International Journal of Science Academic Research
Vol. 04, Issue 09, pp.6269-6271, September, 2023
Available online at http://www.scienceijsar.com

ISSN: 2582-6425

Review Article

A REVIEW ON HEAVY METALS BIOREMEDIATION USING DAPHNIA

[1,*]Fatima F. Bebal and [2]Jitendra R. Shedge

[1]Department of Zoology, MPSPS College, Plot No. 629 / 1243, Behind Teacher's Colony, Bandra (E), Mumbai – 400 051, India
[2]Department of Zoology, PTVA's Sathaye College (Autonomous) Dixit Road, Vile Parle (E), Mumbai - 400 057, India

Received 20th July 2023; **Accepted** 15th August 2023; **Published online** 30th September 2023

Abstract

The Daphnia (water fleas) are among the most thoroughly researched model species to date. They may be found practically everywhere and are found in brackish and freshwater bodies of water that are still and range in size from tiny ephemeral pools to gigantic lakes. Daphnia is frequently used in research on host-parasite interactions, phenotypic plasticity, predator-induced defense, ecotoxicology, evolutionary genomics, etc. *Daphnia magna* and *Daphnia pulex* are the most frequently investigated species. In this review article, we will be focusing on Daphnia as a potential bioremediation with respect to heavy metals toxicity. Heavy metals can enter the environment through both natural and artificial mechanisms. These processes include mining, soil erosion, industrial discharge, urban runoff, sewage effluents, the application of pesticides or pharmaceuticals to treat diseases in plants, the byproducts of air pollution, and a number of additional sources. They tend to be recognized as the most hazardous to humans and animals due to the vast range of adverse effects on human health, even at low concentrations.

Keywords: Heavy metals, Bioremediation, Daphnia.

INTRODUCTION

Small planktonic crustaceans of the genus Daphnia exhibit a broad geographic distribution. They may be found practically everywhere and are found in brackish and freshwater bodies that are still and range in size from small ephemeral pools to gigantic lakes. Contrary to other species of genera that are closely related, Daphnia typically do not colonise sea water, however they may do so in salt water lakes or estuaries. They show parthenogenetic life cycles. Due to their role as the primary consumer, daphnia are frequently considered a keystone species in lake and pond ecosystems (Ebert, 2022). Daphnia have uncalcified shells around their bodies called carapaces. Chitin, a polysaccharide, makes up the majority of the carapace. There can be up to ten pairs of appendageson cladocera, and they are as follows: 5 or 6 limbed tree maxillae, mandibles, antennae, and the trunk. A framework for breathing eaters is shaped by their limbs. At the tip of the abdomen are a pair of claws. The body length of cladocera varies from less than 0.5 mm to more than 6 mm. They show sexual dimorphism (males are smaller than females) (Ebert, 2005). One of the most extensively studied ecological model species is the Daphnia. Their predominately asexual reproduction enables the separation of genetic from non-genetic effects by permitting the study of phenotypes ignoring genetic variation. Daphnia are commonly used in studies on host-parasite relationships, phenotypic plasticity, defence against predators, ecotoxicology, and increasingly, evolutionary genomics. *D. magna* and *D. pulex* are the most often investigated species, and an increasing number of genetic and genomic techniques are now readily available for both species.*D. magna* has been used in various studies on metal toxicity and metal removal as well (Ebert, 2022). The earth's crust contains a variety of heavy metals, and their concentrations vary geographically and from place to place. They are necessary for a number of biochemical and physiological processes in organisms when present in extremely low concentrations, but they become toxic when their concentrations are above a particular threshold. Despite the fact that heavy metal exposure is an issue and is even getting worse in many parts of the world it is being unnoticed. Heavy metal exposure is known to have a number of negative health impacts and these effects may last for a very long time (Morais *et al.,* 2012). Heavy metals can enter the environment through a variety of methods, both natural and human-made. These sources include sewage effluents, pesticides, industrial discharge, urban runoff, mining, soil erosion, and so on. While the majority of individuals are exposed to these chemicals through food and drinking water, other people are primarily exposed to them at work. Heavy metal concentrations in the ecosystem are rising, making it an important concern today (Morais *et al.,* 2012). Metal buildup in the biological system, whether required or not, becomes harmful after crossing a specific level. Heavy metal pollution, which affects the atmosphere and water environment, poses a threat to the health of humans and animals as well as to their very existence (Fikirdeşici-Ergen *et al.,* 2017). Several chemical, physical, and biological methods can be used to treat heavy metal-contamination. The cost of these processes can be significant, and they offer varying efficiency for various metals. As a result, various alternative techniques have been created, one of which is bioremediation (i.e., use of organisms to remove environmental pollutants). This technique is very effective, less expensive and more environmentally friendly than other techniques (Fikirdeşici-Ergen *et al.,* 2017). To remove the heavy metal toxicity from the environment many strategies have been implicated. In terms of heavy metal toxicity, one of the most suitable organisms for bioremediation is Daphnia. Many investigations on metal toxicity and metal removal have used *D. magna*, one of the crucial species for heavy metal studies. *D. magna* in the water column are sensitive and useful tools for determining sediment pollution. For instance, the zooplankton *D. magna*, a sentinel of lentic inland ecosystems and a keystone species of freshwater ecosystems, has been used widely for biotoxicity testing in water columns due to its high fecundity, sensitivity,

Corresponding Author:** ***Fatima F. Bebal,
Department of Zoology, MPSPS College, Plot No. 629 / 1243, Behind Teacher's Colony, Bandra (E), Mumbai – 400 051, India.

Table. Effects of Heavy Metals on Human Health

Sr. No.	Heavy Metals	Authors	Effects on Human Health
1.	Arsenic	Hong *et al.,* 2014	• Cancer of the skin, liver, lungs and bladder. • Decreases production of RBC and WBC. • Abnormal heart rhythm, damaged blood vessels, and a sensation of "pins and needles" in hands and feet.
		Martin *et al.,* 2009	• Darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso, melanosis and keratosis. • Diabetogenic. • Neurobehavioral abnormalities. • Increase thrombocyte agglutination and induce cardiovascular diseases. • Affects fetus development.
2.	Barium	Kravchenko *et al.,* 2014	• Cardiac and renal failure, pulmonary edema, respiratory paralysis, and gastric and intestinal hemorrhages. • Vomiting, diarrhea, cardiac arrhythmia, liver and kidney failure, disorders of nervous system (i.e., tremors), anxiety, dyspnea, and in severe cases can cause ventricular fibrillation, brain swelling, and paralysis.
		Martin *et al.,* 2009	• Abdominalcramps, difficulties in breathing, increased ordecreased blood pressure, numbness around the face, and muscle weakness. • High bloodpressure, changes in heart rhythm or paralysis and possiblydeath.
3.	Cadmium	Genchi *et al.,* 2020	• Damage kidneys, liver, skeletal system, and cardiovascular system, and deterioration of sight and hearing. • Carcinogenesis, primarily in the lung, but also in the prostate, kidneys, breast, urinary bladder, nasopharynx, pancreas, and hematopoietic system.
		Martin *et al.,* 2009	• Severely irritates the stomach, leading to vomiting diarrhea, kidney disease, lung damage, and fragile bones.
4.	Chromium	Wilbur *et al.,* 2012	• Sperm damage and damage to the male reproductive system. • Lung cancer.
		Martin *et al.,* 2009	• Irritation to the lining of the nose; nose ulcers; runny nose; and breathing problems, such as asthma, cough, shortness of breath, or wheezing. • Skin contact can cause skin ulcers. Allergic reactions consisting of severe redness and swelling of the skinhave been noted.
5.	Lead	Martin *et al.,* 2009	• Damage to liver, kidney circulatory and nerve tissues, as well as skin irritation. • Damage the brain and kidneys and ultimately cause death. • In pregnant women, high levels of exposure to lead may cause miscarriage. • Damage the testes.
		Ara *et al.,* 2015	• Anemia, delirium, coma, seizures, and headache, loss of short-term memory or concentration, depression, nausea, abdominal pain, loss of coordination, and numbness and tingling in the extremities. • Fatigue, problems with sleep, headaches, stupor, slurred speech, and anemia.
6.	Mercury	Martin *et al.,* 2009	• Damage thebrain, kidneys, and developing fetuses. • Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. • Lung damage, nausea, vomiting,diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation.
7.	Selenium	Azevedo *et al.,* 2012	• Increased risk of hypertension, myocardial infarction, coronary dysfunction, and atherosclerosis.
		Martin *et al.,* 2009	• Nausea, vomiting, and diarrhea, selenosis,respiratory tract irritation, bronchitis, difficulty breathing, and stomach pains, bronchial spasms, and coughing.
		Vinceti *et al.,* 2001	• Carcinogenic, can cause hepatotoxicity and gastrointestinal disturbances, nailand hair loss and dermatitis, amyotrophic lateral sclerosis, neurotoxicity.
8.	Silver	Martin *et al.,* 2009	• Breathing problems, lung and throat irritation, and stomach pains. • Mild allergic reactionssuch as rash, swelling, and inflammation in some people.
		Drake *et al.*, 2005	• Argyria, argyrosis. liver and kidney damage, irritation of the eyes, skin, respiratory, and intestinal tract, and changes in blood cells

ease of laboratory cultivation, and relatively obvious toxicity mechanism (Xiaomin *et al.,* 2017). Iron (Fe) and Aluminium (Al), two of the top 10 elements found in the Earth's crust, are often the metals that are most abundant throughout all reservoirs. Al and Fe are among the elements with the greatest abundance in the Karatas Lake, as it was predicted. Despite the fact that these elements are found in relatively high concentrations, little is known about their toxicity (especially harmful and synergistic toxic effects), as a result of their low toxicity. Beryllium (Ba) is crucial to this investigation because, due to the potentially hazardous aluminium-barium combination, it has both antagonistic and synergistic effects with Al (Fikirdeşici-Ergen *et al.,* 2017). A study conducted suggests that Daphnia can remove certain heavy metals. There are seven different ways to mix the metals Al, Ba, and Fe and were studied in single, dual, and triple mixtures in *D. magna* culture. This study looked at a variety of topics, including the association between metal removal and culture, variations in metal removal proportions owing to culture, variations in metal removal amounts due to culture, and more. Al, Ba, and Fe have been shown to be the study's most toxic elements for *D. magna* (Fikirdeşici-Ergen *et al.,* 2017). Another study was conducted by Xiaomin and coworkers in which the mortality and Cadmium (Cd) deposition in *D. magna* increased with increasing Cd level in sediment (Xiaomin *et al.,* 2017). R. D. Van Anholt conducted an experiment to test the effects of phosphate precipitation with iron (II) sulphate by introducing adult water fleas (*D. magna)* to river water nearby an iron sulphate dose installation. Tests were conducted during two subsequent treatment periods of 3,000 and 5,000 kg/day of iron sulphate (520 and 620 g/L total Fe, respectively) at the dose site and a reference position downstream (60 g/L total Fe). Although survival was unaffected, the filter-feeding *D. magna* deposited iron and other metals at the dosage location. In comparison to the lower dose and the reference site, the viability of offspring was significantly decreased at the highest dose of iron sulphate. Microscopic sections stained specifically revealed a significant buildup of iron (III) in the digestive tract (Van Anholt *et al.,* 2002).

Conclusion

From the above studies it can be concluded that a lot of work has been done on Daphnia w.r.t. bioremediation of heavy metals. The research conducted shows Daphnia has a great potential to treat the heavy metal toxicity from their surrounding environment. But during these studies the ability of Daphnia to accumulate heavy metals concentration was found to be limited, which affected the efficiency of the treatment. The data also suggested that overdose of certain heavy metals can lead to death of the Daphnia and it can also affect their reproductive cycle. It is suggested to develop some additional techniques that can help efficient accumulation of heavy metals without affecting the organism. To tackle this problem one can develop genetically modified strains of Daphnia with a greater capacity of heavy metal accumulation. It is also found that the data regarding heavy metal toxicity and mortality rate is not sufficient on a national and international level.

REFERENCES

1. Ara, A., & Usmani, J. A. (2015). Lead toxicity: a review. *Interdisciplinary toxicology*, *8*(2), 55.
2. Drake, P. L., & Hazelwood, K. J. (2005). Exposure-related health effects of silver and silver compounds: a review. *Annals of Occupational Hygiene*, *49*(7), 575-585.
3. Ebert, D. (2022). Daphnia as a versatile model system in ecology and evolution. *Evo Devo*, *13*(1), 16.
4. Ebert, D. (2005). *Ecology, epidemiology, and evolution of parasitism in Daphnia*. National Library of Medicine.
5. Fikirdeşici-Ergen, Ş., Üçüncü-Tunca, E., Kaya, M., & Tunca, E. (2017). Bioremediation of heavy metal contaminated medium using Lemna minor, Daphnia magna and their consortium. *Chemistry and Ecology*, *34*(1), 43-55.
6. Fernandes Azevedo, B., Barros Furieri, L., Peçanha, F. M., Wiggers, G. A., Frizera Vassallo, P., Ronacher Simões, M., & Valentim Vassallo, D. (2012). Toxic effects of mercury on the cardiovascular and central nervous systems. *BioMed Research International*, *2012*.
7. Genchi, G., Sinicropi, M. S., Lauria, G., Carocci, A., & Catalano, A. (2020). The effects of cadmium toxicity. *International journal of environmental research and public health*, *17*(11), 3782.
8. Hong, Y. S., Song, K. H., & Chung, J. Y. (2014). Health effects of chronic arsenic exposure. *Journal of preventive medicine and public health*, *47*(5), 245.
9. Kravchenko, J., Darrah, T. H., Miller, R. K., Lyerly, H. K., & Vengosh, A. (2014). A review of the health impacts of barium from natural and anthropogenic exposure. *Environmental geochemistry and health*, *36*, 797-814.
10. Li, X., Peng, W., Jiang, Y., Duan, Y., Ren, J., Liu, Y., & Fan, W. (2017). The Daphnia magna role to predict the cadmium toxicity of sediment: Bioaccumlation and biomarker response. *Ecotoxicology and environmental safety*, *138*, 206-214.
11. Morais, S., Costa, F. G., & Pereira, M. D. L. (2012). Heavy metals and human health. *Environmental health–emerging issues and practice*, *10*(1), 227-245.
12. Martin, S. and Griswold, W. (2009). Human health effects of heavy metals. *Environmental Science and Technology briefs for citizens*, *15*(5).
13. Ming-Ho, Y. (2005). Environmental Toxicology: Biological and Health Effects of Pollutants, Chap.12, CRC Press LLC, ISBN 1-56670-670-2, 2nd Edition, BocaRaton, USA.
14. Van Anholt, R. D., Spanings, F. A. T., Knol, A. H., Van der Velden, J. A., & Wendelaar Bonga, S. E. (2002). Effects of iron sulfate dosage on the water flea (Daphnia magna Straus) and early development of carp (Cyprinus carpio L.). *Archives of Environmental Contamination and Toxicology*, *42*, 182-192.
15. Vinceti, M., Wei, E. T., Malagoli, C., Bergomi, M., & Vivoli, G. (2001). Adverse health effects of selenium in humans. *Reviews on environmental health*, *16*(4), 233-252.
16. Wilbur, S., Abadin, H., Fay, M., Yu, D., Tencza, B., Ingerman, L. and James, S. (2012). ANALYTICAL METHODS. In *Toxicological Profile for Chromium*. Agency for Toxic Substances and Disease Registry (US).

****