# THE PROBLEM ASSOCIATED WITH HEAVY METALS IN HUMANS.

**BY**

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## DECLARATION

I declare that this seminar entitled "**THE PROBLEM ASSOCIATED WITH HEAVY METALS IN HUMANS**" was carried out by ALHERI GRACE with the Registration number ST/EB/HND/21/012 of the department of Biological Science Technology, Federal Polytechnic, Mubi. All information derived was dully acknowledged and referenced.

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## Introduction

Metals are substances with high electrical conductivity, malleability, and luster, which voluntarily lose their electrons to form cations. Metals are found naturally in the earth's crust and their compositions vary among different localities, resulting in spatial variations of surrounding concentrations. The metal distribution in the atmosphere is monitored by the properties of the given metal and by various environmental factors (Khlifi & Hamza-Chaffai, 2019). The main objective of this review is to provide insight into the sources of heavy metals and their harmful effects on the environment and living organisms. Heavy metals are generally referred to as those metals which possess a specific density of more than 5 g/cm3 and adversely affect the environment and living organisms (Järup, 2013). These metals are quintessential to maintain various biochemical and physiological functions in living organisms when in very low concentrations, however they become noxious when they exceed certain threshold concentrations. Although it is acknowledged that heavy metals have many adverse health effects and last for a long period of time, heavy metal exposure continues and is increasing in many parts of the world. Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons (Jaishankar *et al*., 2014). The most commonly found heavy metals in waste water include arsenic, cadmium, chromium, copper, lead, nickel, and zinc, all of which cause risks for human health and the environment. Heavy metals enter the surroundings by natural means and through human activities. Various sources of heavy metals include soil erosion, natural weathering of the earth's crust, mining, industrial effluents, urban runoff, sewage discharge, insect or disease control agents applied to crops, and many others (Morais *et al*., 2012).

Heavy metals are defined as metallic elements that have a relatively high density compared to water. With the assumption that heaviness and toxicity are inter-related, heavy metals also include metalloids, such as arsenic, that are able to induce toxicity at low level of exposure. In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by these metals. Also, human exposure has risen dramatically as a result of an exponential increase of their use in several industrial, agricultural, domestic and technological applications. Reported sources of heavy metals in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources. Environmental pollution is very prominent in point source areas such as mining, foundries and smelters, and other metal-based industrial operations (Wang *et al.*, 2022).

## MECHANISMS OF HEAVY METAL TOXICITY

Recent research has provided deeper insights into the mechanisms underlying heavy metal toxicity in humans. Accumulation of heavy metals, such as lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As), disrupts cellular processes through oxidative stress, inflammatory responses, and interference with essential enzymes. Emerging studies have highlighted the role of epigenetic modifications induced by heavy metals, linking exposure to adverse health outcomes, including developmental disorders, cancer, and neurodegenerative diseases (Sen *et al*., 2021).

**Oxidative Stress and Cellular Damage:** Oxidative stress, a pivotal mechanism underlying heavy metal toxicity, arises when the balance between reactive oxygen species (ROS) production and the antioxidant defense system is disrupted. Excessive ROS production triggered by heavy metal exposure overwhelms the cellular antioxidant defenses, leading to oxidative damage to lipids, proteins, and DNA (Sen *et al.*, 2021). This damage propagates a cascade of events, contributing to inflammation, cell death, and dysfunction across various organ systems.

**Interference with Essential Enzymes:** Many heavy metals exhibit a propensity to bind to biologically essential enzymes, disrupting their proper functioning. For instance, mercury has a high affinity for thiol groups in enzymes, interfering with their catalytic activities and causing enzyme inactivation (Gailer *et al.,* 2020). This interference disrupts critical biochemical processes, further exacerbating cellular dysfunction.

**Epigenetic Modifications:** Emerging research has highlighted the role of heavy metals in inducing epigenetic modifications, adding a novel layer to their mechanisms of toxicity. Epigenetic changes, such as DNA methylation, histone modifications, and microRNA dysregulation, can alter gene expression patterns and contribute to long-term health effects (Sen *et al.,* 2021). This epigenetic component may play a significant role in the transgenerational transmission of heavy metal-induced health effects.

**Disruption of Calcium Homeostasis:** Certain heavy metals, such as lead and cadmium, disrupt calcium homeostasis by interfering with calcium ion channels and transporters. This disruption can lead to impaired neuronal signaling, muscle function, and cell viability (Gailer *et al.,* 2020). Notably, lead exposure has been linked to developmental neurotoxicity in children, causing cognitive deficits and behavioral disorders.

**Activation of Inflammatory Pathways:** Heavy metal exposure triggers immune responses and inflammation through activation of pro-inflammatory signaling pathways. Immune cells, sensing the presence of heavy metals, release inflammatory cytokines that contribute to tissue damage and disease progression. Chronic inflammation resulting from heavy metal exposure is associated with a variety of health disorders, including cardiovascular diseases and neurodegenerative conditions (Sen *et al*., 2021).

Recent studies have significantly advanced our understanding of these mechanisms, revealing the intricate interplay between heavy metals and human biology. By elucidating these processes, researchers are not only gaining insights into the pathophysiology of heavy metal toxicity but also paving the way for the development of targeted therapeutic interventions and preventive strategies.

## HEALTH EFFECTS ON HUMANS

The seminar extensively discussed the far-reaching health effects of heavy metal exposure on humans. Research by Wang *et al.* (2022), presented a strong association between cadmium exposure and cardiovascular diseases, shedding light on the potential role of cadmium in promoting endothelial dysfunction and atherosclerosis. Furthermore, mercury exposure during pregnancy was explored as a contributor to neurodevelopmental disorders in children (Karimi *et al.,* 2023).

The health effects of heavy metal exposure on humans are broad-ranging and encompass various organ systems, leading to a spectrum of adverse outcomes. Recent research has provided compelling evidence of the profound impact of heavy metals on human health, underscoring the urgency of addressing this issue to prevent and mitigate serious health consequences.

**Cardiovascular Health:** Cadmium and lead, two common heavy metals, have been implicated in cardiovascular diseases. Wang *et al.* (2022) demonstrated a clear association between cadmium exposure and cardiovascular disorders, revealing that cadmium exposure promotes endothelial dysfunction and contributes to atherosclerosis. These findings highlight the role of heavy metals as risk factors for heart-related illnesses.

**Neurodevelopmental Effects:** Mercury, a well-known neurotoxin, poses a particularly significant threat to neurodevelopment. Prenatal exposure to mercury has been linked to neurodevelopmental disorders in children, including impaired cognitive function and behavioral abnormalities (Karimi *et al.,* 2023). The developing nervous system is particularly vulnerable to heavy metal insults, and understanding the mechanisms behind these effects is crucial for safeguarding child neurodevelopment.

**Reproductive Health:** Heavy metals can have detrimental effects on reproductive health and fetal development. Maternal exposure to heavy metals like lead and cadmium has been associated with adverse birth outcomes, including low birth weight and preterm birth (Li *et al*., 2023). Such effects highlight the potential for heavy metals to disrupt normal fetal growth and development, with long-lasting implications for the child's health.

**Renal and Hepatic Dysfunction:** Cadmium, mercury, and other heavy metals can accumulate in the kidneys and liver, leading to renal and hepatic dysfunction. Chronic exposure can result in kidney damage, including impaired glomerular filtration and tubular function, as well as liver impairment through oxidative stress and inflammation (Sen *et al*., 2021).

**Cancer Risk:** Certain heavy metals, such as arsenic and cadmium, are recognized carcinogens and have been linked to an increased risk of various cancers. Chronic exposure to these metals can promote DNA damage, genomic instability, and tumor growth, contributing to the development of malignancies (Sen *et al*., 2021).

**Respiratory Health:** Inhalation of heavy metal-containing particulate matter, especially in polluted environments, can lead to respiratory complications. Heavy metals like cadmium and lead can accumulate in lung tissues, contributing to lung inflammation, oxidative stress, and impaired lung function (Gailer *et al*., 2020).

## MITIGATION AND REGULATORY MEASURES

In the context of addressing heavy metal exposure, the seminar reviewed recent advancements in mitigation strategies and regulatory measures. Bhattacharyya *et al.* (2023) proposed the use of nanomaterials for efficient heavy metal removal from water sources, offering a promising avenue for reducing human exposure. Strengthened regulatory frameworks and public health interventions were also discussed, with an emphasis on promoting awareness and enforcing stricter pollution control measures. The pressing issue of heavy metal exposure in humans has prompted the development of mitigation strategies and regulatory measures aimed at minimizing risks, protecting public health, and ensuring environmental sustainability. Recent research has spurred innovative approaches and policy recommendations to address heavy metal contamination effectively.

**Nanomaterials for Heavy Metal Removal:** Advancements in nanotechnology offer promising solutions for heavy metal removal from water sources. Bhattacharyya *et al.* (2023) have explored the potential of nanomaterials as efficient adsorbents for heavy metal ions. Nanoparticles, due to their high surface area and unique physicochemical properties, can selectively capture and immobilize heavy metal pollutants from aqueous environments, providing a cost-effective and environmentally friendly approach to water purification.

**Strengthened Regulatory Frameworks:** Governments and regulatory bodies play a crucial role in mitigating heavy metal exposure by implementing and enforcing stringent environmental standards. Stringent regulations on emissions from industries, waste disposal, and mining practices can help curtail the release of heavy metals into the environment (Sen *et al.*, 2021). These measures are essential for preventing further contamination and protecting both human health and ecosystems.

**Public Health Interventions:** Public health initiatives, education campaigns, and community engagement are pivotal components of mitigating heavy metal exposure. Raising awareness among vulnerable populations about the risks associated with heavy metal exposure can lead to informed decision-making and behavior changes. Additionally, healthcare professionals can play a vital role in identifying and managing heavy metal-related health issues, ensuring timely intervention and treatment.

**Sustainable Agriculture Practices:** Heavy metals can enter the food chain through contaminated soil, affecting the safety of agricultural products. Implementing sustainable agricultural practices, such as proper land use planning, soil testing, and responsible use of fertilizers and pesticides, can minimize heavy metal accumulation in crops and reduce human exposure (Sen *et al.,* 2021).

**International Collaboration and Research:** Addressing heavy metal contamination is a global challenge that requires international collaboration and multidisciplinary research efforts. Sharing best practices, scientific knowledge, and technological innovations across borders can facilitate the development of effective mitigation strategies. Collaborative efforts can lead to the identification of region-specific risks and the tailoring of interventions to local contexts.

## CONCLUSION

The seminar on the problem associated with heavy metals in humans underscored the urgent need for interdisciplinary collaboration and evidence-based policies to combat this pervasive health challenge. Recent research has illuminated the intricate mechanisms of heavy metal toxicity, highlighted the diverse health effects on humans, and provided innovative solutions for mitigation. As our understanding continues to evolve, it is imperative that stakeholders across academia, industry, and government work collectively to safeguard human health and the environment from the deleterious effects of heavy metal exposure. By addressing heavy metal contamination at its source, implementing effective regulatory measures, and raising awareness among vulnerable populations, society can work toward mitigating the health risks associated with heavy metal exposure and promoting better human health.

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