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Mini Review

Heavy Metals Copper, Lead and Arsenic Contamination in Food

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ABSTRACT

Heavy metals refer to any relatively high-density metallic element that is toxic or poisonous even at low concentrations. Heavy metals are natural components of the earth's crust and cannot be destroyed. Metals such as lead, cadmium, mercury and others are found in certain foods. Eliminating them entirely from our food supply is not always possible because these metals are found in the air, water and soil, and then taken up by plants as they grow. The toxicity of these metals is in part due to the fact that they accumulate in biological tissues, a process known as bioaccumulation. This process of bioaccumulation of metals occurs in all living organisms as a result of exposure to metals in food and the environment, including food animals such as fish and cattle as well as humans.

Keywords: Heavy metals; Food supply; Bioaccumulation; Contamination

INTRODUCTION

Toxicity

Copper is a metallic element that occurs naturally as the free metal, or associated with other elements in compounds that comprise various minerals [1]. Most copper compounds occur in Cu^{+1} (I) and Cu^{+2} (II) valence states. Copper is primarily used as a metal or an alloy (e.g., brass, bronze, gun metal). Copper sulfate is used as a fungicide, algicide, and nutritional supplement. Lead is the most important toxic heavy element in the environment. Due to its important physico-chemical properties, its use can be retraced to historical times. Globally it is an abundantly distributed, important yet dangerous environmental chemical. Arsenic is a naturally occurring element in the environment that can enter the food supply through soil, water or air [2]. It has also been known to be used by farmers as a pesticide and a fertilizer. Arsenic is a widely found contaminant which occurs both naturally and as a result of human activity. Arsenic is a metalloid that occurs in different inorganic and organic i.e., containing carbon forms. These are found in the environment both from natural occurrence and from anthropogenic activity. The inorganic forms of arsenic are more toxic as compared to the organic arsenic.

Sources of exposure

Copper particulates are released into the atmosphere by windblown dust, volcanic eruptions, and anthropogenic sources, primarily copper smelters and ore processing facilities. Copper particles in the atmosphere will settle out or be removed by precipitation, but can be resuspended into the atmosphere in the form of dust. Copper is released into waterways by natural weathering of soil and rocks, disturbances of soil, or anthropogenic sources (e.g., effluent from sewage treatment plants). The general population is exposed to copper through inhalation, consumption of food and water, and dermal contact with air, water, and soil that contains copper [3]. The estimated daily intake of copper from food is 1.0-1.3 mg/day for adults. Drinking water is the primary source of excess copper. Populations living near sources of copper emissions, such as copper smelters and refineries and workers in these and other industries may also be exposed to high levels of copper in dust by inhalation. Copper concentrations in soils near copper emission sources could be sufficiently high to result in significantly high intakes of copper in young children who ingest soil. For example, copper concentrations of 2480-6912 ppm have been measured near copper smelters. These levels of copper in soils would result in the intake of 0.74-2.1 mg copper per day in a child ingesting 300 mg of soil.

Occupational exposure is a major source for lead poisoning in adults. Exposed to lead through occupational and

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environmental sources. This mainly results from: Inhalation of lead particles generated by burning materials containing lead, for example, during smelting, recycling, stripping leaded paint, and using leaded gasoline or leaded aviation fuel; and Ingestion of lead-contaminated dust, water (from leaded pipes), and food (from lead-glazed or lead-soldered containers). Once lead enters the body, it is distributed to organs such as the brain, kidneys, liver and bones [4]. The body stores lead in the teeth and bones where it accumulates over time. Lead stored in bone may be remobilized into the blood during pregnancy, thus exposing the fetus.

Arsenic through food, particularly grain-based processed products such as wheat bread, rice, milk, dairy products and drinking water are the main sources. Fish, shellfish, meat and poultry can also be dietary sources of arsenic, although exposure from these foods is generally much lower compared to exposure through contaminated groundwater. In seafood, arsenic is mainly found in its less toxic organic form. Acceptance level of natural mineral water is 0.01 mg/l.

HEALTH EFFECTS DUE TO EXPOSURE TO HEAVY METALS

Copper is an essential nutrient that is incorporated into a number of metalloenzymes involved in hemoglobin formation, drug/xenobiotic metabolism, carbohydrate metabolism, catecholamine biosynthesis, the cross-linking of collagen, elastin, and hair keratin, and the antioxidant defence mechanism. Copper-dependent enzymes, such as cytochrome-c-oxidase, superoxide dismutase, ferroxidases, monoamine oxidase, and dopamine β-monooxygenase, function to reduce activated oxygen species or molecular oxygen. Symptoms associated with copper deficiency in humans include normocytic, hypochromic anemia, leukopenia, and osteoporosis [5]. Copper homeostasis plays an important role in the prevention of copper toxicity; exposure to excessive levels of copper can result in a number of adverse health effects including liver and kidney damage, anemia, immunotoxicity, and developmental toxicity. Many of these effects are consistent with oxidative damage to membranes or macromolecules. Copper can bind to the sulfhydryl groups of several enzymes, such as glucose-6-phosphatase and glutathione reductase, thus interfering with their protection of cells from free radical damage. One of the most commonly reported adverse health effect of copper is gastrointestinal distress [6]. Nausea, vomiting and abdominal pain in humans ingesting beverages contaminated with copper or water containing copper sulfate. Copper is also irritating to the respiratory tract. Coughing, sneezing, runny nose, pulmonary fibrosis, and increased vascularity of the nasal mucosa have been reported in workers exposed to copper dust. The liver is also a sensitive target of toxicity. Liver damage (necrosis, fibrosis, abnormal biomarkers of liver damage) have been reported in individuals ingesting lethal doses of copper sulfate. Liver effects have also been observed in individuals diagnosed with Wilson's disease, Indian childhood cirrhosis, or idiopathic copper toxicosis (which includes tyrollean infantile cirrhosis). These syndromes are genetic disorders that result in an accumulation of copper in the liver; the latter two syndromes are associated with excessive copper exposure [7,8]. There is some evidence from animal studies to suggest that exposure to airborne copper or high levels of copper in drinking water can damage the immune system. Impaired cell-mediated and humoral-mediated immune functions have been observed in mice. Studies in rats, mice, and mink suggest that exposure to high levels of copper in the diet can result in decreased embryo and fetal growth.

Lead is a highly poisonous metal affecting almost every organ in the body. Of all the organs, the nervous system is the mostly affected target in lead toxicity, both in children and adults. The toxicity in children is however of a greater impact than in adults. This is because their tissues, internal as well as external, are softer than in adults. Long-term exposure of adults can result in decreased performance in some tests of cognitive performance that measure functions of the nervous system. Infants and young children are especially sensitive to even low levels of lead, which may contribute to behavioral problems, learning deficits and lowered IQ. After absorption, lead is distributed in the body through Red Blood Cells (RBC). Lead is mostly bound to hemoglobin rather than RBC membrane after entering the cell. The hematopoietic is a sensitive system for critical Lead toxicity and may lead to anemia. Histopathological observations confirmed that Lead ions are transported to the liver, where they can induce chronic damage to the liver [9]. Lead toxicity also increases blood enzyme levels and reduces protein synthesis. Lead imposes toxic effects on kidneys through structural damage and changes in the excretory function. The other organ and tissue systems affected due to lead toxicity are the nervous, cardiovascular, and reproductive systems. Lead toxicity imposes mineralizing of bones and teeth, which is a major body burden. The International Agency for Research on Cancer (IARC) stated that inorganic Lead is probably carcinogenic to humans based on limited evidence in humans and sufficient evidence in animals. Centers for disease control and prevention (USA) have set the standard elevated blood lead level for adults to be 10 μg/dl and for children 5 μg/dl of the whole blood.

The immediate symptoms of acute arsenic poisoning include vomiting, abdominal pain and diarrhea. These are followed by numbness and tingling of the extremities, muscle cramping and death, in extreme cases. Long-term effects: The main adverse effects reported to be associated with long term ingestion of inorganic arsenic in humans are: Skin lesions, cancer, developmental toxicity, neurotoxicity, cardiovascular diseases, abnormal glucose metabolism and diabetes. Inorganic arsenic exposure in utero and in the very young is associated with impaired intellectual development, such as decreased performance on certain developmental tests that measure learning [10]. For this reason, the FDA prioritizes monitoring and regulating products that are more likely to be consumed by very young children. Arsenic is also associated with adverse pregnancy outcomes and infant mortality, with impacts on child health, and exposure in utero and in early childhood has been linked to increases in mortality in young adults due to multiple cancers, lung disease, heart attacks, and kidney failure. Numerous studies have demonstrated negative impacts of arsenic exposure on cognitive development, intelligence, and memory.

CONCLUSION

Prevent copper toxicity by Limiting exposure to copper from contaminated food and drinks, avoiding the use of corroded or rusted copper cookware, dishes, and utensils. Installing filters in the house that removes unwanted minerals from water sources. Lead poisoning causes severe effects and is a matter of serious concern, yet importantly, it is preventable. It is recommended to frequently wash the children´s hands and also to increase their intake of calcium and iron. It is also recommended to discourage children from putting their hands, which can be contaminated, in their mouth habitually, thus increasing the chances of getting poisoned by lead. Vacuuming frequently and eliminating the use and or presence of lead containing objects like blinds and jewellery in the house can also help to prevent exposures. House pipes containing lead or plumbing solder fitted in old houses should be replaced to avoid lead contamination through drinking water. Substitute high-arsenic sources, such as groundwater, with low-arsenic, microbiologically safe sources such as rain water and treated surface water. Low-arsenic water can be used for drinking, cooking and irrigation purposes, whereas high-arsenic water can be used for other purposes such as bathing and washing clothes. Discriminate between high-arsenic and low-arsenic sources. For example, test water for arsenic levels and paint tube wells or hand pumps different colors. This can be an effective and low-cost means to rapidly reduce exposure to arsenic when accompanied by effective education. Blend low-arsenic water with higher-arsenic water to achieve an acceptable arsenic concentration level. Install arsenic removal systems either centralized or domestic and ensure the appropriate disposal of the removed arsenic. Technologies for arsenic removal include oxidation, coagulation-precipitation, absorption, ion exchange, and membrane techniques. There are increasing numbers of effective and low-cost options for removing arsenic from small or household supplies, though there is still limited evidence about the extent to which such systems are used effectively over sustained periods of time.

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