IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, September 2024

The Role of Heavy Metals in the Development of Chronic Health Conditions

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Abstract*: While many heavy metals have biotoxic effects on human biochemistry, other heavy metals are nonetheless important as trace components. Therefore, it's important to comprehend the mechanisms such as concentrations and oxidation states that lead to their deleterious effects. In addition, because the environment fundamentally sustains life, it is critical to understand their origins, leaching procedures, chemical transformations, and patterns of deposition. According to literature sources, these metals are released into the environment by both natural and man-made processes, including industrial and mining operations as well as vehicle emissions. They either wash away via run-off into surface waters, resulting in water and subsequently soil contamination, or they leach into the subterranean fluids, traveling along water routes and finally depositing in the aquifer. Exchange and coordination processes are often the cause of poisoning and toxicity in ecosystems. They damage their structures and impede the bioreactions that carry out their activities when consumed, forming stable biotoxic chemicals. This essay examines a few heavy metals, their effects, and how biotoxic they are to humans*

Keywords: Human Health, Heavy Metal, Toxicity, Exposure effects

I. INTRODUCTION

Environmental elements with a metallic component are inherent. Because it is impossible to fully eradicate them from the environment once they penetrate it, their existence is seen to be unique. Metals are a significant class of hazardous substances that are present in many environmental and occupational settings. Because of the frequent exposure, there is presently a great deal of interest in the effects of these hazardous chemicals on human health.
As more and more metals are used in industry and everyday life, the issues caused by environmental contamination from dangerous metals have grown significantly.

Sources and Emissions

Organic wastes, transportation, electricity production, burning of garbage, and industrial effluents all contribute significantly to the environmental dispersion of toxic metals. Depending on whether they are in gaseous form or as particles, they may be transported by wind several kilometers from the origins. In the end, metallic contaminants are carried by wind and land or the surface of waterways. As a result, air pollution contributes to environmental contamination.
Industrial effluents containing metals are a primary cause of metallic contamination in the hydrosphere. The flow of drainage water from catchment regions polluted by waste from mining and smelting facilities is another method of dispersion. Table 1 lists the most hazardous metals found in industrial effluents.

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

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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

The chemical reactivity of metal ions with membrane systems, enzymes, and structural proteins of cells is generally the cause of their toxicity to mammalian systems. The organs that acquire the greatest quantities of the metal in vivo are often the target organs of a given metal toxicity. This often depends on the metal's chemical makeup, including its volatility, lipid solubility, and valiancy state, as well as the exposure route.

Table 2 lists the target organs and clinical signs of long-term exposure to the metal.

These days, we are also worried about the possible carcinogenicity of metal complexes in addition to the typical toxicities of metals. Cancers have been linked to exposure to certain metals, including nickel and chromium, in human populations.

It has been shown that metals may harm humans and other test animals both acutely and chronically. The negative impacts of each specific metal are briefly listed here.

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 PollutedFood	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 PollutedFood	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 DefectsAnd EEG Changes, Pneumoconiosis.
Mercury	Nervous System, Renal	Industrial Dust And Fumes And Polluted Water And Food	Proteinuria

Arsenic:

Arsenic that is soluble in inorganic matter might be hazardous right away. Large doses may have adverse effects on the digestive system, including violent vomiting, blood and circulation problems, nervous system damage, and finally death. Such high dosages have the potential to cause brain damage, increase the liver, break up red blood cells in the circulation, diminish blood cell formation, color the skin, induce tingling and loss of feeling in the limbs, and enlarge the liver when not fatal.

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Taiwanese drinking water contaminated with inorganic arsenic for an extended period of time has resulted in black foot disease, a condition that severely damages lower limb blood vessels and finally leads to progressive gangrene. It is less evident how exposure to arsenic affects other aspects of health. The strongest evidence is seen in relation to circulatory diseases such as heart attacks and high blood pressure. The evidence is weakest for strokes, long-term neurological damage, and cancer at locations other than the lung, bladder, kidney, and skin; it is strongest for diabetes and its consequences on reproduction. in addition to further skin alterations such hyperkeratosis and pigmentation abnormalities. Several research using a variety of study approaches have shown these effects. For each of these endpoints, exposure-response correlations and elevated risks have been noted. Although Taiwan has conducted the most in-depth research on the consequences, studies on people in other nations have also produced a significant amount of data. Drinking water with 50µg of arsenic per liter has been linked to an increased risk of bladder and lung cancer as well as skin diseases related to arsenic exposure. Lung cancer is causally linked to occupational arsenic exposure, mostly by inhalation. High hazards and exposure-response linkages have been noted. At cumulative exposure levels > 0.75× year increased hazards have been noted.

consequences on human health Even at very low levels of exposure in humans, lead is a hazardous heavy metal. Depending on the dosage and exposure circumstances, it may have either an acute or chronic impact on the human body. Because of its systemic toxicity, lead affects many organs in the body, including the nervous system, the cardiovascular system, the kidneys, the gastrointestinal tract, the haematological system, and the reproductive system. Usually, blood sample is used to screen for lead exposure in humans. Late in a person's life, the lead that has been stored in their bones may resurface as a result of lead exposure. The main ways that exposure happens are via breathing in dust particles, breathing in lead-contaminated air, and consuming dust, food, and drink. For those living close to point sources of exposure, such as sites polluted with lead, nations where leaded gasoline is still in use, locations where lead-containing product waste is burned, and secondary lead recovery activities, inhalation is a significant mode of exposure. One of the main sources of exposure to lead, other from ingesting it via food and water, is lead paint. Both adults and children may inhale dust from houses with leaded paint, and youngsters may consume it via pica behavior.

Cadmium:

consequences on human health Cadmium exposure occurs in both inhalation and ingestion for humans; however, the majority of documented health effects in the literature are attributable to food exposure inhalation via tobacco smoke, and occupational exposure. In non-smokers, dietary consumption explains 90% of all exposure. Many microorganisms, as well as plants and animals, are harmful to cadmium in the environment. Because cadmium does not break down in the environment into less harmful compounds, it builds up in the kidneys and liver of both vertebrates and invertebrates. There are several anthropogenic sources of cadmium that leak into the environment. The main source of cadmium pollution in the environment is wastewater, and diffuse pollution is caused by fertilizer usage on agricultural soils and emissions from industry. When plants are cultivated in polluted soils, they absorb cadmium, which exposes people to it via their food and respiration. However, when cadmium-contaminated soils are disturbed and the dust is breathed, human exposure also occurs. Consumptions of meat, particularly liver and kidneys, as well as marine animal products, may lead to an unusually high cadmium consumption.72 It is not thought that cadmium is necessary for human biological activity. The kidney is the primary human organ affected by cadmium exposure in both the general population and those who are exposed at work. Individuals who smoke tobacco and those with low iron levels are thought to be more vulnerable. Skeletal damage resulting from either direct cadmium impact on bone cells or renal damage is a secondary critical consequence.

Mercury:

Primary Health Effects of Mercury and Environmental Effects on Human Health The kind of mercury that causes toxicity is determined by whether it is elemental, inorganic, or organic. As a result, the exposure scenario differs greatly for these many mercury compounds, which makes toxicity evaluation more difficult. The main way that humans are exposed to methylmercury is via their diet, particularly when it comes to seafood and fish. The lungs retain around 80% of the elemental mercury vapor that is breathed, and this vapour then passes across the blood-brain barrier to have neurological consequences. Although fatalities have been observed, large levels of absorption are not necessarily the

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result of ingesting elemental mercury. Elementary mercury vapour inhalation has been linked to a number of symptoms, including headaches, tremors, emotional instability, sleeplessness, memory loss, and abnormalities in the neuromuscular system and thyroid and renal functions. High doses have been fatal, however neurotoxic and renal damage are the main side effects.94 Humans are primarily exposed to inorganic mercury through their diets, but some groups of people may be significantly exposed to both inorganic and elemental mercury through the use of products like skin-lightening creams, soaps, and traditional medicine and/or ritualistic practices.One well-known strong neurotoxic that has a deleterious effect on the growing human brain is methylmercury. It easily crosses both the blood-brain and placental barriers, thus any exposure during pregnancy should be taken very seriously. The International Agency for Research on Cancer believes that methylmercury may cause cancer.

Copper:

The typical concentration of copper, a naturally occurring metallic element, in soil is around 50 parts per million. In trace levels, it is a necessary nutrient for both humans and animals and may be found in all creatures and plants. The primary causes of copper emissions into the environment are the mining, smelting, and refining processes; companies that use copper to make wire, pipes, and sheet metal; and the burning of fossil fuels. Copper is a common material for water pipes, and copper-containing brass and bronze alloys may be used to make bathroom fixtures. The main cause of copper in drinking water is the acidic water that causes copper to leach out of pipes and bathroom fixtures. Bath fixtures that have blue-green stains on them indicate that there is copper in the water. Copper is also released into the environment when it is used in agriculture to combat plant diseases and when it is treated to get rid of algae in water bodies. Health Effects: Absorption/Metabolism Research on the oral absorption of copper has shown that between 24 and 60 percent of it is absorbed. The quantity of copper in the diet and its competition with other metals like iron and zinc that are present in food may have an impact on how much is absorbed. Studies on copper exposure by inhalation are nonexistent. Although the quantity of cutaneous absorption is unknown, some research suggests that it is rather low. Positive Effects: Copper is an essential part of several enzymes that humans need for regular metabolic processes. For people, 0.9 milligrams of copper is the Recommended Daily Allowance. The normal American diet contains between one and sixteen milligrams of copper per day on average. Ten milligrams per day is the acceptable maximum dosage for a prolonged length of time. Nuts, beans, chocolate, shellfish, and organ meats are among the foods high in copper. Anemia, low white blood cell counts, osteoporosis in youngsters, and connective tissue deficiencies resulting in skeletal issues are some of the effects of copper deficiency. Short-Term Effects: Consuming too much copper may result in acute poisoning, which can temporarily upset the digestive system and produce symptoms including nausea, vomiting, and stomach discomfort. It was shown that liver poisoning occurred at levels high enough to cause mortality. Anemia may develop as a consequence of red blood cell damage brought on by high copper exposure levels. Long-Term Effects: Because mammals have effective systems in place to control the amount of copper stored in their bodies, they are often shielded from high amounts of copper in their diet. Nonetheless, prolonged overexposure to copper at high enough levels may harm the kidneys and liver. Wilson's illness is a hereditary ailment characterized by an accumulation of copper in the liver. Liver poisoning symptoms, including as discomfort, edema, and jaundice, often don't show up until puberty. Carcinogenicity: Although studies on workers exposed to copper have shown an elevated risk of cancer, these individuals were also exposed to other substances that have the potential to cause cancer at work. Research on animals has not shown an increased risk of cancer. At now, copper is classified by the EPA as a Group D carcinogen, meaning that there is not enough data to make a classification. It has not been evaluated for possible categorization into any of the new cancer classification groups. Effects on Reproduction and Development There are no records of developmental consequences in individuals exposed to high copper levels. A few studies with animals given large doses of copper have shown developmental consequences, including as delayed bone formation, lower litter sizes and body weights, and delayed growth and development.

Nickel:

Only very low concentrations of the chemical nickel are found in the environment. Nickel is used by humans in a wide range of applications. Nickel is most often used as a component in steal and other metal products. It is present in everyday metal goods like jewelry. Foods inherently have trace levels of nickel. It is well known that chocolate and fats

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have very high concentrations. People who consume significant amounts of vegetables grown on dirty soils will absorb more nickel. Given that plants are known to acquire nickel, veggies will have a high nickel absorption. Smokers' lungs absorb more nickel than nonsmokers do. And lastly, detergents include nickel. Nickel exposure in humans may occur by eating, drinking, smoking, or breathing in air. Exposure to nickel may also occur via skin contact with soil or water polluted with nickel. While nickel is necessary in modest amounts, excessive absorption may be harmful to human health. When too much nickel is absorbed, the following outcomes occur: Increased risk of developing cancers of the nose, throat, lung, and prostate feeling ill and lightheaded after being around nickel gas respiratory malfunction, pulmonary embolism, birth abnormalities, Chronic bronchitis and asthma, skin rashes and other allergic reactions, often from jewelry, cardiac conditions. Nickel fumes may induce pneumonitis and are irritating to the respiratory system. Sensitized people may develop a dermatitis called "nickel itch" as a consequence of exposure to nickel and its derivatives. Itching is often the first symptom and may happen up to 7 days prior to skin eruption. Skin ulceration may develop after the first erythematous, or follicular, skin eruption. Once developed, nickel sensitivity seems to last forever.

Tin:

To safeguard the public from the negative effects of hazardous substances and to provide treatments for those who have been damaged, scientists conduct a variety of studies. Analyzing how a chemical enters, is used by, and is released by the body may help identify whether or not it will be harmful to humans. Testing on animals may be required for some compounds. Additionally, identifying health impacts like cancer or birth problems may be aided by animal studies. Without using laboratory animals, scientists would be without a fundamental means of gathering data necessary to make informed judgments that safeguard the public's health. It is the duty of scientists to handle study animals with kindness and care. Today's rules safeguard the wellbeing of research animals, therefore scientists have a need to adhere to tight requirements for animal care. Inorganic tin compounds often don't have any negative consequences since they normally enter and exit your body quickly after ingestion or breathing. However, in study tests, those who ingested excessive doses of inorganic tin had difficulties with their liver, kidneys, and stomachaches. Research conducted on animals using inorganic tin has shown results similar to those seen in humans. There is no proof that inorganic tin compounds alter genetic makeup, induce birth abnormalities, or have an impact on reproductive processes. It is unknown whether inorganic tin compounds may cause cancer. Human exposure to some organotin compounds by inhalation, oral ingestion or dermal contact has been shown to have negative consequences; however, the primary impact will vary depending on the specific organotin compound. Short-term human exposure to high concentrations of certain organotin compounds has been linked to complaints of neurological issues, gastrointestinal distress, respiratory irritation, and irritation of the skin and eyes. Long years after the incident, certain neurological issues remained. Reports of fatal occurrences have been made when very large dosages were consumed.

lead:

The majority of research investigating a potential connection between cancer and lead exposure has focused on employees who have been exposed to high amounts of inorganic lead at work. Blood lead concentrations in individuals with considerable occupational exposure to lead have been reported to be significantly higher than typical blood lead concentrations in the general population. Numerous research have investigated the potential association between lead exposure at work and lung cancer. A slight increase in lung cancer risk has been seen in many of these investigations. The majority of these studies, however, had limitations because they failed to include other variables that might possibly influence the risk of lung cancer, such as smoking or exposure to other heavy metals, such as arsenic, which is often present in conjunction with lead exposure in industrial settings. Higher blood lead levels have also been linked to a little increased risk of lung cancer, according to many studies examining lead levels in the general population. The risk of stomach cancer was examined in many of these similar occupational investigations. Higher lead exposure was linked to an increased risk of stomach cancer, according to the majority of studies. The studies did not account for other variables that may have potentially increased stomach cancer risk, even though it is doubtful that smoking or exposure to arsenic would have an impact on these findings. Research has also examined potential associations between lead exposure at work and malignancies of the brain, kidney, bladder, colon, and rectum. These investigations have

DOI: 10.48175/568

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produced a range of outcomes. While some studies have not discovered any correlations, others have. It is evident that there is a worry about the relationship between lead exposure and cancer, and more study is required to clarify the potential connection between lead exposure and various malignancies.

II. CONCLUSION

In conclusion, based on experimental research, the field of toxicology has advanced our understanding of the health effects of exposure to toxic elements (metals and metalloids) on humans, including immunological, neurological, kidney damage, endocrine disruption, developmental retardation, and various cancers. The continuing studies provide further light on novel discoveries as well as the biochemical and molecular processes that underlie the emergence of disease disorders in humans.

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