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NEGATIVE EFFECTS OF MERCURY ON LIVING ORGANISMS

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Abstract
Mercury (Hg) is a heavy metal with high toxicity and poses a significant threat to living organisms. This article discusses the harmful effects of mercury on human and animal health, its routes of exposure, bioaccumulation processes, and cellular toxicity mechanisms. Mercury severely affects the central nervous system, kidneys, and immune system. Methylmercury, in particular, is the most toxic form, entering the human body through the food chain. Studies have shown that mercury disrupts enzymatic systems, increases oxidative stress, and damages genetic material. This article highlights the importance of preventing mercury poisoning and ensuring environmental safety.

Keywords: Mercury, heavy metals, toxicity, methylmercury, bioaccumulation, central nervous system, oxidative stress, poisoning, environmental hazard, enzymes.

Introduction

Environmental pollution has become one of the major global challenges of modern times. Among various pollutants, heavy metals pose a serious threat to human health. Mercury is a naturally occurring element, but its widespread distribution is largely due to industrial activities. It contaminates air, water, and soil, persisting in the environment for long periods and causing harm to living organisms. Mercury can enter the human body through inhalation, ingestion (especially via contaminated fish), and skin absorption. In aquatic environments, mercury is converted by microorganisms into methylmercury, a highly toxic and bioactive form. This compound accumulates along the food chain (bioaccumulation), leading to high concentrations in humans.

At the cellular level, mercury exerts its toxic effects by binding to proteins and disrupting enzyme activity. It damages cell membranes and increases the production of reactive oxygen species, resulting in oxidative stress. This leads to cellular and tissue damage.

The central nervous system is particularly sensitive to mercury exposure. Neurological symptoms such as memory loss, tremors, behavioral changes, and neurodegenerative disorders may occur. Additionally, mercury negatively affects kidney function and weakens the immune system.

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Therefore, studying the toxic effects of mercury, understanding its mechanisms of action, and developing preventive strategies are essential tasks in modern medicine and environmental science.

Relevance:

Currently, environmental contamination by heavy metals is considered one of the major global ecological and medical challenges. Among these, mercury (Hg) poses a particular threat due to its high toxicity, persistence in the environment, and ability to bioaccumulate. The rapid growth of industrialization, especially in chemical, mining, and energy sectors, has significantly increased mercury emissions into the biosphere.

The relevance of mercury lies in the fact that even small amounts can cause severe damage to living organisms. In particular, methylmercury easily enters the human body through the food chain and exerts strong neurotoxic effects on the central nervous system. Today, cases of mercury poisoning are still reported in many regions of the world, especially in developing countries. Moreover, the negative impact of mercury on fetal development is of great concern. Exposure to mercury during pregnancy may lead to congenital defects, neurological disorders, and impaired cognitive development in children. Therefore, the World Health Organization (WHO) has classified mercury as one of the most hazardous chemicals. Another important aspect of mercury is its ability to accumulate in the body and exert long-term latent effects. This makes early diagnosis difficult and contributes to the development of chronic diseases. Thus, studying the effects of mercury on living organisms, understanding its toxic mechanisms, and developing preventive strategies remain highly relevant issues in modern medicine, environmental science, and public health.

Aim and Objectives

Aim of the study:

The main aim of this study is to investigate the toxic effects of mercury on living organisms, particularly the human body, to determine its mechanisms of toxicity, and to scientifically evaluate its harmful impact on various organ systems such as the central nervous system, kidneys, and immune system.

Objectives of the study:

- ✓ To study the physicochemical properties of mercury and its sources of environmental distribution;
- ✓ To analyze the routes of mercury exposure (inhalation, ingestion, and dermal contact);
- ✓ To identify the toxic properties of different forms of mercury, especially methylmercury;
- ✓ To examine the processes of bioaccumulation and biomagnification;
- ✓ To analyze the cellular mechanisms of mercury toxicity (enzyme inhibition, oxidative stress, and cellular damage);
- ✓ To determine the pathological effects of mercury on the central nervous system, kidneys, and other organs;
- ✓ To study the clinical manifestations and complications of mercury poisoning;
- ✓ To evaluate the long-term effects of mercury on human health;
- ✓ To develop preventive measures and recommendations for environmental safety.

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Materials and Methods: In this study, a comprehensive approach was used to investigate the toxic effects of mercury on living organisms. The research was conducted based on both theoretical analysis and experimental data.

Research materials:

The following materials were used:

• Scientific literature (international articles, WHO reports, monographs);
• Modern sources in toxicology and environmental science;
• Laboratory observation data (experiments conducted on animal models);
• Information on mercury and its compounds (elemental mercury, inorganic and organic forms such as methylmercury).

Research methods:

• Literature review method: existing scientific publications related to the topic were systematically analyzed and summarized;
• Experimental method: the toxic effects of mercury were studied under laboratory conditions using animal models (mainly white rats);
• Biochemical analysis methods: enzyme activity and oxidative stress markers (MDA, SOD, catalase) were measured in blood and tissues;
• Histological methods: morphological changes in organs (liver, kidneys, brain) were examined under a microscope;
• Statistical analysis: obtained data were processed using statistical methods to evaluate reliability and significance.

The collected data were compared and analyzed to assess the overall impact of mercury on living organisms.

Results and Discussion:

The results of the study demonstrated that mercury exerts a complex and systemic toxic effect on living organisms. Experimental observations in animal models exposed to mercury revealed significant morphological and biochemical alterations.

Biochemical analysis showed that mercury exposure significantly suppresses the antioxidant defense system. In particular, a decrease in the activity of superoxide dismutase (SOD) and catalase, along with an increase in malondialdehyde (MDA) levels, was observed. These findings indicate the development of oxidative stress. Oxidative stress leads to damage of cell membranes, increased lipid peroxidation, and ultimately cell death.

Histological examinations revealed pronounced pathological changes in the liver, kidneys, and brain tissues. In the liver, hepatocyte degeneration, vacuolization, and necrotic areas were observed. In the kidneys, damage to nephrons and impaired filtration function were detected. In brain tissue, neuronal degeneration and disruption of synaptic connections were identified, confirming the strong neurotoxic properties of mercury.

Experimental findings also showed that mercury directly affects enzyme systems by binding to proteins and disrupting their functional activity. This leads to disturbances in metabolic processes.

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Enzymes containing sulfhydryl (-SH) groups were found to be particularly sensitive to mercury toxicity.

During the discussion, the obtained results were compared with findings from other scientific studies. Numerous studies have reported that mercury enhances oxidative stress, induces DNA damage, and activates apoptotic pathways. These observations are consistent with our findings and support their scientific validity. Furthermore, the ability of mercury to bioaccumulate and exert long-term latent effects was emphasized. Methylmercury, in particular, can accumulate through the food chain and reach high concentrations in higher organisms, including humans.

Overall, the results confirm that mercury has a strong toxic impact on living organisms, especially affecting the nervous system and parenchymal organs.

Conclusion:

Based on the conducted research and analysis, it can be concluded that mercury is one of the most hazardous heavy metals for living organisms. Its toxic effects are complex and lead to significant pathological changes at the cellular, tissue, and systemic levels. Once inside the body, mercury disrupts enzymatic systems, binds to proteins, reduces their functional activity, and enhances oxidative stress. As a result, cell membranes are damaged, lipid peroxidation increases, and cell death occurs. The central nervous system, kidneys, and liver are particularly sensitive to mercury exposure. The findings demonstrate that due to its bioaccumulation properties, mercury gradually accumulates in the body and exerts long-term latent effects. Methylmercury, the most toxic form, enters the human body through the food chain and can cause severe neurological and systemic disorders. Therefore, preventing mercury exposure, protecting the environment, ensuring food safety, and strengthening public health measures are of great importance. Furthermore, deeper investigation of mercury's toxic mechanisms and the development of effective treatment strategies remain key priorities for future scientific research.

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