

HEAVY METAL TOXICITY: UNDERSTANDING THEIR HARMFUL IMPACT ON HUMAN HEALTH



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Abstract

As industrialization and environmental contamination increase, exposure to heavy metals becomes unavoidable. Mining, burning of fossil fuels, and industrial processes release heavy metals that contaminate water, air, soil, and marine life. At least 23 million people around the world are affected by toxic waste from metal-mining activity, living on flood-plains contaminated by potentially harmful concentrations of these pollutants (Gill 2023 Sep 21). These metals are part of the connection between environmental factors and public health. Diseases including Alzheimer's, Parkinson's, and Huntington's have been linked to heavy metal intake, and it is important to better understand the link between heavy metal exposure and disease at the molecular level. This literature review looks into the complex relationship between heavy metal exposure and the molecular processes that lead to metabolic syndrome and cognitive impairment. It provides evidence of a correlation between heavy metal exposure and impaired functions as well as diseases. The review also explains the molecular mechanisms involved, which support the development of targeted treatments that can repair or prevent the harmful health effects of heavy metal exposure. The comprehensive analysis highlights the importance of stricter environmental laws and pollution controls to reduce heavy metal exposure. Additionally, early detection and intervention plans are crucial in mitigating the harmful effects of heavy metals.

“Heavy metal is immortal but, we’re not”

- Rob Halford

Heavy Metal Overview

- Heavy metals are dense, toxic elements that accumulate in biological systems, disrupting vital cellular functions (Koyama et al. 2024).
- This review is focused on heavy metals lead, mercury, cadmium, chromium, and arsenic.

Methodology

- Reviewed existing studies on heavy metal health impacts.
- Evaluated environmental studies and quantified heavy metal levels using advanced techniques.
- Assessed the methodologies for measuring heavy metal exposure effects.

Key Findings

1. Heavy Metal Sources and Exposure

- Common sources include cigarette smoke, fossil fuels, industrial processes, lead-based paint in dwellings, soil, contaminated food and water (Jaishankar et al.).

2. Harmful Impacts of Heavy Metals

- Health issues including metabolic syndrome and cognitive impairment (Kim et al. 2023).
- Millions affected worldwide, with conditions like Alzheimer's linked to heavy metal intake (Bakulski et al. 2020).

3. Study Results

- Research highlights significant differences in heavy metal concentrations in various environments (Sojka and Jaskuła, 2022).
- Laboratory techniques and thorough sampling indicate widespread contamination (Sojka and Jaskuła, 2022).

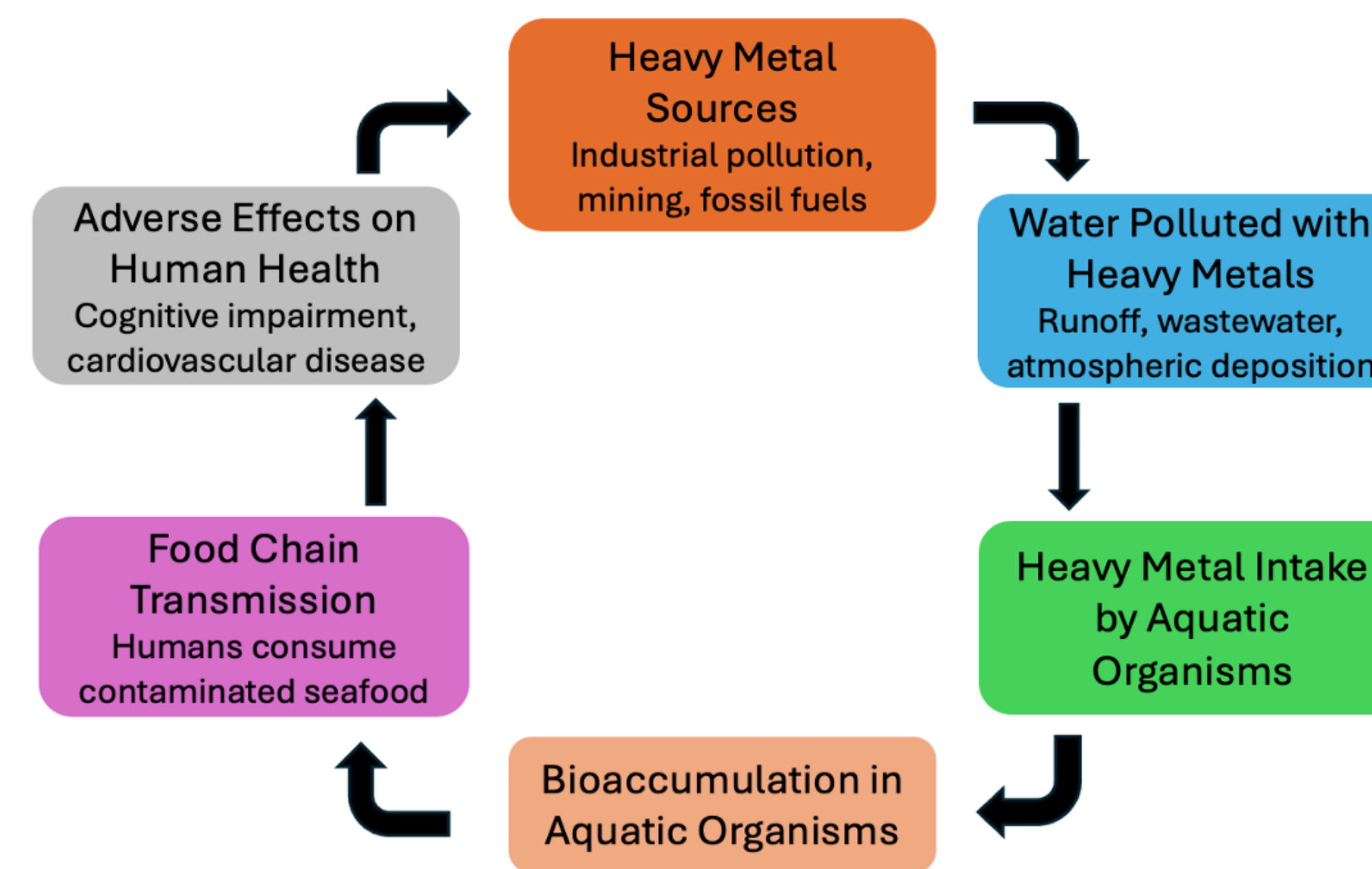


Figure 1: Flowchart showing the transmission of heavy metals from industrial sources to human health through water pollution, aquatic intake, bioaccumulation, and food chain transmission, leading to cognitive impairment and cardiovascular diseases (Sonone et al. 2020).

4. Molecular Mechanisms of Toxicity

- Heavy metals cause health problems by altering gene expression and protein interactions (Nguyen and Kim, 2022).
- They interact with genes and transcription factors, impacting metabolic and cognitive health (Nguyen and Kim, 2022).

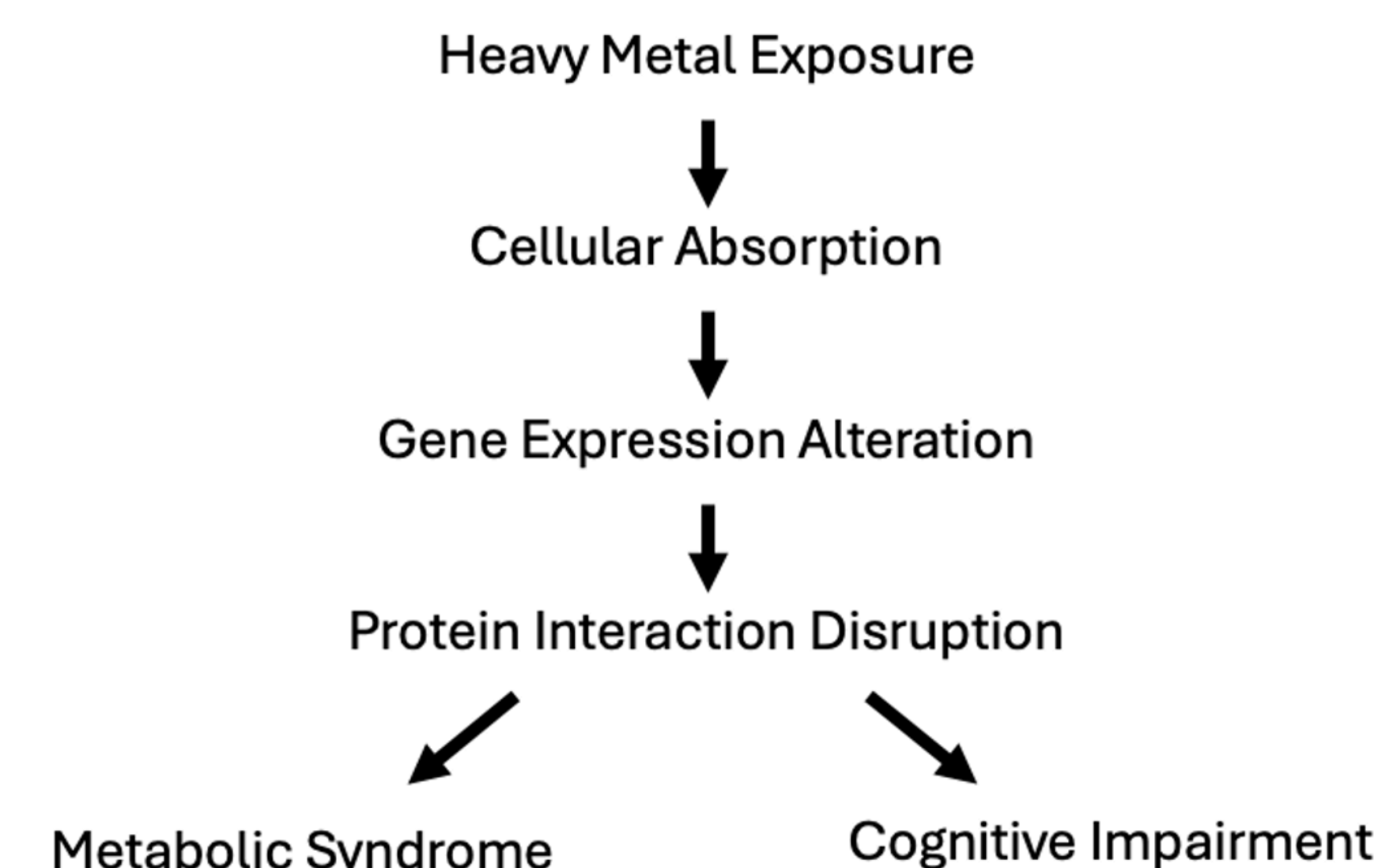


Figure 2: The process demonstrating how heavy metal exposure causes metabolic syndrome and cognitive impairment through cellular absorption, alteration of gene expression, and disruption of protein interactions (Nguyen and Kim 2022a).

5. Biosorption as a Mitigation Strategy

- Heavy metals can be removed from contaminated settings using algae, bacteria, and agricultural waste (Pereira et al. 2021).
- High heavy metal absorption efficiency provides a sustainable and cost-effective remediation technique (Wang and Chen 2009).
- Industrial wastewater and contaminated soils can be treated by biosorption (Wang and Chen 2009).

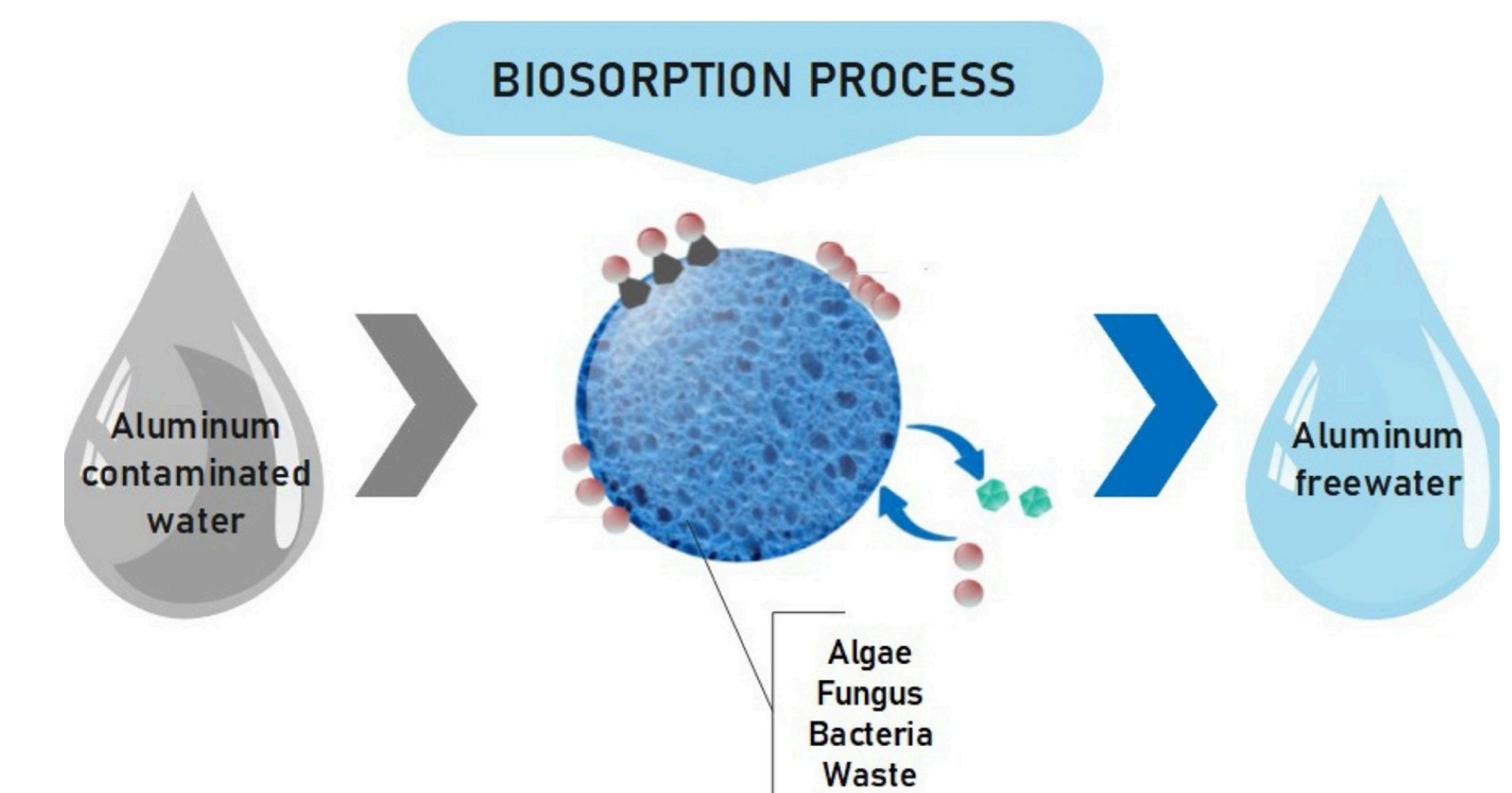


Figure 3: The biosorption process using algae, fungus, bacteria, and agricultural waste to remove aluminum from contaminated water (Pereira et al. 2021).

Prevention & Mitigation Strategies

- Enforce rules to lower heavy metal pollution.
- Develop more technologies for the removal of heavy metals.
- Increase public awareness and education on heavy metal exposure.

Further Research

- Study the long-term health implications of low-level heavy metal exposure.
- More longterm research on how heavy metals cause metabolic syndrome and cognitive impairment at the molecular level.
- Study the effects of numerous heavy metals and environmental pollutants.

References

