximately 90 % of body burden is in bone.

Metabolism

In soluble form, it can be absorbed from all segments of respiratory tract. The absorption depends on several factors like salt solubility, starvation, age of animal and presence of sulphate in diet. For example the soluble Barium Chloride is studied on hamsters. By intragastric intubation the absorption of $^{133}BaCl_2$ in hamsters was around 11-32% of the dose (Cuddihy and Ozog, 1973) Whereas in rats, the absorption varies from 7-85%, with highest absorption in fasted (20%) and in young (85%) rats. As $BaSO_4$ remains unabsorbed during brief passage through alimentary canal, it can be used as X-Ray contrast material for gastrointestinal examination. Although it is also reported that if a low dose of Barium i.e. around 10 microgram per Kg of body weight is given by gastric intubation, Barium Sulphate shows same rate of absorption as that of Barium Chloride. (McCauley and Washington, 1983). Hydrochloric Acid present in stomach can solubilise the small quantities of Barium Sulphate. Increase levels of Barium in blood and urine is found in humans ingesting 58-400g of Barium sulphate in X-Ray contrast materials (Clavel *et al.,* 1987)

Distribution

The accumulation of alkaline earth metals generally takes place in skeleton, which have 91% of body burden (WHO, 1990). The Barium accumulation is 1.5-5 times higher than that of calcium. This is due to the preference for Barium due to uptake on bone

surfaces than due to diffuse uptake. In case of soft tissues, the Barium accumulation is lower than or in proportion to calcium content, after intravenous injection. But some exceptional cases are of submaxillary gland, which concentrates Barium from serum in preference than any other alkaline earth metal (Bligh and Taylor, 1962) the heart (McCauley and Washington, 1983) and the eye in which the concentration of Barium is sometimes very high. Skeletal uptake of Barium decrease with increase in age. (Einbrodt *et al.,* 1972).

Excretion

In a healthy person, barium excretion is done 91% in faeces, 6% in sweat and 3% in urine (Schroeder *et al.,* 1972). In three days approximate 75% of barium is removed from body. And in next seven to forty two days 10-20% is cleared. Soluble Barium, intravenously injected in a healthy person can be excreted through both faeces and urine in a ration of 3:1 to 9:1 After 3-6 hours of intravenous injection of soluble salt was measured in saliva and seminal fluid of healthy man, shows values of 0.22-o.33% and 0.81% respectively (Harrison *et al.,* 1967)

Biological Monitoring

For biological monitoring of barium there are not so established biomarkers. Barium is present in plasma form in blood (Schroeder *et al.,* 1972). During welding, as there is exposure of soluble barium compounds, the median plasma levels up to 24.7 microgram per litre. Urine samples of patients were determined by ICP-MS . Median urine levels up by 101.7 microgram per litre during exposure to Barium compounds during welding (Zschiesche *et al.,* 1992).

Effects of Barium in Body

Acute Effects: The most common symptoms due to barium are nausea, abdominal pain, diarrhoea and vomiting. It may cause paralysis as this is toxic to tissue. In some cases barium poisoning may lead to loss of tendon reflexes, heart fibrillation and general muscular paralysis including the respiratory muscles, leading to death. Poisoning due to medicinal products and households containing Barium has been reported. The compound includes nitrate, sulphide, carbonate and chloride (Downs *et al.,* 1995; Gould *et al.,* 1973).

Chronic Effects: Inhalation may cause pulmonary reaction. In a medical evaluation of Barium workers, High blood pressure is reported in group exposed to Barium as that of Control group (NIOSH, 1982). The alleviated mortality rates due to cardiovascular diseases and heart diseases were found in people with high barium content. Although the possibility to conclude a relationship between cardiovascular disease and barium exposure is not possible (Brenniman and Levy, 1981). A study of elderly Japanese people concludes that barium in ribs can be used as long term exposure. High cerebrovascular damage was noted in people with high concentration of Barium in ribs (Yoshinaga *et al.,* 1995). Barium ion act also act as physiological antagonist to potassium, so the symptoms of Barium poisoning is due to Ba^{2+} induced hypokalemia. This is due to the transfer of potassium from extracellular to intracellular compartments rather than to urinary or gastrointestinal losses. Due to this imbalance between cells and intercellular fluids, in the cell membranes, there is blockage of K^{+} channel of Na-K pump due to barium (Yellen, 1987).

Conclusion

Barium is present in environment and distributed by various man made and natural activities. It is widely used in many industries. Various health issues are created due to this. To avoid health problems, safe alternatives must be used by people.

Conflict of Interest

The article is approved by all authors and no conflict of Interest is there.

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