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EFFECTS OF HEAVY METALS ON HUMAN HEALTH

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ABSTRACT

Some heavy metals have bio-importance as trace elements but the biotoxic effects of many of them in human biochemistry are of great concern. Hence, there is a need for proper understanding of mechanism involved, such as the concentrations and oxidation states, which make them harmful. It is also important to know their sources, leaching processes, chemical conversions and their modes of deposition in polluting the environment, which essentially supports life. Literature sources point to the fact that these metals are released into the environment by both natural and anthropogenic means, especially mining and industrial activities, and automobile exhausts. They leach into the underground waters, moving along water pathways and eventually depositing in the aquifer, or are washed away by run-off into surface waters thereby resulting in water and subsequently soil pollution. Poisoning and toxicity in ecosystem occur frequently through exchange and co-ordination mechanisms. When ingested, they form stable biotoxic compounds, thereby mutilating their structures and hindering bioreactions of their functions. This paper reviews certain heavy metals and their impact and biotoxic effects on man.
Keywords:
Human Health, Heavy Metal, Toxicity, Exposure effects.

INTRODUCTION

Metallic elements are intrinsic components of the environment. Their presence is considered unique in the sense that it is difficult to remove them completely from the environment once they enter in it. Metal constitute an important class of toxic substance which are encountered in numerous occupational and environmental circumstances. The impact of these toxic agents on human health is currently an area of intense interest due to the ubiquity of exposure.

With the increasing use of a wide verity of metals in industry and in our daily life, problems arising from toxic metal pollution of the environment have assumed serious dimensions.

SOURCES AND EMISSIONS

Toxic metals, to a large extent, are dispersed in the environment through industrial effluents, organic wastes, refuse burning, and transport and power generation. They can be carried to places many miles away from the sources by wind, depending upon whether they are in gaseous form or as particulates. Metallic pollutants are ultimately washed out of the air into land or the surface of water ways. Thus air is also a route for the pollution of environment.

Metal containing industrial effluents constitute a major source of metallic pollution of hydrosphere. Another means of dispersal is the movement of drainage water from catchment areas which have been contaminated by waste from mining and smelting units. The chief toxic metals in industrial effluents are shown in table-1

Table 1: **Toxic** Metal in Industrial Effluents

Metal	Manufacturing Industries
Arsenic	Phosphate and Fertilizer, Metal Hardening , Paints And Textile
cadmium	Phosphate Fertilizer, Electronics, Pigments And Paints
chromium	Metal Plating , Tanning, Rubber And Photography
copper	Plating, Rayon And Electrical
Lead	Paints, Battery
Nickel	Electroplating , Iron Steel
Zinc	Galvanizing, Plating Iron And Steel
Mercury	Chlor-Alkali, Scientific Instruments , Chemicals

TOXIC EFFECTS

In general the toxicity of metal ions to mammalians systems is due to chemical reactivity of the ions with cellular structural proteins, enzymes and membrane system. The target organs of specific metal toxicities are usually those organs that accumulate the highest concentrations of the metal in vivo. This is often dependent on the route of exposure and the chemical compound of the metal i.e. its valiancy state, volatility, lipid solubility etc.

The target organs and clinical manifestations of chronic exposures to the metal are given in table 2

Besides the general toxicities of metals, we are today also concerned with the potential carcinogenicity of metal compounds. Certain metals such as chromium and nickel have been linked with cancers in exposed human populations.

Metals have been shown to causes acute as well as chronic poisoning in man and other experimental animals. Harmful effects of individual metals are presented briefly below.

Table 2: Clinical Aspects of Chronic Toxicities

Metal	Target Organs	Primary Sources	Clinical effects
Arsenic	Pulmonary Nervous System, Skin	Industrial Dusts, Medicinal Uses Of Polluted Water	Perforation of Nasal Septum, Respiratory Cancer, Peripheral Neuropathy: Dermatomes, Skin, Cancer
Cadmium	Renal, Skeletal Pulmonary	Industrial Dust And Fumes And Polluted Water And Food	Proteinuria, Glucosuria, Osteomalacia, Aminoaciduria, Emphysemia
Chromium	Pulmonary	Industrial Dust And Fumes And Polluted Food	Ulcer, Perforation of Nasal Septum, Respiratory Cancer
Manganese	Nervous System	Industrial Dust And Fumes	Central And Peripheral Neuropathies

Lead	Nervous System, Hematopoietic System, Renal	Industrial Dust And Fumes And Polluted Food	Encephalopathy, Peripheral Neuropathy, Central Nervous Disorders, Anemia.
Nickel	Pulmonary, Skin	Industrial Dust, Aerosols	Cancer, Dramatis
Tin	Nervous , Pulmonary System	Medicinal Uses, Industrial Dusts	Central Nervous System Disorders, Visual Defects And EEG Changes, Pneumoconiosis.
Mercury	Nervous System, Renal	Industrial Dust And Fumes And Polluted Water And Food	Proteinuria

1 Arsenic:

Soluble inorganic arsenic can have immediate toxic effects. Ingestion of large amounts can lead to gastrointestinal symptoms such as severe vomiting, disturbances of the blood and circulation, damage to the nervous system, and eventually death. When not deadly, such large doses may reduce blood cell production, break up red blood cells in the circulation, enlarge the liver, color the skin, produce tingling and loss of sensation in the limbs, and cause brain damage.

Long-term exposure to inorganic arsenic in drinking water in Taiwan has caused black foot disease, in which the blood vessels in the lower limbs are severely damaged, resulting eventually in progressive gangrene. The relationship between arsenic exposure and other health effects is less clear. The evidence is strongest for high blood pressure, heart attacks and other circulatory disease. The evidence is weaker for diabetes and reproductive effects; it is weakest for strokes, long-term neurological effects, and cancer at sites other than lung, bladder, kidney and skin. as well as other skin changes such as hyperkeratosis and pigmentation changes. These effects have been demonstrated in many studies using different study designs. Exposure–response relationships and high risks have been observed for each of these end-points. The effects have been most thoroughly studied in Taiwan but there is considerable evidence from studies on populations in other countries as well. Increased risks of lung and bladder cancer and of arsenic-associated skin lesions have been reported to be associated with ingestion of drinking-water at concentrations £ 50µg arsenic/litre.

Occupational exposure to arsenic, primarily by inhalation, is causally associated with lung cancer. Exposure–response relationships and high risks have been observed. Increased risks have been observed at cumulative exposure levels ≥ 0.75 (mg/m^3) × year (e.g. 15 years of exposure to a workroom air concentration of 50 $\mu g/m^3$).

Effects on human health Lead is a toxic heavy metal even at very low levels of exposure in humans. Its effect on the human body can be both acute and chronic depending on dose and exposure scenarios. Lead targets multiple organs in the body due to its systemic toxicity which can cause neurological, cardiovascular, renal, gastro-intestinal, haematological and reproductive effects. Human exposure to lead is usually tested through blood sampling. The lead stored in the bones can emerge as a remobilised form of lead exposure late in the life of the individual. Exposure occurs primarily through inhalation of dust particles, air contaminated with lead and ingestion of foodstuffs, water and dust. Inhalation is an important exposure pathway for people in the vicinity of point sources such as lead contaminated sites, countries where leaded fuel is still used and areas where waste from products containing lead is burnt as well as secondary lead recovery operations. Apart from ingestion of lead on foodstuffs and in drinking water a major exposure source is leaded

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paint. Dust in homes containing leaded paint can be inhaled by adults and children and ingested by children through pica behaviour.

2 Cadmium:

Effects on human health Humans are exposed to cadmium by inhalation and ingestion although the main health impacts recorded in the literature are through dietary exposure (kidney and bone damage) and inhalation from smoking tobacco and occupational exposure (lung damage). Dietary intake accounts for 90% of all exposure in non-smokers. Cadmium in the environment is toxic to plants and animals and many micro-organisms. Cadmium does not degrade in the environment to less toxic products which contributes to its bioaccumulation in the kidneys and liver of vertebrates and invertebrates. Cadmium enters the environment from a variety of anthropogenic sources. Wastewater is key source of environmental cadmium contamination and diffuse pollution occurs through industrial air emissions and widespread use of fertilizers on agricultural soils. Plants (including rice and tobacco) that are grown in contaminated soils take up cadmium and lead to human dietary (and inhalation) exposures. However, human exposure also occurs when cadmium contaminated soils are disturbed and the dust is inhaled. Diets high in meat (especially liver and kidneys) or products from marine mammals may result in a particularly high intake of cadmium.72 Cadmium is not considered essential for biological function in humans. The main human organ impacted by cadmium exposure is the kidney in both the general population and the occupationally exposed. Tobacco smokers are considered to be at particular risk as are people with low iron levels. A secondary critical effect is skeletal damage as a secondary response to kidney damage or direct action on the bone cells by the cadmium.

3 Mercury:

Main effects of Mercury on Human Health and the environment effects on human health Toxicity of mercury is dependent on whether it takes the form of elemental mercury, inorganic mercury or organic mercury compounds (particularly alkylmercury compounds such as methylmercury and ethylmethyl salts and dimethylmercury). Accordingly, the exposure scenario varies considerably for these different forms of mercury and complicates toxicity assessment. In terms of methylmercury, dietary ingestion is the major source of human exposure, especially for seafood and fish. Around 80% of inhaled elementary mercury vapour is retained in the tissue of the lungs where it goes on to penetrate the blood-brain barrier where neurological effects take place. Ingestion of elementary mercury does not always lead to high levels of absorption but deaths have been reported. Inhalation of elementary mercury vapour has been observed to lead to symptoms including tremors, emotional lability, insomnia, memory loss, neuromuscular changes, and headaches as well effects on the kidney and thyroid. High exposures have led to death but the critical effects are neurotoxic and renal.94 The main route of exposure to inorganic mercury for humans is dietary although for some sub-sections of the population products such as skin-lightening creams, soaps and the use in traditional medicine and/ritualistic practices can result in significant exposures to both inorganic an elemental mercury.Methylmercury is a well known potent neurotoxin which causes adverse impacts on the developing human brain. It passes readily through the placental barrier and the blood-brain barrier making any exposure during pregnancy of great concern. Methylmercury is considered possibly carcinogenic by the International Agency for Research on Cancer.

4 Copper:

Copper is a naturally-occurring metallic element that occurs in soil at an average concentration of about 50 parts per million (ppm). It is present in all animals and plants and is an essential nutrient for humans and animals in small amounts. The major sources of environmental copper releases include the mining, smelting and refining of copper, industries producing products from copper such as wire, pipes and sheet metal, and fossil fuel combustion. Water pipes are often made of copper and bath fixtures may be made from brass and bronze alloys that contain copper. The principal source of copper in drinking water results from the leaching of copper from pipes and bath fixtures due to acidic water. Blue-green stains left in bath fixtures are a sign of the presence of copper in water. Other releases of copper to the environment include agricultural use against plant diseases and treatments applied to water bodies to eliminate algae. Health Effects Absorption/Metabolism Studies investigating oral absorption of copper have found the percentage absorbed ranging from 24-60 percent. Factors affecting the amount absorbed include the amount of copper in the diet and competition with other metals found in food such as iron and zinc. There are no studies examining inhalation exposure to copper. The amount of dermal absorption is also not known, but a few studies indicate that it is very low. Beneficial Effects Copper is a component of several enzymes necessary for normal metabolic functions in humans. The Recommended Daily Allowance (RDA) of copper for adults is 0.9 milligrams (mg). The median intake of copper from the typical U.S. diet ranges from 1 to 1.6 mg/day. The safe highest level of intake for an extended period of time (chronic exposure) is 10 mg/day. Food sources rich in copper include shellfish, organ meats, nuts, beans and cocoa. Effects of copper deficiency can include anemia, low numbers of white blood cells, osteoporosis in infants and children, and defects in connective tissue leading to skeletal problems. Short-Term (Acute) Effects Acute poisoning from ingestion of excessive copper can cause temporary gastrointestinal distress with symptoms such as nausea, vomiting, and abdominal pain. Liver toxicity was seen in doses high enough that resulted in death. High levels of exposure to copper can cause destruction of red blood cells, possibly resulting in anemia. Long Term (Chronic) Effects Mammals have efficient mechanisms to regulate copper stores in the body such that they are generally protected from excess dietary copper levels. However, at high enough levels, chronic overexposure to copper can damage the liver and kidneys. Wilson's disease is an inherited (genetic) disorder in which copper builds up in the liver. Symptoms of liver toxicity (jaundice, swelling, pain) usually do not appear until adolescence. Carcinogenicity (ability to cause cancer) although some studies of workers exposed to copper have shown increased cancer risks, they were also exposed in the workplace to other chemicals with carcinogenic potential. Increased cancer risk has not been found in animal studies. Copper is currently categorized by the EPA as a Group D carcinogen (inadequate evidence to classify) and has not yet been reviewed for placement into one of the new cancer classification categories. Reproductive/Developmental Effects There are no reports of developmental effects occurring in humans exposed to elevated levels of copper. Developmental effects have been observed in a few studies of animals given high doses of copper, including delayed growth and development, delayed bone formation, and decreased litter size and body weights.

5 Nickel:

Nickel is a compound that occurs in the environment only at very low levels. Humans use nickel for many different applications. The most common application of nickel is the use as an ingredient of steal and other metal products. It can be found in common metal products such as jewelry. Foodstuffs naturally contain small amounts of nickel. Chocolate and fats are known to contain severely high quantities. Nickel uptake will boost when people eat large quantities of vegetables from polluted soils. Plants are known to accumulate nickel and as a result the nickel uptake from vegetables will be eminent. Smokers have a higher nickel uptake through their lungs. Finally, nickel can be found in detergents. Humans may be exposed to nickel by breathing air, drinking water, eating food or smoking cigarettes. Skin contact with nickel-contaminated soil or water may also result in nickel exposure. In small quantities nickel is essential, but when the uptake is too high it can be a danger to human health. An uptake of too large quantities of nickel has the following consequences: Higher chances of development of lung cancer, nose cancer, larynx cancer and prostate cancer Sickness and dizziness after exposure to nickel gas Respiratory failure, Lung embolism, Birth defects, Asthma and chronic bronchitis, Allergic reactions such as skin rashes, mainly from jewelry, Heart disorders. Nickel fumes are respiratory irritants and may cause pneumonitis. Exposure to nickel and its compounds may result in the development of a dermatitis known as "nickel itch" in sensitized individuals. The first symptom is usually itching, which occurs up to 7 days before skin eruption occurs. The primary skin eruption is erythematous, or follicular, which may be followed by skin ulceration. Nickel sensitivity, once acquired, appears to persist indefinitely.

6 Tin:
Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons who have been harmed. One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal care guidelines because laws today protect the welfare of research animals. Because inorganic tin compounds usually enter and leave your body rapidly after you breathe or eat them, they do not usually cause harmful effects. However, humans who swallowed large amounts of inorganic tin in research studies suffered stomachaches, anemia, and liver and kidney problems. Studies with inorganic tin in animals have shown similar effects to those observed in humans. There is no evidence that inorganic tin compounds affect reproductive functions, produce birth defects, or cause genetic changes. Inorganic tin compounds are not known to cause cancer. Inhalation (breathing in), oral (eating or drinking), or dermal exposure (skin contact) to some organotin compounds has been shown to cause harmful effects in humans, but the main effect will depend on the particular organotin compound. There have been reports of skin and eye irritation, respiratory irritation, gastrointestinal effects, and neurological problems in humans exposed for a short period of time to high amounts of certain organotin compounds. Some neurological problems have persisted for years after the poisoning occurred. Lethal cases have been reported following ingestion of very high amounts.

7 lead:
Most of the studies looking for a possible link between lead exposure and cancer have focused on workers with high levels of occupational (work-related) exposure to inorganic lead. People with heavy workplace exposures to lead have been found to have blood lead concentrations many times higher than the average blood lead concentration in the general population. Several studies have looked for a link between exposure to lead in the workplace (mainly among battery workers and

smelter workers) and lung cancer. Some of these studies have found a small increase in lung cancer risk. However, most of these studies were limited in that they didn't take into account other factors that might affect lung cancer risk, such as smoking or exposures to arsenic or other heavy metals that typically also occur along with lead exposures in industrial settings. Some studies looking at blood lead levels in the general population have also found a small increased risk of lung cancer in people with higher lead levels. Several of these same workplace studies also looked at stomach cancer risk. Most of the studies found an increased risk of stomach cancer with higher lead exposure. Although it is unlikely these results would be affected by smoking or arsenic exposure, the studies didn't take into account other factors that could also have affected stomach cancer risk. Studies have also looked at possible links between workplace exposures to lead and other cancers, including cancers of the brain, kidney, bladder, colon, and rectum. The results of these studies have been mixed. Some studies have found links, while others have not. The link between lead exposure and cancer is clearly a concern, and more research is needed to better define the possible link between lead exposure and a number of cancers.

Concluding Remarks:

Conclusively, based on experimental studies, the advances of toxicology has improved our knowledge about human exposure to toxic elements (metals and metalloids) and their health effects, such as developmental retardation, several types of cancer, kidney damage, endocrine disruption, immunological, neurological effects and other disorders. The ongoing research works throw more light onto new insights and biochemical and molecular mechanisms involved in the development of pathological conditions in human.

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