Helminthic Parasites as Heavy Metal Bioindicators in Aquatic Ecosystems

Mehdi Najm (PhD)
Department of Parasitology and Mycology, School of Medicine, Mazandaran University of Medical Sciences, Sari, Iran

Mahdi Fakhar (PhD)
Molecular and Cell Biology Research Center, Department of Parasitology and Mycology, School of Medicine, Mazandaran University of Medical Sciences, Sari, Iran

Corresponding Author: Mahdi Fakhar

E-mail: mahdif53@yahoo.com

Tel: +981133543248

Address: Mazandaran University of Medical Sciences, Farah-Abad Road, Payambare-Azam

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ABSTRACT

Heavy metals have raised one of the most important problems in ecology and organisms life especially human being and animals. A variety of indicators including tissues of fish, birds and sediment have been used recently to measure the aquatic pollution with heavy metals. The aim of this study was to search the published articles in Iran and the world on the role of helminthic parasites as a bioindicator (biological indicators) in assessing the concentration of heavy metals. This study was a non-systematic review and data were collected from available databases such as, Google Scholar, Pubmed, Web of Science, Scopus and Scientific Information Database (SID).Most studies showed that helminthic parasites(particularly acanthocephalan and cestoda) could be used as bioindicators in assessing the concentration of heavy metals. However, limited investigations were conducted on nematoda and trematoda parasites and limited information was available regarding heavy metal bioindicatorsin Iran.

Keywords: Parasitology, Acanthocephala, Heavy Metals.

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INTRODUCTION

Nowadays, with the advent of widespread knowledge about biotechnology and the use of living organisms to solve problems as well as producing useful products, a new horizon has been opened to take more effective steps to solve the current global problems. Recent advances in the field of biotechnology and conducted studies on worms and other parasites have demonstrated that parasites, especially worms can eliminate many problems in control and prevention of diseases, diagnosis, and treatment of patients and laboratory and environmental decontamination. For example, it has been made possible to use the pig whipworm eggs in the treatment of inflammatory bowel disease (IBD) or the p53 gene present in worms to prevent cancer (1). From the perspective of ecology, helminthic parasites can have a close relationship with their host and surrounding environment .In other words, environmental conditions can have a direct impact on the longevity of parasites (2-3).Environmental factors such as pollution can also play an important role by affecting the host's overall health and even its extinction(4). The concept of environmental contaminants is the pollutants for example heavy metals which are naturally entered into the ecosystem through a leak in the atmosphere as a result of human industrial activities, agriculture and sewage disposal (5).The elements with high atomic weightthat can have metal property at room temperature are called heavy metals. Heavy metals such as Lead (Pb), Cadmium (Cd), Zinc (Zn) and Mercury (Hg) are entered to the environment from the waste and wastewaters of industries, textiles and paint factories, iron and steel industries and consumption of fossil fuels, etc.Factories and industries are considered as the major sources of such heavy metals. Industrial waste and consumption of phosphate fertilizers and pesticides are important factors for increasing the contaminants in aquatic ecosystems. Moreover, heavy metals accumulated in the body of fishes and then transferred to the human body through the food chain. Although some amounts of these metals are essential for the body's metabolic activities, the high concentration of these metals can pose as a serious threat to the human health and the global standards (6). Some metals such as Pb and Cd are from a kind of Zeno antibiotics metals that are not necessary adverse effect of Cd consumption in human is Itia-Itia disease which was first reported in Japan due to consumption of contaminated rice(7).

The word bioindicator means using living organisms as biological indicators to identify the quantity of environmental conditions, including environmental heavy metal pollution. In previous studies, fish and aquatic birds were used as biological indicators (bioindicator) to measure heavy metals in aquatic ecosystems (8-10). Hence, helminthic parasites can also be considered as a suitable biological indicator for measuring heavy metals because the worms against to their host tissue are the stable and reliable indicator for evaluating the environmental pollution. Also they have the potential for the accumulation of heavy metals from their surroundings than their hosts too. Despite the public perception that all parasites can have devastating effects on their hosts including pathogenicity, it has been well-established that parasites can also have useful and beneficial effects on their hosts. Recent studies showed that the concentration of heavy metals in the tissues of their host was higher than helminthic parasites(11-17). So, the aim of this study was to review the performed recent studies regarding the role of helminthic parasites as a bioindicator in Iran and regions of the world.

MATERIAL AND METHODS

This study was a non-systematic review (narrative review). The data were collected from available databases such as Google Scholar, Pubmed, Web of Science, Scopus, SID, Iranmedex and Magiranand the keywords searched included heavy metals, bioindicator and worms separately.

1. Accumulation of heavy metals in the tissues of helminthic parasites:

Nowadays, one of the applications of biotechnology in parasitology is to use parasites as biological indicators (bioindicator) in evaluating the quantity and quality of heavy metals such as Cd, Pb, etc., as well as their application as Bioremediation to clean the environment (like rivers and ocean) from metal pollutants or heavy metals(1). These parasites have a free life and complex life cycle and can be more sensitive to environmental alterations compared to other parasites (18). In addition, these parasites, particularly in remote areas of the aquatic environments, including seas and oceans are a rapid and sensitive method to estimate the actual amount contaminants (1).

According to the studies conducted by different researchers, it has been demonstrated that among helminthic parasites such as trematoda, cestoda, nematode, and acanthocephalan, only acanthocephalan and cestoda have a higher potential for absorption of heavy metals (1).

1-1. Studies conducted in Iran

The only study conducted in Iran representing the role of heavy metals as a bioindicators in accumulation of heavy metals that has been performed by Malek et al, in the Persian Gulf. They have expressed that the accumulation of Pb and Cd metals in cestod tissue (Anthobothrium sp.) is more than the host tissue (Shark) (19). Also, another study which represented the role of acanthocephala as a bioindicators in the absorption of heavy metals in Iran was conducted by Najm et al. (2014) on stickleback fish(20) in which the accumulation of metals (Cd. Pb. Chromium(Cr), Zn, and Copper) was evaluated in acanthocephala parasites (*Corynosoma caspicum*) more than their host (stickleback fish). The comparison between two recent studies (19-20) showed that concentration of Pb in cestod was higher than acanthocephala parasites, which could be due to high level of Pb concentration in the Persian Gulf by excessive use of motor boats or the large size of parasites (Cestod) in the absorption of metals. However, the concentration of Cd in the context cestod was less than acanthocephala tissue, which could be due to lack of agricultural lands around the Persian Gulf and consequently the lack of agricultural waste, phosphate fertilizers, and pesticides around the Persian Gulf. The amount of these metals in stickleback fish tissue compared to shark tissue had higher rates, which could be caused by (metabolism) more activity of small fish or reduction of heavy metals related to the length (size) of fish (21). Najm et al (20) showed that the concentrations of Pb and Cr and Cd in stickleback fish were higher than international standards especially the concentration of Cd in which found amount was higher than all international standards. While, the concentration of Zn and Cu were lower than the set of global standards. Since metals such as Pb, Cd and Cr are xenobiotic, their high levels can be considered as a serious threat to the human health and society (see table 1).

2-1. Studies conducted in other regions

Most studies in other regions representing the role of helminthic parasitesas bioindicators in the identification of environmental contaminants showed that helminthic parasitescould be useful as indicators and have suitable potential to absorb heavy metals from their environment (11-13,22-28).

2-1-1. Studies conducted on trematod and nematoda

The only study conducted on trematodes representing their role, as a bioindicator in the absorption of heavy metals have been on *Fasciola hepatica* in cattle such as cow in which the concentrations of Pb and Cd were measured (29). The studies conducted on nematoda also demonstrated the fact that nematoda are not a good indicator for the absorption of heavy metals in low concentrations (29-36) (see table 2).

For example, in a study conducted on the parasite *Ascarissuum* (*A.suum*), they achieved that the concentration of Pb in the liver of hosts were at least two times higher than intestinal parasite Ascaris (37). In another study on complex anisakis nematod (*A.complex*) and its host (Sea Whale), it was recommended that this parasite has a great capacity for absorption of Pb and Hg from its host's tissue (38).

2-2-1. Studies conducted on acanthocephalan and cestoda:

The first study conducted on the absorption of heavy metals by acanthocephalan refers to the accumulation of Cd in the larvae of *Pomphorhynchus leavis* (cystacanth) parasite, which achieved the concentration of Cd in the larvae less than the amount it received in the intermediate host (39). Most laboratory and field investigations showed that the concentration of heavy metals in the body acanthocephalan is thousands of times greater than the concentration of host tissue (39-46) (Table 2).

Table 1- Specified amounts of heavy metals in food by international standards (micrograms per gram dry weight) (WHO,2011)

Metal Standards	Lead(Pb)	Zinc(Zn)	Chromium(Cr)	Cadmium(Cd)	Copper(Cu)
WHO	0/3	100	10	0/2	10
FDA	2	50	10	0/3	20
U.K(MAFF)	0/2	50	20	0/3	20

Table 2- Studies conducted in Iran (*) and other countries on the role of helminthic parasites in the absorption of heavy metals

Researcher	Year	Parasite	Host	Reference
Greichus et al.	1980	Nematod	Wild Boar	37
Brown et al.	1989	Acanthocephala	Pulex	39
Sures et al.	1994	Nematod and Acanthocephala	Fish	30
Sures et al.	1995	Acanthocephala (adult worm and larva)	Fish and crustacean	40
Turcekova et al.	1996	Cestod	Perch (Sea Bird)	48
Sures et al.	1997	CestodandAcanthocephala	Fish	26
Sures et al.	1998	Trematod and Nematod	Cow and Pig	29
Szefer et al.	1998	Nematod	Porpoise	31
Tenora et al.	1999	Nematod	European Eels	32
Barus et al.	1999	Nematod	European Eels	34
Zimmermann et al.	1999	Acanthocephala and Nematod	Fish	42
Sures et al.	1999	Acanthocephala	Fish	11
Sures et al.	2000	Acanthocephala	Rat	43
Barus et al.	2000	Cestod	Perch (Sea Bird)	51
Morley et al.	2001	Trematod	Fish	2
Sures et al.	2001	Acanthocephala	Golden Fish	16
Sures et al.	2002	Cestod	Rat	53
Sures et al.	2002	Acanthocephala	Perch (Sea Bird)	46
Fascual et al.	2003	Nematod	Whale	38
Sures et al.	2003	Acanthocephala	Fish	45
Malik et al.	2007	Cestod	Shark	19
Nachev et al.	2013	Acanthocephala and Nematod	Fish	6
Najm et al.	2014	Acanthocephala	Fish	20

It should be noted that the larvae of parasites (acanthocephalan) in the intermediate host is unable to absorb high amounts of heavy metals but adult worms begin to absorb these metals after infecting the final host. For example, in a comparison of the concentrations of Pb and Cd in larvae and adult worms of *Acanthocephalus lucii*, it was concluded that adult worms can absorb Pb 370 times more than the host muscle and 30 times more than the larvae while Cd was absorbed over 1200 time more than the host muscle in adult worm and 180times more than the larvae. It was also demonstrated that the concentration of Pb and Cd in the context of this parasite has been more than the host tissue (muscle, liver and intestine) (40). These parasites and their hosts, in addition to Pb can also compete for other metals (47). Acanthocephalan is not only effective in absorbing heavy metals but can also quickly react to environmental changes. In an experimental study of water chemistry on the accumulation of Pb on host-parasite systems, it was represented thatsalinity reduced the weight of Pb in the host tissue but did not affect the acanthocephala parasite. In other words, the parasites after 4 to 5 weeks exposure to contaminated water to be reached in a constant state of concentration which the amount of the metal in them are higher than the amount of its surrounding waters (43). In 1998, Sures and Siddal also suggested that although acanthocephala larvae cannot absorb heavy metals in the intermediate host, the adult worm could absorb metals with higher concentrations 4 days after infecting the final host (41). In the study conducted by Nachevet al on Barbel fish, Pomphorhynchus acanthocephalan parasites and nematod larvae of strongyloides spp. it was demonstrated that these two parasites could absorb essential and non-essential elements of their host body and store in them which represents the role of nematode larvae in the high level heavy metal absorption compared with cestoda and acanthocephalan larvae. Unlike their adult worm, acanthocephala larvae and cestoda do not tend to attract heavy metals from their host tissue but the opposite is true about the larva of nematoda (7).Other studies have also been done on cestoda representing the role of cestoda as a bioindicator in the absorption of heavy metals (2-36-48-49-50-51-52-53-54-55) (Table 2).

The mechanism of action in heavy metal uptake by helminthic parasites:

Helminthic parasites mostly live in gut of the host and since they cannot build their required cholesterol and fatty acids, they absorb nutrients from the host's intestinal lumen. In the meantime, the organometallic compounds, which have been absorbed by the host along with bile salts after the passage of the bile duct, are ingested in the small intestine of the host by these parasites. The bile salts are essential to activate the larval stage of the parasitic especially acanthocephalan larval stage (cystacanth) and increase the absorption by adult worm (44). In other words, the mechanism which enable acanthocephalans to take up heavy metals from the intestinal of the host shows to be based on the presence of bile acids, which form organo-metallic complexes that are simply absorbed by the worms due to their lipophilicity, (1) which a similar mechanism may also occur in cestoda . Consequently, these parasites can reduce heavy metals from the host intestinal wall and store in their own. Overall, helminthic parasites act as a filter to absorb heavy metals from the host tissue and can have beneficial effects for human and animal health. Heavy metals can be hazardous to human health due to consumption of fish and other marine originated proteins as well as their application in the poultry industry, helminthic parasites can be used as filters to absorb heavy metals from the host tissues and have beneficial effects for overall human and animal health (56).

CONCLUSION

In conclusion, recent studies conducted in Iran and other countries suggest the role of parasitic worms as bioindicators in the absorption of heavy metals, the same environmental pollutants. These parasites can have beneficial effects for human beings and animals. It can be concluded that helminthic parasites, particularly acanthocephalan inherent as a bioremediation, play a role in clearing the surrounding environment (like rivers, seas and oceans) from metal contaminants or similar heavy metals (57). This study confirms the fact that parasites should not be considered as harmful organismsalthough this is consistent with the philosophy of creation and no inventory is created without wisdom and useless (57). Finally, we should mentionthat since aquatic ecosystems, including marine and aquatic organisms within them have been exposed to heavy metal pollution, it is recommended to perform further studies on various helminthic parasites in other final hosts including sea lion, fish and birds kingfisher and intermediate host of these parasites such as brine shrimp (saltwater crustacean or brine shrimp) (58) in water resources of Iran including major rivers, the Caspian Sea, Persian Gulf and Oman Sea.

CONFLICT OF INTEREST

The authors declare no conflict of interest between them.

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