Bioaccumulation and Assessment of Lead, Arsenic and Nickel in Grey Mullet (*Mugil cephalus*) from the Maharashtra Coast, India

Suketu Gopal Das[1]; Kiran Mavjibhai Pariya[2]

[1,2]Department of Zoology, VPM's B. N. Bandodkar College, Thane, 400601

Publication Date: 2026/09/19

Abstract: The present research investigated the presence of lead (Pb), arsenic (As), and nickel (Ni) in the edible muscle tissue of grey mullet (M. cephalus) collected from the Maharashtra coast, India. In addition, it also evaluated the associated non-carcinogenic health risks arising from their dietary intake. Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) method was utilized to determine the concentration of metal present in the sample. All targeted metal concentrations were below the analytical limits of quantification (LOQ), with LOQ values of 0.015 mg/kg for As, 0.008 mg/kg for Pb, and 0.0037 mg/kg for Ni. To further evaluate the prospects of torment, health risk indices were calculated using LOQ based concentrations. For all the targeted metals evaluated, the estimated daily intakes (EDIs) were found to be 1.38 × 10^{-5} mg/kg/day for As, 7.33 × 10^{-6} mg/kg/day for Pb, and 3.39 × 10^{-6} mg/kg/day for Ni, respectively. Target hazard quotients (THQs) were substantially lower than the concerned levels of hazard index (HI) calculated at 0.048. Based on these result, it can be concluded that there are no significant non-carcinogenic health risks associated with the consumption of grey mullet from the Maharashtra coast due to Pb, As or Ni exposure.

Keywords: *Assessment, Bioaccumulation, Heavy Metals, Mugil cephalus, and Target Hazard Quotient.*

How to Cite: Suketu Gopal Das; Kiran Mavjibhai Pariya (2026). Bioaccumulation and Assessment of Lead, Arsenic and Nickel in Grey Mullet (*Mugil cephalus*) from the Maharashtra Coast, India. *International Journal of Innovative Science and Research Technology*, 11(9), 391-395. https://doi.org/10.38124/ijisrt/26sep167

I. INTRODUCTION

The rapid growth of urban cities has led to an increase in the number of industrial operations, and as a result, undeclared sewage discharge into the coastal and marine environment surged up. This surge has become a global environmental problem. Various heavy metals such as lead (Pb), arsenic (As) and nickel (Ni) present a high risk to humans because of their capacity to persist and bio-accumulate in food webs, toxicity (Rainbow, 2002; Burger & Gochfeld, 2005).

Fish are one of the key means of relaying metal contaminants from ecosystems to humans. Grey mullet, one of the commercially targeted and widely consumed fish species from Indian coastal region. Benthic feeding behavior, coupled with continual contact with sediments, make it a suitable indicator species for assessing metallic contaminants (Kalay & Canli, 2000, Monier M et al., 2023). Long term exposure to lead, arsenic and nickel within contaminated seafood has resulted in numerous health problems such as cardiovascular disorders, neurological disorders, renal damage and hepatic dysfunction (Jaishankar et al., 2014; ATSDR, 2019).

Urban sewage discharge, agricultural runoff, industrial activity and port operations have exerted a significant amount of anthropogenic pressure on the Maharashtra coast. However, limited information exists regarding the levels of metal contamination in key commercial fish species from the region. As a result, the goal of the study was to measure the levels of Pb, As and Ni using ICP-OES in *M. cephalus* and look at the potential for non-carcinogenic health risks to the consumers of these fish through a conservative, guideline-based approach.

II. MATERIALS AND METHODS

- *Study Area and Sample Collection:*

M. cephalus specimens were collected along the Maharashtra coast from selected fish landing centers. Under chilled conditions the samples were transported to the laboratory and immediately processed to minimize contamination and degradation.

- *Sample Preparation and Metal Analysis:*

Consumable muscle tissues were excised carefully, then rinsed with deionized water (i.e. distilled water), oven-dried at 60 °C until constant weight was achieved, and homogenized. Acid digestion of the samples was carried out

ISSN No: - 2456-2165 https://doi.org/10.38124/ijisrt/26sep167

following standard procedures that are recommended by APHA (2017). Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) method was used to quantify the concentrations of Pb, As, and Ni. Analytical quality assurance was ensured through the use of reagent blanks, calibration with certified reference standards, and replicate analyses.

- *Health Risk Assessment:*

The estimated daily intake (EDI), Target Hazard Quotient (THQ) and Hazard Index (HI) were calculated to estimate and evaluate potential risks to human health due to the consumption of *M. cephalus.* All the tested metals were below the detectable limit, LOQ values were used in risk calculation to provide a conservative estimate for exposure (Chien et al., 2002; Storelli, 2008).

A daily ingestion rate (IR) of 0.055 kg/person/day for fish was derived from typical consumption statistics that are regularly used in health risk assessments studies for Asian and Indian populations (USEPA, 2011; Ahmed et al., 2015). Average body weight (BW) of an adult was assumed to be 60 kg, as recommended for risk assessment studies conducted in developing countries (USEPA, 2011; FAO/WHO, 2011).

- *Estimated Daily Intake (EDI):*

$$\mathrm{EDI} = \frac{\mathrm{C \; x \; IR}}{\mathrm{BW}}$$

Where,

- C - Metal concentration (mg/kg, LOQ-based),
- IR - ingestion rate (kg/day),
- BW - body weight (kg).

- *Target Hazard Quotient (THQ):*

$$\mathrm{THQ} = \frac{\mathrm{EDI}}{\mathrm{RfD}}$$

The assessment values of oral reference dose (RfD) for arsenic were 0.0003 mg/kg/day, for lead were 0.0035 mg/kg/day, and for nickel were 0.02 mg/kg/day (USEPA, 2011).

- *Hazard Index (HI):*

$\mathrm{HI}=\sum_{i=1}^{n} HQ\mathrm{i}$ = HQ1+HQ2 + HQ3+……. +HQn

The value of HI below one indicates the absence of significant non-carcinogenic health risk.

III. RESULTS

The muscle tissue of *M. cephalus* had the concentrations of Pb, As and Ni below the analytical limits of quantifications of the ICP-OES method. Therefore all the metals were reported as not detected (ND) with respective LOQ values of 0.015 mg/kg for arsenic, 0.008 mg/kg for lead and 0.0037 mg/kg for nickel.

Using the LOQ based concentrations, the estimated daily intake values were calculated for As was 1.38 x 10^{-5} mg/kg/day, for Pb was 7.33 x 10^{-6} mg/kg/day and for Ni was 3.39 x 10^{-6} mg/kg/day respectively. These values are significantly lower compared to their respective reference doses.

The estimated THQ values were found to be 0.046 for As, 0.002 for Pb and 0.0002 for Ni. Additionally the cumulative hazard index (i.e. total of the individual THQ) was found to be 0.048, (< 1) thus indicating that there are no adverse non-carcinogenic effects resulting from the consumption of *M. cephalus.*

IV. DISCUSSION

Undetectable tissue burden for the concentrations of Pb, As and Ni in the muscle tissue of grey mullet from the investigated coastal area indicates minimal level of metal contamination. Similar findings of low level accumulation of these metals in the mullet and other coastal fishes have been reported from different parts of Indian coast.

The conservative LOQ based approach for health risk assessment reaffirms that these fishes are safe for human consumption. While arsenic substantially contributed towards the overall hazard index, this can be mostly attributed to the low reference doses as opposed to the elevated concentrations observed in the similar studies (Jaishankar et al., 2014). The aggregate HI remained well below the acceptable level, indicating that current exposure levels do not pose a health concern.

V. CONCLUSION

The current study demonstrates that lead, arsenic and nickel are below the limit of detection in the *M. cephalus* collected from the Maharashtra shoreline. The health risk assessment based on the conservative LOQ derived concentration indicates that the estimated daily intake and target hazard quotient are relatively low with summative hazard index of 0.048. Therefore the results of this study indicates that there is no substantial non cancer health risk to consumers of *M. cephalus.* Nevertheless, continued monitoring of metal concentration in the coastal fish species is warranted for the long term seafood safety.

- *Acknowledgement*

The authors would like to acknowledge the support and facilities provided by VPM’s B. N. Bandodkar College of Science / Department of Zoology / Library / Non - Teaching / Principal for carrying out this research. We are grateful to all individuals who contributed to the completion of this study through technical assistance, data collection, or constructive discussions. The authors also thank the anonymous reviewers for their valuable comments that helped improve the quality of the manuscript.

ISSN No: - 2456-2165 https://doi.org/10.38124/ijisrt/26sep167

DECLARATIONS

➢ *Funding:*

The authors received no specific funding for this work from any funding agency in the public, commercial or non-profit organizations.

➢ *Authors Contributions:*

Suketu Gopal Das has contributed in this by conceptualizing, investigating, sample collection, methodology, laboratory analysis, data curation, interpretation of data, analysis, and writing the original draft.

Kiran Mavjibhai Pariya has contributed by supervising, validation, interpretation of data, administration, review and editing and final approval of manuscript.

All authors have read and approved the final manuscript.

➢ *Data Availability*

The datasets generated and analyzed during the study are included in this article.

➢ *Ethics Declaration*

This study did not involve any human participants or experimental animals. The fish samples were obtained from commercial fish landing centers and no live animal experimentation was conducted. All sample collection and laboratory procedures were conducted following a standard scientific and ethical practices to minimize contamination and ensure data reliability. The authors confirm that the study complied with institutional, national and international guidelines related to ethical handling and use of aquatic organisms for research purposes.

➢ *Consent to Participate*

Not applicable. No human participants were involved in the study.

➢ *Consent to Publish*

Not applicable. This study does not contain any individual person's data in any form.

➢ *Conflict of Interest*

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

➢ *Clinical Trial Registration*

Not applicable. This study is not a clinical trial and does not involve human participants.

REFERENCES

[1]. Ahmed, M. K., Baki, M. A., Islam, M. S., Kundu, G. K., Habibullah-Al-Mamun, M., Sarkar, S. K., & Hossain, M. M. (2015). Human health risk assessment of heavy metals in tropical fish and shellfish collected from the river Buriganga, Bangladesh. Environmental science and pollution research international, 22(20), 15880–15890.
[2]. Alharbi, O. M. (2026). Bioaccumulation and Health Risk Assessment of Heavy Metals in Commercial Fish from the Red Sea, Saudi Arabia.
[3]. APHA. (2017). Standard methods for the examination of water and wastewater.
[4]. Arigbede, O., Olutona, G., & Dawodu, M. (2019). Dietary intake and risk assessment of heavy metals from selected biscuit brands in Nigeria.
[5]. ATSDR. (2019). Toxicological profile for lead, arsenic, and nickel.
[6]. Burger, J., & Gochfeld, M. (2005). Heavy metals in commercial fish in New Jersey. Environmental research, 99(3), 403-412.
[7]. Chien, L. C., Hung, T. C., Choang, K. Y., Yeh, C. Y., Meng, P. J., Shieh, M. J., & Han, B. C. (2002). Daily intake of TBT, Cu, Zn, Cd and As for fishermen in Taiwan. Science of the total environment, 285(1-3), 177-185.
[8]. FAO/WHO. (2011). Codex Alimentarius Commission.
[9]. Ghosh, S., Bakshi, M., Kumar, A., Ramanathan, A. L., Biswas, J. K., Bhattacharyya, S., ... & Rinklebe, J. (2019). Assessing the potential ecological risk of Co, Cr, Cu, Fe and Zn in the sediments of Hooghly–Matla estuarine system, India. Environmental Geochemistry and Health, 41(1), 53-70.
[10]. Islam, M. S. M. M., Bhattacharjee, S. C., Fahim, K. M., Islam, M. A., Sarkar, M. A. A., Karim, M. R., ... & Alam, M. Metallic Footprints: Mapping Trace Metal Distribution, Source and Human-Ecological Risk of Coastal Sediments Next to Heavy Industrial Area in Bangladesh. Rezaul and Chakraborty, Dipankar and Alam, Mahbub, Metallic Footprints: Mapping Trace Metal Distribution, Source and Human-Ecological Risk of Coastal Sediments Next to Heavy Industrial Area in Bangladesh.
[11]. Iwegbue, C. M., Nwozo, S. O., Overah, C. L., Bassey, F. I., & Nwajei, G. E. (2013). Concentrations of selected metals in some ready-to-eat-foods consumed in Southern Nigeria: estimation of dietary intakes and target hazard quotients. *Turkish journal of agriculture-food science and technology*, *1*(1), 1-7.
[12]. Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., & Beeregowda, K. N. (2014). Toxicity, mechanism and health effects of some heavy metals. Interdisciplinary toxicology, 7(2), 60.
[13]. KALAY, M., & CANLI, M. (2000). Elimination of essential (Cu, Zn) and non-essential (Cd, Pb) metals from tissues of a freshwater fish Tilapia zilli. Turkish Journal of Zoology, 24(4), 429-436.
[14]. Khan, S., Cao, Q., Zheng, Y. M., Huang, Y. Z., & Zhu, Y. G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environmental pollution, 152(3), 686-692.
[15]. Monier, M. N., Soliman, A. M., & Al-Halani, A. A. (2023). The seasonal assessment of heavy metals pollution in water, sediments, and fish of grey mullet,

ISSN No: - 2456-2165 https://doi.org/10.38124/ijisrt/26sep167

red seabream, and sardine from the Mediterranean coast, Damietta, North Egypt. Regional Studies in Marine Science, 57, 102744.
[16]. Rainbow, P. S. (2002). Trace metal concentrations in aquatic invertebrates: why and so what?. Environmental pollution, 120(3), 497-507.
[17]. Satarug, S., Garrett, S. H., Sens, M. A., & Sens, D. A. (2011). Cadmium, environmental exposure, and health outcomes. Ciencia & saude coletiva, 16(5), 2587-2602.
[18]. Storelli, M. M. (2008). Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: estimation of target hazard quotients (THQs) and toxic equivalents (TEQs). Food and Chemical Toxicology, 46(8), 2782-2788.
[19]. USEPA. (2011). Risk assessment guidance for Superfund.

Fig 1 Specimen of Grey Mullet Used for Analysis

Fig 2 Tissue Sample After Oven Drying at 60 °C

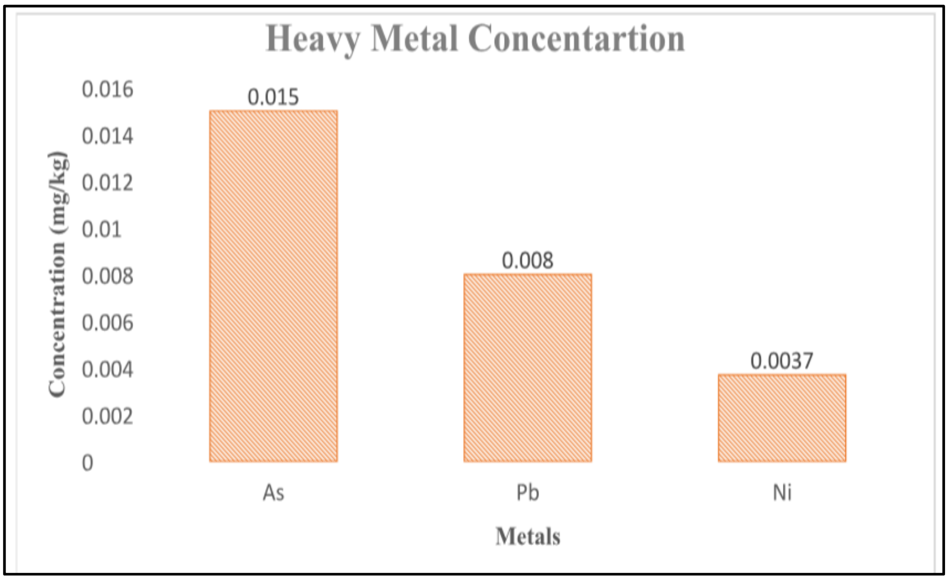

Fig 3 Heavy Metal Concentration (mg/kg) in *M. cephalus* (LOQ-Based Values)

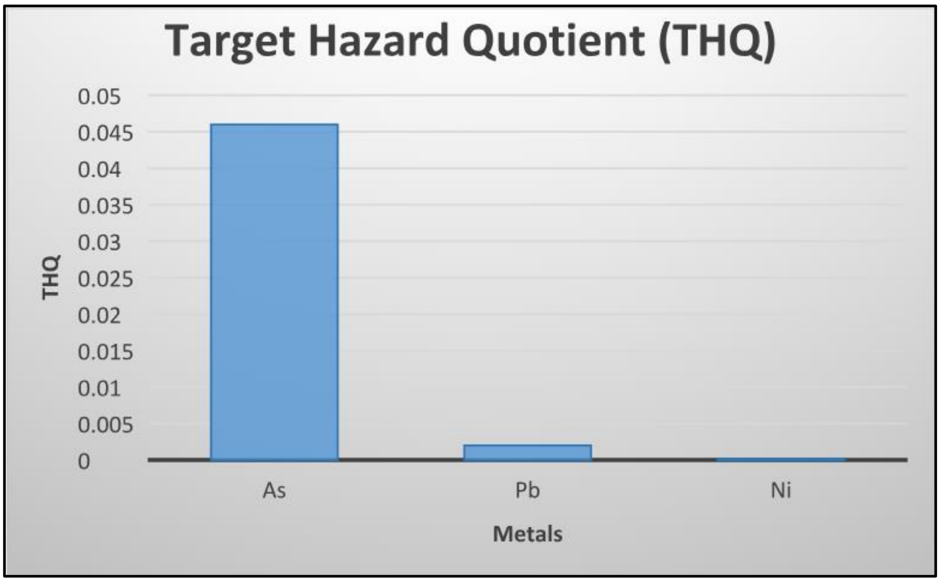

Fig 4 Target Hazard Quotient (THQ) Values of Heavy Metals

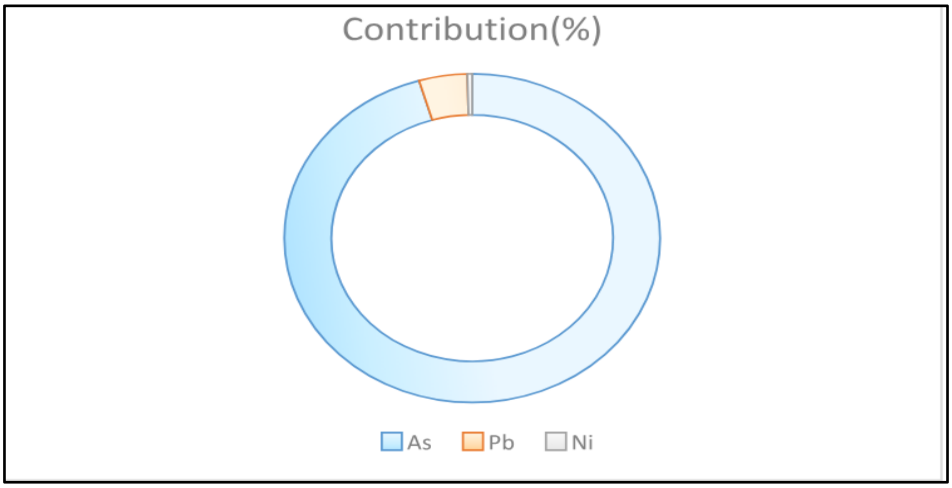

Fig 5 Contribution (%) of Metals to Total Hazard Index (HI)

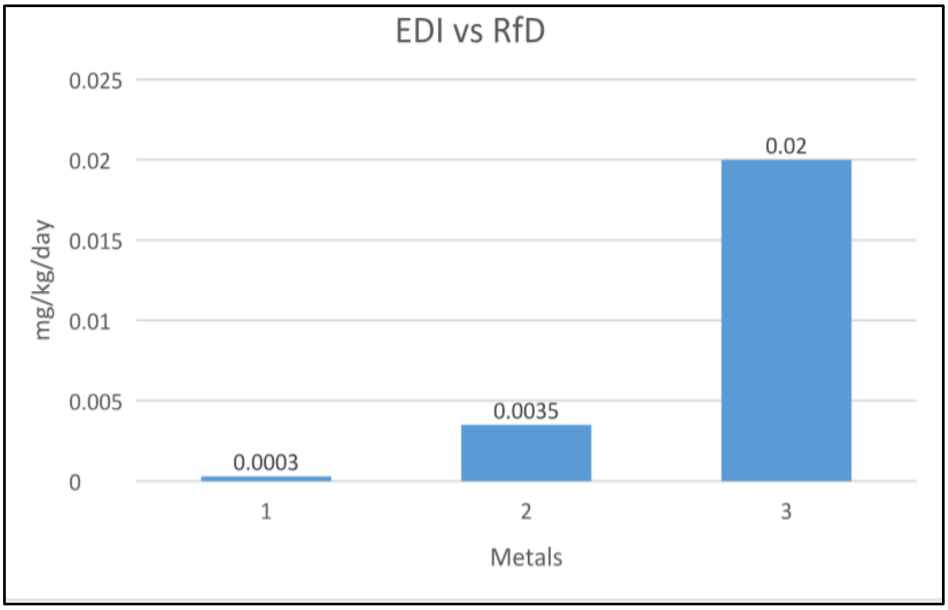

Fig 6 Comparison of EDI with Reference Dose (RfD)