Hindawi
Adsorption Science & Technology
Volume 2023, Article ID 9813746, 1 page
https://doi.org/10.1155/2023/9813746

Retraction

Retracted: A Brief Review on Heavy Metal Bioaccumulation Studies from Red Sea

Adsorption Science and Technology

Received 19 December 2023; Accepted 19 December 2023; Published 20 December 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] H. M. Alnashiri, "A Brief Review on Heavy Metal Bioaccumulation Studies from Red Sea," *Adsorption Science & Technology*, vol. 2022, Article ID 6201299, 8 pages, 2022.

Hindawi
Adsorption Science & Technology
Volume 2022, Article ID 6201299, 8 pages
https://doi.org/10.1155/2022/6201299

Review Article

A Brief Review on Heavy Metal Bioaccumulation Studies from Red Sea

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Received 26 December 2021; Revised 30 January 2022; Accepted 11 February 2022; Published 21 February 2022

Academic Editor: Jeevan Kumar Reddy Modigunta

The Red Sea forms an important marine ecosystem with its rich species diversity and the different ecosystems, including the coral reefs. The region has received relatively less heavy metal pollution owing to comparatively lesser industrial pollution. This study attempts to review the records of heavy metal bioaccumulation reported in the last two decades. This review is an endeavour to audit the heavy metal bioaccumulation, revealed over the past twenty years, such as As, Cr, Cu, Fe, Cd, Hg, Mn, Zn Ni, Co, Se, and Pb, as reported from various regions of the Red Sea in organisms such as plankton, molluscs, crustaceans, and fish. Though the results of various studies reviewed here are not comparable to each other due to differences in organisms, types of tissues studied, and different methods of analysis as well as nature of their inhabiting sites, this review will be a baseline data of the heavy metal bioaccumulation, which can help in future evaluation in the context of the rapid developmental activity prevalent in the coasts of the Red Sea. The findings compiled emphasize the need for a comprehensive biomonitoring program that can conserve the unique biodiversity of the Red Sea.

1. Introduction

Heavy metals form one of the most common inorganic pollutants in air, water, and soil, and their occurrence in increasing concentration within the environment is representing a significant threat to human health due to their toxic effects on living systems. Pollution of the marine environment and the accumulation of toxic materials in edible marine organisms are increasing concerns worldwide. Heavy metal biomonitoring is an important tool to assess the level of contamination of ecosystems.

2. Heavy Metals

Heavy metals have been defined as metals with a specific gravity of more than four or five, positioned within atomic numbers 22 to 34 and 40 to 52 on the periodic table and having specific biological responses [1]. About half of these heavy metals are biologically essential for the proper functioning of the biochemical process. This group includes manganese, iron, copper, zinc, selenium, cobalt, molybdenum, chromium, nickel, vanadium, arsenic, and tin [2]. According to the compound and quantity, these may cause risks to human health. The nonessential metals are silver, antimony, thallium, aluminium, beryllium, cadmium, lead, titanium, and mercury, having no recognized biological role, and are the more prominent contaminants in the aquatic ecosystems [2].

Heavy metals form a hazardous group of potentially toxic pollutants, particularly in estuaries and coastal waters [3]. The heavy metals are released into the natural environment through industrial and sewage effluents, shipping operations, etc. The contaminants can enter human food through various routes, especially fishery products. Increasing heavy metals in waterbodies than the permissible levels determined by the WHO and EPA turn the waterbody unsafe for human uses as drink or food purposes [4, 5].

3. Studies in the Red Sea

Several studies reported heavy metal bioaccumulation in marine organisms from the Red Sea also. Even though most of them were below the permissible levels, an alarming increase could be noticed in recent studies. This is due to the enormous increase in the developmental activities and industrial installations along the coast of the Red Sea. In this context, an attempt was made to consolidate the recent works on heavy metal bioaccumulation investigations conducted in Red Sea fauna and flora and to display the increased level of heavy metal bioaccumulation by discussing the studies conducted in the last two decades until recent days.

Saad and Fahmy [6] related the substantial dispersal of metals (Mn, Cu, Zn, and Cd) in the bottom and surface water layers, and their buildup in the plankton found that in plankton, the sequence was Cu›Zn›Mn›Cd, with a mean concentration of 195.92, 179.18, 40.72, and 3.82 μg/g dry weight (Tables 1, 2, 3, and 4). Examination of the water and plankton values affirms amassing of substantial metals in the plankton, addressing the first trophic level in the food chain of marine organisms.

El-Sikaily et al. [7] studied the concentration of the same eight heavy metals in bivalves collected from 8 locations from the coastal zone of the Red Sea (Suez Gulf). The concentrations of Cu in mussel samples collected from the Red Sea showed an average value of $5.95 \pm 1.57\,\mu g\,g^{-1}$ wet mass. The bioaccumulation of Cu was not much different in the eight studied sites. Accumulation of Mn and Zn in the collected mussel samples from the Red Sea exhibited an average value of $4.82 \pm 1.36\,\mu g\,g^{-1}$ and $17.39 \pm 3.98\,\mu g\,g^{-1}$ wet mass, respectively. Pb concentrations recorded an average value of $1.46 \pm 0.14\,\mu g\,g^{-1}$ wet weight. The average value of Ni concentrations was $3.33 \pm 1.36\,\mu g\,g^{-1}$ wet weight (Tables 2, 3, 4, and 5).

Hilal and Ismail [8] recorded enormous contrasts in metal bioaccumulation (in μg/g of dry weight) in various organ parts or tissues of various fishes. In muscle tissue, cadmium was recorded at a level from 0.5 μg/g to 2.0 μg/g dry weight, whereas higher accumulation was observed in gill, stomach, and liver tissues (up to 7.0 μg/g). Accumulation of cobalt was most prominent in the gills (4.3 to $15.0\,\mu g\,g^{-1}$) and stomach (1.8 to $11.0\,\mu g\,g^{-1}$) and lower in the liver (1.9 to $6.8\,\mu g\,g^{-1}$) and muscles (1.7 to $7.1\,\mu g\,g^{-1}$). Essentially, chromium accumulation was most noteworthy in the gills (4.3 to $44.2\,\mu g\,g^{-1}$) and stomach (1.8 to $22.0\,\mu g\,g^{-1}$) and least in the liver (1.9 to $11.5\,\mu g\,g^{-1}$). Copper was likewise low in muscle (0.5 to $2.0\,\mu g\,g^{-1}$); however, it was most noteworthy in liver tissue (6.7 to $40.6\,\mu g\,g^{-1}$). Iron levels were most noteworthy in the liver (30 to $1031\,\mu g\,g^{-1}$) and lower in different organs (3.9 to $391.0\,\mu g\,g^{-1}$). Muscle tissues contained lower groupings of magnesium (1.0 to $3.3\,\mu g\,g^{-1}$) than different organs, especially the gills (3.8 to $19.0\,\mu g\,g^{-1}$), which contained likewise higher centralizations of nickel and lead (4.5 to 19.2 and 8.7 to $35.0\,\mu g\,g^{-1}$, separately) which contrasted with the livers (1.0 to 11.4 and 1.9 to $6.3\,\mu g\,g^{-1}$) and muscles (1.0 to 5.0 and 2.5 to $8.3\,\mu g\,g^{-1}$). The gonads contained the most noteworthy convergence of zinc (77.5 to $271.7\,\mu g\,g^{-1}$), while muscles showed the least (1.9 to $35.0\,\mu g\,g^{-1}$) (Tables 1, 2, 4, 5, and 6).

The studies on levels of trace metals in meat, meat products, and fish from Saudi Arabia indicated that significant variation occurred in the concentrations of these metals across both meat and fish products. Most appraised metals specified health risks since their values are higher than the accepted levels cited as per the international food standards (Tables 1, 2, 5, 7, and 8) [9].

Grouping of cadmium, copper, lead, and zinc is estimated in the gills, liver, and muscles of 10 fishes (*Epinephelus areolatus*, *E. transmits Anthias squamipinnis*, *snubnose sovereign*, *Plectorhinchus chaetodonoides*, *Dicentrarchus labrax*, *Lutjanus kasmira*, *Lutjanus ehrenbergii*, *Acanthurus gahhm*, and *Acanthopagrus bifasciatus*), three scavengers (*Panulirus penicillatus*, *Metapenaeus dalli*, and *Portunus pelagicus*), and two squids (*Parateuthis tunicate* and *Chtenopteryx sicula*) gathered from Jeddah coastal waters. The acquired outcomes pronounced that the normal convergences of weighty metals were as per the following: Cu (0.358, 0.327, and 1.536), Cd (0.098, 0.20, and 0.106), Zn (3.00, 7.390, and 4.999), and Pb (0.3, 0.257, and 0.196) μg/g wet load in the muscle, gills, and liver, separately. The normal grouping of Cd, Cu, Pb, Zn, and Hg in the shellfishes (*Metapenaeus dalli*, *Portunus pelagicus*, and *Panulirus penicillatus*) and squid species (*Chtenopteryx sicula* and *Parateuthis tunicate*) has moderately higher contrast, and the muscular tissues in the analyzed samples are shown in Tables 1, 2, 4, and 5 [10].

El Gendy et al. [11] investigated the metal concentrations of Zn, Pb, Cd, Cu, Ni, and Co in the gill tissue, muscles, and exoskeleton of the shrimp *Penaeus semisulcatus* (Tables 1, 2, 3, 4, 5, and 6). The highest concentrations of Cd, Pb, and Zn (respectively, 6.33, 24.0, and 21.33 μg/g wet weight) were noted in the gills, but the highest level of Ni, Cu, and Co (3.0, 11.67, and 1.36 μg/g wet weight, respectively) was recorded in the exoskeleton of the shrimp. The analysis of heavy metal levels revealed that Pb and Cd were high in Jazan. The use of agricultural chemicals may be the cause of high concentration of Cd in Jazan. In contrast, the boat and ship services between Jazan Port and Farasan Island might be the reason for the significant increase in Pd levels in seawater.

The total concentration of 10 substantial metals (Cd, Cu, Fe, Mn, Cr, Pb, Se, As, and Zn) was not really settled in various tissues of four chosen normal red ocean fish species, namely, *Plectorhynchus schotaf*, *Lethrinus nebulosus*, *Epinephelus* sp., and *Cetoscarus pulchellus*. There was an exceptionally critical ($P < 0.01$) distinction among the four species of fish and between internal organs for the gathering of every one of the 10 metals (Tables 1–9). The centralization of Fe was most noteworthy firmly followed by Zn, while Cd was recognized in the least fixation. The liver amassed the most noteworthy centralization of metals, and muscles had the convergence of every single concentration on metal. It has been seen that *Lethrinus nebulosus* collected the most elevated grouping of all out examined components in this review, which shows that this species can possibly aggregate all of metals in each tissue [12].

The concentration of Cu, Pb, Cd, and As in the fish from Arabian Sea, Indian Ocean, and Red Sea was determined. The findings of the study show that Cd occurrence is common in fish from the three locations irrespective of the fish size. This seeks regular monitoring for heavy metals,

Table 1: Bioaccumulation of cadmium reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Plankton	3.82	μg/g dw	Saad and Fahmy [6]	1996
Abudefduf saxatilis	0.6	μg/g dw	Hilal and Ismail [8]	2008
Blackspot emperors	1.23	μg/g dw	Alturiqi and Albedair [9]	2012
Grouper	2.3	μg/g dw	Alturiqi and Albedair [9]	2012
Sardine	3.17	μg/g dw	Alturiqi and Albedair [9]	2012
Red sea bream	0.006	$\mu g\,g^{-1}\,\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Red mullet	0.018	$\mu g\,g^{-1}\,\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Emperor	0.019	$\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Cetoscarus	0.71	μg/g	Al-Ghanim et al. [12]	2015
Plectorhynchus	0.96	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	0.97	μg/g	Al-Ghanim et al. [12]	2015
Lethrinus	1.07	μg/g	Al-Ghanim et al. [12]	2015
Penaeus	1.57	μg/g	El Gendy et al. [11]	2015
Penaeus semisulcatus	6.33	μg/g	Younis et al. [25]	2021
10 fish spp.	0.098	mg/g dw	Younis *et al.* [10]	2015
Mugil cephalus	0.005	$\mu g\,g^{-1}$	Bahhari *et al.* [14]	2017
Lethrinus miniatus	0.007	$\mu g\,g^{-1}$	Bahhari *et al.* [14]	2017
Liptopenaeus vannamei	0.63	$\mu g\,g^{-1}$	Mortuza and Al-Misned [15]	2017
Nereis succinea	0.85	μg/g	Said et al. [20]	2017

Table 2: Bioaccumulation of copper reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Plankton	195.92	μg/g dw	Saad and Fahmy [6]	1996
Bivalves	5.95	μg/g dw	El-Sikaily *et al.* [7]	2004
Abudefduf saxatilis		μg/g dw	Hilal and Ismail [8]	2008
Grouper	7.93	μg/g dw	Alturiqi and Albedair [9]	2012
Blackspot emperors	2.3	μg/g dw	Alturiqi and Albedair [9]	2012
Sardine	9.74	μg/g dw	Alturiqi and Albedair [9]	2012
Red sea bream	0.278	$\mu g\,g^{-1}$	Obaidat et al. [13]	2015
Penaeus	5.33	μg/g	El Gendy et al. [11]	2015
Emperor	0.299	$\mu g\,g^{-1}$	Obaidat et al. [13]	2015
Red mullet	0.386	$\mu g\,g^{-1}$	Obaidat *et al.* [11]	2015
Plectorhynchus	15.72	μg/g	Al-Ghanim et al. [12]	2015
Cetoscarus	27.89	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	45.12	μg/g	Al-Ghanim et al. [12]	2015
Lethrinus	53.9	μg/g	Al-Ghanim et al. [12]	2015
10 fish spp.	0.328	mg/g dw	Younis *et al.* [10]	2015
Penaeus semisulcatus	11.67	μg/g	Younis et al. [25]	2015
Lethrinus miniatus	0.34	$\mu g\,g^{-1}$	Bahhari *et al.* [14]	2021
Nereis succinea	0.95	μg/g	Said et al. [20]	2017
Liptopenaeus vannamei	3.82	$\mu g\,g^{-1}$	Mortuza and Al-Misned [15]	2017
Gastropods	13.4	μg/g	Erving [16]	2017
Mugil cephalus	0.442	$\mu g\,g^{-1}$	Bahhari *et al.* [14]	2017

especially Cd, in the fish traded internationally. Levels of heavy metals in red mullet fish, red sea bream fish, and emperor fish are shown in Tables 1, 2, 5, and 9. The average concentration of Cu in red mullet, red sea bream fish, and emperor was 0.386 ± 0.170, 0.278 ± 0.125, and $0.299 \pm 0.109\,\mu g\,g^{-1}$ w.w, respectively, for Red Sea fish; 0.381 ± 0.203, 0.318 ± 0.150, and $0.279 \pm 0.144\,\mu g\,g^{-1}$ w.w, respectively, for Indian Ocean fish; and 0.269 ± 0.136, 0.341 ± 0.111, and $0.333 \pm 0.132\,\mu g\,g^{-1}$ w.w, respectively, for fish from Arabian Sea [13].

Table 3: Bioaccumulation of manganese and nickel reported from the Red Sea.

Species	Heavy metal	Concentration	Unit	Author(s)	Year
Plankton	Mn	40.72	μg/g dw	Saad and Fahmy [6]	1996
Bivalves	Mn	4.815	μg/g dw	El-Sikaily et al. [7]	2004
Abudefduf saxatilis	Mn	1.3	μg/g dw	Hilal and Ismail [8]	2008
Blackspot emperors	Mn	7.72	μg/g dw	Alturiqi and Albedair [9]	2012
Sardine	Mn	10.93	μg/g dw	Alturiqi and Albedair [9]	2012
Grouper	Mn	11.57	μg/g dw	Alturiqi and Albedair [9]	2012
Cetoscarus	Mn	4.99	μg/g	Al-Ghanim et al. [12]	2015
Plectorhynchus	Mn	2.92	μg/g	Al-Ghanim et al. [12]	2015
Lethrinus	Mn	11.69	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	Mn	9.33	μg/g	Al-Ghanim et al. [12]	2015
Nereis succinea	Mn	0.87	μg/g	Said et al. [20]	2017
Liptopenaeus vannamei	Mn	0.9	$\mu g\, g^{-1}$	Mortuza and Al-Misned [15]	2017
Gastropods	Mn	3.56	μg/g	Erving [16]	2017
Bivalves	Ni	3.33	μg/g dw	El-Sikaily et al. [7]	2004
Abudefduf saxatilis	Ni	3.9	μg/g dw	Hilal and Ismail [8]	2008
Penaeus	Ni	0.8	μg/g	El Gendy et al. [11]	2015
Liptopenaeus vannamei	Ni	0.19	$\mu g\, g^{-1}$	Mortuza and Al-Misned [15]	2017

Table 4: Bioaccumulation of selenium and zinc reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Lethrinus	1	μg/g	Al-Ghanim et al. [12]	2015
Cetoscarus	1.6	μg/g	Al-Ghanim et al. [12]	2015
Plectorhynchus	1.81	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	3.3	μg/g	Al-Ghanim et al. [12]	2015
Plankton	179.18	μg/g dw	Saad and Fahmy [6]	1996
Bivalves	17.39	μg/g dw	El-Sikaily *et al.* [7]	2004
Abudefduf saxatilis	10.9	μg/g dw	Hilal and Ismail [8]	2008
Grouper	21.23	μg/g dw	Alturiqi and Albedair [9]	2012
Sardine	22.21	μg/g dw	Alturiqi and Albedair [9]	2012
Blackspot emperors	37.8	μg/g dw	Alturiqi and Albedair [9]	2012
Plectorhynchus	2.91	μg/g	Al-Ghanim et al. [12]	2015
Cetoscarus	3.87	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	5.2	μg/g	Al-Ghanim et al. [12]	2015
Lethrinus	5.42	μg/g	Al-Ghanim et al. [12]	2015
10 fish spp. (muscles)	3.0081	mg/g dw	Younis *et al.* [10]	2015
Penaeus	17.33	μg/g	El Gendy et al. [11]	2015
Penaeus semisulcatus	21.33	μg/g	Younis et al. [25]	2015
Gastropods	0.129	μg/g	Erving [16]	2017
Liptopenaeus vannamei	14.05	$\mu g\, g^{-1}$	Mortuza and Al-Misned [15]	2017
Lethrinus miniatus	1.495	$\mu g\, g^{-1}$	Bahhari *et al.* [14]	2017
Mugil cephalus	2.891	$\mu g\, g^{-1}$	Bahhari *et al.* [14]	2017

Bahhari et al. [14] estimated the levels of four heavy metals Cu, Pb, Zn, and Cd in gills as well as muscles of two marine fishes, *Mugil cephalus* and *Lethrinus miniatus*, and seawater sampled in summer 2014 from two locations of Jizan coastal region of Red Sea, Saudi Arabia. The level of zinc was greater than that of other heavy metals throughout samples, in the following order Zn›Cu›Pb›Cd. The mean of the highest metal concentration was recorded for Zn ($11.087 \pm 1.672\,\mu g\, g^{-1}\,\mu g\, g^{-1}$ wet weight) in the gill tissues of *L. miniatus*, Cu ($0.548 \pm 0.249\,\mu g\, g^{-1}\,\mu g\, g^{-1}$ wet weight) in the gill tissues of *M. cephalus*, Pb ($0.131 \pm 0.092\,\mu g\, g^{-1}\,\mu g\, g^{-1}$ wet weight) in the gills of *M. cephalus*, and

Table 5: Bioaccumulation of lead reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Bivalves	1.46	μg/g dw	El-Sikaily *et al.* [7]	2004
Abudefduf saxatilis	5.6	μg/g dw	Hilal and Ismail [8]	2008
Sardine	3.24	μg/g dw	Alturiqi and Albedair [9]	2012
Blackspot emperors	7.5	μg/g dw	Alturiqi and Albedair [9]	2012
Grouper	8.18	μg/g dw	Alturiqi and Albedair [9]	2012
Red sea bream	0.002	$\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Red mullet	0.016	$\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Plectorhynchus	0.24	μg/g	Al-Ghanim et al. [12]	2015
Lethrinus	0.47	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	0.49	μg/g	Al-Ghanim et al. [12]	2015
Cetoscarus	0.69	μg/g	Al-Ghanim et al. [12]	2015
Emperor	0.001	$\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Penaeus	2.33	μg/g	El Gendy et al. [11]	2015
Penaeus semisulcatus	24.0	μg/g	Younis et al.	2021
10 fish spp.	0.3	mg/g dw	Younis *et al.* [10]	2015
Mugil cephalus	0.003	$\mu g\,g^{-1}$	Bahhari *et al.* [14]	2017
Lethrinus miniatus	0.005	$\mu g\,g^{-1}$	Bahhari *et al.* [14]	2017
Gastropods	3.22	μg/g	Erving [16]	2017
Liptopenaeus vannamei	1.06	$\mu g\,g^{-1}$	Mortuza and Al-Misned [15]	2017

Table 6: Bioaccumulation of cobalt and chromium reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Abudefduf saxatilis	10.3	μg/g dw	Hilal and Ismail [8]	2008
Cetoscarus	41.72	μg/g	Al-Ghanim et al. [12]	2015
Plectorhynchus	8.66	μg/g	Al-Ghanim et al. [12]	2015
Lethrinus	26.4	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	26.53	μg/g	Al-Ghanim et al. [12]	2015
Liptopenaeus vannamei	4.35	$\mu g\,g^{-1}$	Mortuza and Al-Misned [15] [15]	2017
Abudefduf saxatilis	3.2	μg/g dw	Hilal and Ismail [8]	2008
Penaeus	0.5	μg/g	El Gendy et al. [11]	2015
Penaeus semisulcatus	1.36		Younis et al. [25]	2021

Table 7: Bioaccumulation of iron reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Abudefduf saxatilis	20.5	μg/g dw	Hilal and Ismail [8]	2008
Grouper	4.87	μg/g dw	Alturiqi and Albedair [9]	2012
Blackspot emperors	76.43	μg/g dw	Alturiqi and Albedair [9]	2012
Sardine	141.38	μg/g dw	Alturiqi and Albedair [9]	2012
Lethrinus	260.9	μg/g	Al-Ghanim et al. [12]	2015
Plectorhynchus	262.62	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	302.04	μg/g	Al-Ghanim et al. [12]	2015
Cetoscarus	308.01	μg/g	Al-Ghanim et al. [12]	2015
Gastropods	300.5 ppm	μg/g	Erving [16]	2017

Table 8: Bioaccumulation of mercury reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Blackspot emperors	0.026	μg/g dw	Alturiqi and Albedair [9]	2012
Sardine	0.041	μg/g dw	Alturiqi and Albedair [9]	2012
Grouper	0.043	μg/g dw	Alturiqi and Albedair [9]	2012
Epinephelus	0.11	μg/g	Al-Ghanim et al. [12]	2015
Lethrinus	0.12	μg/g	Al-Ghanim et al. [12]	2015
Cetoscarus	0.12	μg/g	Al-Ghanim et al. [12]	2015
Plectorhynchus	0.17	μg/g	Al-Ghanim et al. [12]	2015

Table 9: Bioaccumulation of arsenic reported from the Red Sea.

Species	Concentration	Unit	Author(s)	Year
Emperor	0.002	$\mu g\,g^{-1}\,\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Red sea bream	0.003	$\mu g\,g^{-1}\,\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Red mullet	0.352	$\mu g\,g^{-1}\,\mu g\,g^{-1}$	Obaidat *et al.* [13]	2015
Lethrinus	0.38	μg/g	Al-Ghanim et al. [12]	2015
Cetoscarus	0.45	μg/g	Al-Ghanim et al. [12]	2015
Plectorhynchus	0.63	μg/g	Al-Ghanim et al. [12]	2015
Epinephelus	0.74	μg/g	Al-Ghanim et al. [12]	2015

Cd ($0.064 \pm 0.017\,\mu g\,g^{-1}\,\mu g\,g^{-1}$ wet weight) in the gills of *L. miniatus*. Levels of analyzed metals in water samples were found to follow a similar order as found in the fish tissues Zn›Cu›Pb›Cd (Tables 1, 2, 4, and 5). They recommended more extensive investigations.

The review was directed to survey heavy metal concentration in water, white shrimp, and sediment (*Litopenaeus vannamei*) from Red Sea coast of Jizan, Saudi Arabia. The concentration of heavy metals in water was over the suggested drinking water norm arrangement by the WHO/USEPA. The concentration of heavy metals in silt and *L. vannamei* was less than the proposed levels of international food standards by the WHO/USEPA, aside from the Cr level in tissues of *L. vannamei* (Tables 1, 2, 3, 4, 5, and 6). The unprecedented levels of Cr contamination in the tissues of shrimp from the Red Sea, Jazan, is alarming, as increased Cr in the human body is likely to cause serious health issues [15].

The study conducted by Erving [16] found that molluscs accumulated high levels of heavy metals such as manganese, iron, lead, zinc, and copper. The gastropods are exposed to high levels of heavy metals along the Egyptian coast of the Red Sea, and these heavy metals are getting accumulated in their shells and soft tissues. The sampling area with the highest contamination sources carries these toxic heavy metals along the coastal Red Sea zone reaching the habitat of these molluscs. The lead mine close to the examining site was viewed as an expected wellspring of heavy metals (Tables 2, 3, 4, 5, and 7).

Studies on harmful heavy metals like cadmium, arsenic, mercury, and lead present in fishes by investigating 73 fish species and 1027 consumable fish tissues from 12 stations along the eastern and western coast of Saudi Arabia uncovered significant variations in metal concentrations across the area and fish species. Some heavy metals were within the maximum permissible limits. Besides, high hazard (HI > 10) was reported in some fish species like *Epinephelus tauvina*; the regular consumption may cause health issues [17].

In a study conducted on the polychaete worm *Nereis succinea* [18], the four heavy metals, Pb, Mn, Cu, and Cd, were recorded from two Red Sea areas. The average values of Mn (0.87 ± 0.56), Cd (0.85 ± 0.33), and Cu (0.95 ± 0.13) are seen to be 3 times greater than the second site in comparison to the first site, Mn (0.18 ± 0.02), Cd (0.26 ± 0.23), and Cu (0.31 ± 0.34) [19] (Tables 1, 2, and 3).

Natural contamination by substantial metals in the earthly climate happens through an assortment of human exercises, for example, water transport, mining, refining, mineral purifying, burning of nonrenewable energy sources, and utilization of composts and pesticides in horticulture and metal-related businesses. The effluents delivered by these businesses contain an assortment of substantial metals, like chromium, cadmium, copper, lead, zinc, and nickel, and their delivery in water ecosystems may fundamentally add to the expanded presence of harmful heavy metals in marine conditions. Due to their high solubility in water, heavy metals are absorbed without difficulty by living beings. Their circulation in natural water bodies and their toxicity to plants and animals are considered a major inorganic pollutant in aquatic systems. Even if it is accumulated in low concentrations, their defiance to disintegration and their continued presence in aquatic systems show that their concentration in different strata is likely to increase by biomagnification. This will produce adverse effects on them due to the toxic effects of the heavy metals.

The Red Sea is destined as one of the world's most distinctive ecosystems in terms of coastal and neritic environments as they are reservoirs of endemic and tolerant marine biodiversity and the related systems of coral reefs, marine fauna, and other varied and unique coastal ecosystems [20]. More than 1200 species of fish have been documented from the Red Sea [21, 22]. For the most part, ordinary utilization of fish is suggested because it is a good source of omega-3 unsaturated fatty acids, which have been related to medical advantages. In any case, tissue of some fish species contains substantial metals in high concentrations, which might present a wellbeing hazard for people that consume them in critical amounts. Consequently, during the last couple of years, the assessment of heavy metals in fish has become a matter of great concern worldwide, particularly in Saudi Arabia [17].

Wide variation in heavy metal accumulation can be noted among different species of the same group, even from a particular locality [12]. The comparative studies conducted on meiobenthos of Jizan and Farasan showed a significant variation in the abundance value, which might be attributed to anthropogenic activities. Pollution due to sewage treatment and industrial effluents, discharge of desalination plants, and the heavy metal and oil by the fishing activities along the Jizan coast impacted the meiobenthos community [21, 22]. It is suggested that the adoption of bioprocess using volatile bacterial metabolites could reduce the concentrations of heavy metals in the sewage discharge that reach the Red Sea from the sewage treatment plants located along the Red Sea coast [22, 23].

Studies in the Red Sea coast of Egypt [18, 24] show that the concentration of heavy metals like Cd, Mn, Pb, Cu, Fe, and Zn were quantified in the liver, gills, and muscles of 14 different fish species. The heavy metal accumulation showed significant variation among fish species and organs. The liver tissue of most of the species showed high Cu, Zn, and Fe levels, whereas Pb and Mn were high in the gills. El-Moselhy et al. [19] recorded notable differences in heavy metal accumulation in different fish species studied and found that Cd, Fe, Ni, and Cr were higher than the standard concentration.

That is the reason for selecting some sentinel organisms of wider tolerance and distribution, like mussels being used for pollution monitoring programs like mussel watch programs. Monitoring of heavy metal accumulation in bivalves is an important step in surveillance. No such wider monitoring is done along the Red Sea, even though we have a wide range of studies in this direction [25, 26]. Concentrations of 10 heavy metals were estimated in different organ tissues of four selected common Red Sea fish species, *Lethrinus nebulosus*, *Cetoscarus pulchellus*, *Plectorhynchus schotaf*, and *Epinephelus spp.* Fe and Zn recorded high values while Cd was low in the tissues [27].

4. Conclusion

A scientific treatment of wastewater and planning of efficient and eco-friendly industrial activities throughout the Red Sea coastal region are highly recommended to reduce the pollution risk of the marine ecosystem by heavy metals. The heavy metals like Fe, Cr, Cu, Co, Zn, Mn, and Cd reaching the Red Sea were originating from terrestrial sources due to weathering of the Precambrian rocks located near the coastal zone, whereas Ni, As, Sb, Pb, and Hg were originating mainly by the developmental activities.

For proper marine recourse management, a broad understanding of the status and threats of biological diversity of the region is necessary. Regular monitoring is required in the Red Sea coast as many industrial and tourism projects are coming up. This will help to monitor the impact of these changes in the marine ecosystem. Since the Red Sea covers the coastal regions of Eretria, Sudan, Egypt, Saudi Arabia, and Yemen, a comprehensive biomonitoring system should be implemented to protect the fishery resources, unique biodiversity, and fragile coral reef ecosystems of the Red Sea from heavy metal and other land-based pollutants.

Data Availability

Data and information for the review article are included in the manuscript.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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