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Probiotic Candidate Bacteria's Capacity to Adsorb Heavy Metals within the Human Body

Nayereh Rezaie Rahimi [1,2], *Reza Fouladi-Fard* [3,4*]

[1] *Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran.*
[2] *Department of Environmental Health Engineering, School of Public Health, Shiraz University of Medical Sciences, Shiraz, Iran.*
[3] *Environmental Health Research Center, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran.*
[4] *Research Center for Environmental Pollutants, Qom University of Medical Sciences, Qom, Iran.*

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Corresponding Author:
Reza Fouladi-Fard

Email:
rezafd@yahoo.com

Tel:
+98 9119525525

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Below our peaceful surroundings, heavy metals (HMs) pollution quietly endangers ecosystems and human health, causing a harmful crisis that affects both our environment and health. The environment contains HMs, which play a crucial role in protecting life [1]. HMs are commonly defined as metals with a density exceeding 5 g/cm^3 that have harmful effects on both the environment and organisms [2]. The rise of HMs pollution is attributed to the growing number of factories, expanding urban population, human activities, agriculture, and the overall increase in human population giving rise to concerns [3-5]. Some HMs, such as Zn, Cu, and Fe, are essential trace elements, while others like Cd and Pb lack any useful biological role and can be toxic even in tiny quantities. The growing prevalence of HMs in our resources is remarkable. It becomes a more significant issue as many industries discharge metal-laden wastewater into freshwater without appropriate treatment [6, 7]. HMs from the air and soil can enter our bodies through various pathways like eating, breathing, and skin contact. These pollutants can harm vital organs like kidneys, liver, and bones. When these metals build up inside living organisms, they can create major problems. Common health issues linked to HMs exposure include decreased survival, growth inhibition, tissue damage, oxidative stress, respiratory problems, and gut microbial dysbiosis [8]. The food chain may be affected by the integration of harmful metals through rainwater, especially when the water has an acidic pH and comes into contact with the ground [9]. Common HMs that contribute to environmental pollution are mercury, cadmium, arsenic, chromium, nickel, copper, and lead [1]. The thresholds for arsenic in air and drinking water according to the World Health Organization (WHO) guidelines are 1.5 × 10^{-3} µg/m^3 and 0.01 mg/L, respectively. Certain foods such as fish, shellfish, meat, poultry, dairy products, and cereals can contain arsenic. Arsenic exists in two forms including inorganic and organic, each having different effects on human health. Inorganic arsenic can cause irritation in the gastrointestinal and lung

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systems, skin changes, reduced production of red and white blood cells, increased cancer risk, as well as issues such as infertility, miscarriages, heart problems, brain damage, and DNA damage. On the other hand, organic arsenic might result in stomach discomfort and nerve damage, without affecting DNA or being linked to cancer [10].

Many types of bacteria, such as *Bacillus, Bifidobacterium, Enterococcus, Lactobacillus, Leuconostoc, Pediococcus, Propionic bacterium*, and *Streptococcus*, have been used as probiotics [11]. The WHO defines probiotics as "live microorganisms which when administered in adequate amounts are beneficial to the host." [12] Recently, a few research studies have shown that certain types of *Lactobacillus* bacteria could become useful probiotics to help reduce and treat the harmful effect by HMs toxicity in the human body [13]. Probiotics work positively in the gut and support the immune system. Additionally, they offer advantages such as helping to prevent diabetes, urinary infections, candidiasis, osteoporosis, depression, anxiety, lactose intolerance, hypercholesterolemia, immune disorders and any other food allergy, irritable bowel syndrome, urinary tract infections, and symptoms of colds and flu. Moreover, they can even lower blood pressure [14-16]

The gut microbiota plays a vital role in limiting the uptake and spread of harmful HMs. Gut microbiota is made up of different types of tiny organisms like bacteria, fungi, archaea, viruses, and protozoa. The gut microbiota assists in processes such as digesting food, regulation of the body metabolism, and proper functioning of the nervous and immune systems. The differentiation between the gut microbiota of humans and rodents contributes, in part, to the contrasting biological half-life of mercury in these two species, thereby resulting in different rates of elimination [17, 18].

Using probiotics in our diet help to remove HMs from our gut. This process is known as "gut remediation". Probiotics can effectively limit the body's intake of HMs through various mechanisms, such as trapping them in the intestines, reducing their harmful impact, modifying the body's response to such substances, and preserving digestive health [8]. Recently, many strategies have been tried to reduce HMs pollution. However, most of them have been expensive and environmentally unfriendly [19]. In order to prevent further pollution and reduce the risks associated with HMs, it is crucial to effectively manage and control their release into the environment from various sources, such as factories, car emissions, and waste disposal [20].

Typically, individuals are exposed to significantly lower levels of HMs over long periods. As a result, understanding the effects of HMs exposure on human health becomes crucial, taking into account both the dosage and duration of exposure. Studies have shown that using probiotics can be an affordable and effective way to prevent or reduce gut and overall health problems caused by these metals [17].

Therefore, it is important to study the potential benefits and advantages of probiotics in addressing the challenges posed by HMs toxicity. Efforts have led to a deeper understanding of probiotic bacteria's capacity to combat HMs toxicity, offering hope and solutions for a healthier world.

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