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HEAVY METAL CONTENT IN PACIFIC AND ATLANTIC OYSTER MEAT: A SYSTEMATIC REVIEW

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Abstract

One of the extra seafood elements is shellfish. Microorganisms will quickly change inorganic forms of seawater containing high amounts of metals from ports, ship traffic, and industrial waste into organic molecules. Plankton and algae will absorb these organic substances, which will then be consumed by other marine creatures such as shellfish. Methods: PubMed, Scopus, Scimago, MDPI, and Web of Science databases were selected as search platforms. Results. The results showed that Zn had the highest concentration in oysters, followed by Cu, Cd, and Pb. The main contaminants found in the Luoyangjiang River estuary were Cd, Cu, Pb, and Zn. Zinc was the highest metal detected in total soft tissue, genitals, and shells with average concentrations of 28.55±6.76, 30.55±3.89, and 8.22±2.98 µg/g, respectively. The Pb concentration in one of the six Egeria congica analyzed exceeded the EU permissible limit of 0.5 mg kg 1 (ww). The average Zn value in all species exceeded the CFIA permissible limit of 50 mg kg 1 (ww). Conclusion. Oysters can reflect long-term exposure to copper and zinc contamination. P. viridis oysters are better indicators of environmental pollution than Crassostreid oysters. Oysters from the Gulf of Paria had significantly higher average levels of cadmium, copper, nickel, and zinc than oysters from the northern coast of Venezuela. Green mussels at different ages and sizes affected Pb levels.

Keywords: *accumulation, heavy metals, oyster, mollusk.*

1. INTRODUCTION

The buildup of heavy metals in oysters has drawn more attention since eating oysters can be harmful to human health. Dang et al. (2022) report that the concentration of heavy metals in oysters and clams was As > Cd > Pb > Hg, with As being the most prevalent metal among those tested (1). The possible health concerns linked to heavy metal buildup in these bivalves are highlighted by this study. The spatiotemporal trends of heavy metals in oysters from the coastal waters of the northern South China Sea were further examined by Wang et al in 2022(2). The spatiotemporal trends of heavy metals in oysters from the coastal waters of the northern South China Sea were further studied by Wang et al. in 2022(2). Tang (2023) suggested that there was a decrease in heavy metal levels between 1989 and 2015, although there were variations in some places, such as the Pearl River Estuary. The health hazards associated with oyster consumption and heavy metal exposure were measured using various indices; since 2005, the risk levels have decreased significantly. Tang's (2023) study emphasized the importance of monitoring heavy metal concentrations in oysters to ensure food safety and protect public health. The above findings provide significant perspectives for researchers who want to study heavy metals such as lead (Pb) and mercury (Hg) in oysters, thus supporting the evaluation of possible hazards associated with heavy metal contamination in seafood(3). Recent investigations have shown that the content of heavy metals in marine shells is a fascinating issue. Jian et al. (2021) examined the presence of trace elements in coral sand samples and eggshells of green turtles from Xisha Islands nesting locations. They discovered strong relationships between the amounts of Cd and Se and the levels of Zn, Cu, and Pb in eggshells. Furthermore, there was a correlation between the concentrations of coral sand sediments and eggshells for Mn, Zn, Se, As, Cd, and Pb. While the concentration of Se was within the danger quota scenario, the concentration of Cu was higher than the hazardous reference value for bird eggs. Recent studies have focused on the bioaccumulation of heavy metals in the farmed oyster Crassostrea gigas(4). To assess the bioavailability of trace metals in oysters collected from an experimental aquaculture farm, Jonathan et al. (2017) conducted a study in Mexico. The findings showed that the main sources of hazardous metal enrichment in oysters were sewage discharge, fertilizers used in agriculture, and shrimp production(5). This study aims to examine the heavy metal content of oyster meat due to contamination of waters where oysters live in various regions of the world.

2. METHODOLOGY

2.1 Sources of Information used for Research

The sources used for information are Scopus, Scimago, MDPI, PubMed, and Web of Science.

2.2. Inclusion Criteria

1. Laboratory research to examine the heavy metal content in oyster meat due to the influence of environmental pollution in oyster habitats..
2. Articles in English
3. Published between 2005 and 2024.

2.3. Exclusion Criteria

(1) Systematic review study.

(2) Observational research.

(3) Intervention study.

(4) Articles not in English.

2.4. Consort Flow Diagram

360 articles found from the source Scopus, Scimago, MDPI, PubMed, Web of Science.

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Found 140 articles about heavy metal content in oyster meat.

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33 articles were excluded because they did not meet the inclusion criteria.

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7 articles were studied in this review from 2005-2024.

2.5 Procedure

We carefully examined electronic databases like Google Scholar, Scopus, Scimago, MDPI, PubMed, and PubMed for English-language publications. The amount of heavy metals in oyster meat from contaminated waters was the main area of interest. Boolean associations of descriptors were used to make first decisions. Next, article titles, summaries, and complete texts were read. Researchers meticulously recorded and compiled the number of publications found in the electronic databases during the study selection procedure, along with the number of papers that were eliminated or duplicated.

2.6 Characteristics of samples taken according to inclusion criteria

Authors, year, country	Methode used	Results	Conclusion
Shaari 2016. Malaysia	Oysters were sampled from wild, rack, and string cultures, then their tissues were freeze-dried, ground, and stored for analysis. Shells were cleaned, dried, ground, and	Zinc was the highest metal detected in total soft tissue, sex and shell with average concentrations of 28.55±6.76, 30.55±3.89 and 8.22±2.98 μg/g respectively. The	The research concluded that metal concentrations in Crassostrea sp. were within safe limits and reflected environmental contamination levels. Zn was the highest detected metal, with no significant differences between sampling sites or sexes.

	homogenized before chemical analysis following modified US EPA Method 200.3.	analyzed metals accumulated more in the gills than other organs with average values of 74.11±13.03 µg/g Zn, 4.82±0.82 µg/g Cu, 0.61±0.06 µg/g Pb, and 0.45±0.1 µg/g Cd.	
Astudillo, 2005. Venezuela	Samples were digested with nitric, sulphuric, and hydrochloric acids, then analyzed using atomic absorption spectrophotometry. Methods were validated with Standard Reference Materials to ensure quality control.		
	The results showed that mercury in sediments at all sites in Trinidad and Venezuela exceeded NOAA and Canadian sediment quality guidelines, while cadmium, copper, nickel, lead, and zinc also exceeded these guidelines at some sites. Oysters from the Gulf of Paria had significantly higher average levels of cadmium, copper, nickel, and zinc than oysters from the northern coast of Venezuela, but this difference was not seen in shellfish.	P. viridis mussels are better indicators of environmental pollution than Crassostreid oysters. Oysters can reflect longer-term exposure to copper and zinc contamination.	
Sarong, 2015. Indonesia	Sampling was conducted at four	The results of the study revealed that	The oysters from the Lamnyong River estuary

	sites within the Lamnyong river estuary, with oysters collected in May 2013 and March 2014. Heavy metal analysis of oyster tissues was performed using Atomic Absorption Spectrophotometry following standard procedures.	Pb, Cd and Zn were detected in oysters. Zn concentration increased from 3.778 ppm to 11.567 ppm in May 2013 and March 2014 respectively; Pb concentration was not detected to 0.017 ppm in May 2013 and March 2014 respectively; while Cd concentration decreased from 0.152 ppm to 0.015 ppm in the same period. The highest Pb concentration was found at station IV (0.029 ppm), Cd at station I (0.093 ppm), and Zn at stations II and III (8.069 ppm and 8.030 ppm respectively).	are contaminated with lead, cadmium, and zinc, exceeding safe consumption limits. Heavy metal concentrations in these oysters increased from May 2013 to March 2014.
Krismonita, 2023. Indonesia	Purposive sampling was used to collect green mussels from cultivation rafts in Pasaran Island, following Indonesian National Standards. Heavy metals Pb, Hg, and Cd were analyzed using Atomic Absorption Spectrophotometry.	The results of the study showed that green mussels at various ages and sizes affected the Pb metal content, while an increase of one unit of age and size of green mussels did not affect the Hg and Cd metal content. The highest bioconcentration of Pb and Hg metals was obtained at the age of 9 months, while Cd metal was obtained at the age of 3 months.	Green mussels can accumulate heavy metals from their environment, posing health risks even at low concentrations. The study highlights the need for careful monitoring of heavy metal contamination in coastal areas.
Ke, 2024. China	This study was conducted in an	The results showed significant variations	The primary contaminants found in

	aquaculture area in the Luoyangjiang River estuary, where eight sampling sites were selected. Water, sediment, and oysters categorized by shell length were collected from each site.	in dissolved phase metal concentrations and suspended particles (SPM) across sampling sites, while sediment metal concentrations were more consistent but similar to those in SPM. Large oysters consisted of 50% Magallana angulata and 50% Magallana gigas, while small oysters were identified as Magallana sikamea. The levels of Cd, Cu, Pb, and Zn in both oyster size groups exceeded data from previous studies, indicating contamination in the estuary. In our study area in the Luoyangjiang River estuary, the main pollutants identified were Cd, Cu, Pb, and Zn.	the Luoyangjiang River estuary, where we conducted our investigation, were Cd, Cu, Pb, and Zn. Additionally, the accumulation of heavy metals was greatly impacted by species differences in oysters. The biological mechanism of metal accumulation varies among species, and this variation may be caused by a variety of variables. Since oysters are dependable biomonitoring indicators in aquaculture settings, precise identification of oyster species is crucial. Our research is useful in lowering the dangers of heavy metal pollution in bivalve aquaculture, guaranteeing the safety of seafood, and preserving the wellbeing of this strategically significant agricultural region both environmentally and economically.
Suami, 2019. Congo	Samples were collected, washed, dissected, frozen, and stored before being digested and analyzed using ICP-MS and AAS. Quality control involved triplicate measurements and certified reference material to ensure precision and reliability.	The results showed that heavy metal concentrations varied significantly between sampling locations and species analyzed ($P < 0.05$). High concentrations of Cr, Mn, Co and Fe were found in Egeria congica; Cu in Macrobrachium spp., and Hg and Sb in Parapenaeus spp. The Cu levels	High metal concentrations in oysters and shrimp from the Atlantic Coast of DRC pose potential health risks to consumers. Metal pollution is attributed to activities like oil exploitation, fuel traffic, and erosion.

		in 33.3% of Macrobrachium spp. samples and 16.7% of Egeria congica samples exceeded the FAO permissible limit of 30 mg kg 1 (wet weight (ww). The Pb concentration in one of the six Egeria congica analyzed exceeded the EU permissible limit of 0.5 mg kg 1 (ww). The average Zn values in all species exceeded the CFIA permissible limit of 50 mg kg 1 (ww)..	

3. RESULTS

Yaqin's (2018) research found that although the Condition Index (CI) of window oysters (Placuna placenta) can be used as a morphological marker for lead (Pb) contamination, the correlation between CI and Pb content in tissue is stronger than in shells, although there is no statistically significant correlation. This study collected 100 Placuna placenta oysters from Mandalle waters and measured their morphometry in the laboratory. Lead content in tissues and shells was analyzed using Atomic Absorption Spectrophotometry. Meanwhile(6), Suami's (2019) research provides a comprehensive analysis of metal concentrations in oysters and shrimp from the Atlantic Coast of the DRC, using advanced ICP-MS techniques to reveal significant levels of contamination, thus contributing valuable data on environmental pollution in this region. Sample testing methods include samples collected, washed, dissected, frozen, and stored before digestion and analysis using ICP-MS and AAS. Quality control involves triplicate measurements and certified reference materials to ensure precision and reliability(7). Krismonita's (2023) research highlighted significant heavy metal contamination in green mussels from Lampung Bay, emphasizing bioaccumulation and potential health risks, and utilized Atomic Absorption Spectrophotometry (AAS) for precise heavy metal analysis, making it an important study for environmental monitoring and public health. The method of sampling green mussels from the cultivation raft on Pasaran Island was carried out intentionally, following the Indonesian National Standard. Heavy metals Pb, Hg, and Cd were analyzed using Atomic Absorption Spectrophotometry(8).

A study by Sarong (2015) provides important insights into the levels of cadmium, lead and zinc contamination in oysters from the Lamnyong River estuary, highlighting the significant environmental and public health concerns resulting from heavy metal pollution in this rapidly developing region of Banda Aceh, Indonesia. The practical implications of this study are - The oysters from the estuary of Lamnyong River are not safe for human consumption due to contamination by lead, cadmium, and zinc exceeding permissible limits(9). Astudillo's (2005) research revealed that P. viridis mussels are a more effective indicator of environmental pollution than Crassostreid oysters, with the discovery of a significant correlation between metal concentrations in P. viridis tissue and sediment, thus indicating its potential use in developing coastal environmental monitoring systems in the Caribbean. Contribution to the research results of Astudillo (2005) - P. viridis oysters are better indicators of environmental pollution than Crassostreid oysters(10).

- Oysters can biologically accumulate copper and zinc, reflecting long-term metal exposure.
- Further research is needed to develop protocols for the use of local organisms as biological indicators.
- There is a need for stricter regulation and monitoring of industrial, agricultural, and domestic waste disposal to prevent heavy metal pollution in aquatic environments.
- Seasonal variations in heavy metal concentrations should be considered in environmental assessments and management plans to ensure the safety of aquatic organisms and human health.

Shaari's (2016) research highlighted significant bioaccumulation of heavy metals in the gills of Crassostrea sp., indicating its potential as a reliable bio-indicator for monitoring environmental contamination in aquatic ecosystems. This paper discusses the impact of heavy metal pollutants on aquatic environments, particularly focusing on bivalve molluscs. This paper highlights oysters as an effective bioindicator for monitoring heavy metal contamination(11). This study by Ke (2024) showed that biomonitoring using oyster tissues provided a more reliable assessment of heavy metal pollution in the Luoyangjiang River estuary compared to direct measurements of metal concentrations in environmental media, with significant correlations found between metal concentrations in oysters and various environmental matrices. Practical Implications of Ke's (2024) study are - Biomonitoring using oysters provides a more reliable assessment of heavy metal pollution compared to direct measurements in environmental media.

- Differences in oyster species have a significant impact on heavy metal accumulation, highlighting the need to consider species-specific biological mechanisms in pollution studies.
- This study emphasizes the importance of considering both dissolved and particulate pathways when interpreting heavy metal accumulation in bivalves(12)

4. CONCLUSIONS

Oysters can reflect long-term exposure to copper and zinc contamination. P. viridis oysters are better indicators of environmental pollution than Crassostreid oysters. Oysters from the Gulf of Paria had significantly higher average levels of cadmium, copper, nickel, and zinc than oysters from the northern coast of Venezuela. Green mussels at different ages and sizes affected Pb levels.

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