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Assessment of Health Risks Posed by Trace Metals in Environmental Media, Crops and Human Hair in a Mining-impact Area

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Introduction

Mining activities, particularly those associated with the extraction of metals, have long been recognized for their potential to adversely affect both the environment and public health. One of the significant concerns in mining regions is the contamination of the surrounding environment by trace metals, which are often released into various environmental media, such as soil, water and air, during the extraction, processing and transportation of mined materials. These metals include elements such as Lead (Pb), Arsenic (As), Cadmium (Cd), Mercury (Hg) and Chromium (Cr), which are classified as potentially toxic and pose significant health risks to humans and wildlife. In mining areas, trace metals can accumulate in the soil, water bodies and vegetation, entering the food chain and subsequently affecting human health. Crops grown in contaminated soils can uptake these metals, leading to their accumulation in edible plant parts, which may be consumed by humans or livestock. This bioaccumulation of trace metals in food crops has been a subject of concern for public health, as prolonged exposure to even low concentrations of toxic metals can lead to a range of health issues, including neurological damage, cancer, kidney dysfunction and developmental delays, particularly in vulnerable populations such as children and pregnant women [1].

Human hair is another important medium for assessing metal exposure, as it serves as a biomarker for the past exposure to heavy metals. The analysis of trace metals in human hair can provide insights into the level of contamination and the extent to which individuals have been exposed to these harmful substances. Hair acts as a record of exposure over time, with trace elements being incorporated into the hair shaft as it grows. As such, hair analysis has gained recognition as a non-invasive and effective method for monitoring environmental and occupational exposures to toxic elements [2].

Description

Mining, especially of heavy metals such as gold, copper and zinc, often involves the use of toxic chemicals and produces a significant amount of waste, some of which contains high concentrations of trace metals. These metals can be released into the environment through various pathways, including the leaching of mining waste into water sources, the dispersion of airborne particulates containing metal dust and direct contamination of soil from mining activities. This contamination can have lasting effects on local ecosystems, agricultural productivity and public health. In mining-affected areas, environmental contamination is commonly observed in the form of elevated concentrations of toxic metals in soil, water and air. For example, high levels of lead and arsenic in soil may result from the deposition of mining waste or the direct use of these metals in processing ores. Water contamination is typically caused by the leaching of these metals from mining tailings or waste dumps into nearby rivers and streams. Airborne pollution can occur when dust generated during mining operations settles on the surrounding land or is inhaled by local populations [3].

The uptake of trace metals by crops depends on several factors, including the chemical form of the metal, soil pH and the plant species. Some metals, such as lead and cadmium, are more readily absorbed by certain types of plants, while others, such as arsenic, may accumulate in specific plant tissues. In agricultural systems near mining areas, the primary route of human exposure to toxic metals is through the consumption of contaminated crops. Chronic consumption of such crops can lead to long-term health risks, particularly in populations that rely heavily on locally grown produce for sustenance. For instance, arsenic contamination in rice is a major concern in areas impacted by mining, as rice is highly susceptible to arsenic uptake from soil and water. Similarly, vegetables like spinach and lettuce can accumulate high concentrations of cadmium and lead when grown in polluted soils, thereby posing a health risk to those who consume them regularly. Given the widespread consumption of such crops, especially in regions with limited access to alternative food sources, the health risks associated with metal-contaminated crops can be substantial [4].

Human hair analysis provides a valuable tool for assessing long-term exposure to trace metals. Metals such as mercury, lead and cadmium can accumulate in human hair as a result of environmental exposure, dietary intake, or occupational hazards. Because hair grows at a relatively constant rate and incorporates trace elements over time, it serves as a useful biomarker for estimating past exposure to metals. In contrast to blood or urine, which reflect short-term exposure, hair analysis can provide a more comprehensive picture of cumulative exposure to toxic metals. Hair analysis is non-invasive, making it an ideal method for assessing the exposure of populations, especially children and pregnant women, who may be particularly vulnerable to the health effects of trace metals. Several studies have demonstrated a correlation between elevated metal levels in hair and adverse health outcomes, including developmental delays, cognitive impairment and increased risk of cancers [5].

Conclusion

The assessment of health risks posed by trace metals in environmental media, crops and human hair in mining-impacted areas is an essential step toward understanding the full scope of contamination and its potential impacts on public health. Mining activities release toxic metals into the environment, where they can contaminate soil, water and air, leading to the uptake of these metals by crops and their eventual entry into the food chain. The health risks associated with chronic exposure to these metals are significant, with potential effects on neurological development, kidney function, cancer risk and reproductive health. By examining the concentrations of trace metals in soil, water, crops and human hair, this study provides a comprehensive picture of the pathways through which metal contamination occurs and how it can affect human health. Human hair, as a biomarker of long-term exposure, offers a unique opportunity to assess the cumulative effects of metal contamination over time. This non-invasive method can be used to monitor the exposure of local populations, providing valuable data for public health and environmental management efforts.

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Conflict of Interest

None.

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