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Comparative Analysis of Heavy Metal Concentration of Cu, Ni, Mn in *C. obtusa* and *T. duplicata* Snails and its health risk assessment

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Abstract:

T. duplicata and *C. obtusa* are marine gastropods that serve as valuable bioindicators for assessing heavy metal accumulation in coastal environments. These species, similar to other mollusks, have the capacity to absorb and concentrate heavy metals from their surroundings. The bioaccumulation of these toxic substances within the snails not only threatens marine ecosystems but also poses potential health risks to humans who consume contaminated marine life. This study aimed to investigate the concentration levels of heavy metals, specifically nickel (Ni), manganese (Mn), and copper (Cu), in the two snail species, using Flame Atomic Absorption Spectrometer (FAAS) . These particular heavy metals were selected due to their prevalence in coastal environments, often as a result of industrial discharge, agricultural runoff, and urban pollution. The mean heavy metal concentration for both types of samples follows the order Mn > Ni > Cu. The analysis showed that the mean concentrations of heavy metals in both *T. duplicata* and *C. obtusa* followed the order Mn > Ni > Cu. Manganese (Mn) had the highest concentration, ranging from 28.35 to 112.52 mg/kg, followed by nickel (Ni) with 1.63 to 4.47 mg/kg, and copper (Cu) with 1.53 to 3.36 mg/kg. The independent t-test results indicate no significant differences in heavy metal concentrations between *T. duplicata* and *C. obtusa* for any of the metals tested, as all p-values exceeded the significance threshold (P>0.05). Additionally, the THQ and HI values for all collected samples were less than 1, indicating no adverse health effects from consuming these snails.

Keywords: Snail, intertidal gastropods, heavy metal, health risk assessment (HRA)

1. INTRODUCTION

Intertidal gastropods, including *T. duplicata* and *C. obtusa,* are valuable indicators of environmental quality due to their sedentary nature and capacity to accumulate contaminants such as heavy metal from their surroundings (Samsi et l.,2017). Heavy metals, such as Nickel (Ni), Copper (Cu), and Manganese (Mn), are ubiquitous pollutants in coastal ecosystems, originating from various anthropogenic activities such as industrial discharge, urban runoff, and agricultural practices. The heavy metal contamination of marine environments is a pressing concern globally, with anthropogenic activities contributing significantly to the accumulation of heavy metals in coastal sediments (Bandara et. al., 2023).

T. duplicata and *C. obtusa* commonly known as “Siput tuntul” and “Siput Belitung” respectively, are prevalent inhabitants of intertidal zones across tropical and subtropical regions (Oo & Oo, 2019). Their sessile lifestyle and filter-feeding behaviour make them susceptible to the uptake of heavy metals present in sediment and water (Shaari et al., 2016). Furthermore, their abundance and widespread distribution make them ideal candidates for biomonitoring studies aimed at assessing heavy metal pollution in coastal environments. Despite their ecological importance and potential as bioindicators, limited research has been conducted on the accumulation of heavy metals in *T. duplicata* and *C. obtusa.* Understanding the bioaccumulation patterns and distribution of heavy metals in these gastropods is crucial for evaluating the extent of contamination in their habitats and assessing associated risks to ecosystem health and human well-being (Demir, 2024).

Moreover, this study seeks to address the potential human health implications of heavy metal contamination through the consumption of *T. duplicata* and *C. obtusa* by local communities. These gastropods are frequently harvested for food in some regions, raising concerns about the transfer of accumulated contaminants along the food chain. Therefore, alongside environmental monitoring, this study will incorporate a human health risk assessment to evaluate the potential exposure and health risks associated with heavy metal ingestion through the consumption of these snails. By elucidating the bioaccumulation dynamics of heavy metals in *T. duplicata* and *C. obtusa*, this study aims to provide critical

insights for assessing associated human health risks. These findings will be invaluable for policymakers, public health officials, and local communities, enabling the development of targeted mitigation strategies and promoting the sustainable management of coastal ecosystems to safeguard human health.

2. MATERIALS AND METHODS

Sampling time and location

This study was conducted over a three-month period in 2024, from April to June. Both types of samples were collected in April 2024. The study focused on two types of snails: *C. obtusa* and *T. duplicata*. Both of the sample were collected from Sekinchan, Selangor. These types of snails were selected due to their lifestyle as bottom feeders, their tolerance and bioaccumulation of heavy metals, making them good indicators of heavy metal pollution (Baroudi et al., 2020).

Procedures

The samples of both snails were deshelled and thoroughly washed. Each sample, weighing 2g for each type, was transferred into a silica crucible. A total of 30 samples for both types of snails were selected for analysis of heavy metal concentration. tissues were digested using a dry ashing procedure (Jothi et al, 2018). The samples from the crucible were then transferred into 50ml beakers. To each beaker, 5 ml of 6 M HCl (hydrochloric acid) was added. The beakers containing the samples with acid solution were placed on a hot plate and digested until a clear solution was obtained. After digestion, the final residues were filtered using filter paper and dissolved in a 1% HNO_3 solution. The solutions were then diluted to a final volume of 100 ml and transferred into centrifuge tubes. All 30 samples of *C. obtusa* and *T. obtus* were stored in the laboratory for analysis of heavy metal content using an Flame Atomic Absorption Spectrophotometer (FAAS).

Data analysis.

The data were analyzed statistically using the Statistical Package for the Social Sciences (SPSS) version 29. Analysis of variance for total heavy metal concentrations across different species was conducted using an independent t-test.

Health Risk Assessment (HRA)

Health Risk Assessment (HRA), particularly through metrics like Total Hazard Quotient (THQ) and Hazard Index (HI) as outlined in the equation 1 (Abdullah et al., 2022), is conducted for snails such as *T. duplicata* and *C. duplicata* primarily to evaluate the potential health risks associated with heavy metal contamination in these species.

$$THQ = \frac{C \times EFR \times ED \times FIR \times 10^{-3}}{RfD \times BW \times AT} \qquad (1)$$

C represents the concentration of heavy metals in these snail species, measured in mg/kg from sample analysis. EFR stands for exposure frequency, which is 365 days per year, and ED denotes exposure duration of 70 years, representing the average lifetime. FIR is the food ingestion rate for daily snail consumption, set at 8 grams per day. RfD refers to the reference dose established by the United States Environmental Protection Agency (US EPA), estimated as the daily oral exposure level that does not cause adverse effects over a lifetime. The conversion factor is 10^{-3} (Onuoha et al., 2016). The RfD for Ni, Cu, and Mn are 0.02 mg/kg/day, 0.04 mg/kg/day, and 0.14 mg/kg/day, respectively. BW stands for average adult body weight, assumed to be 60 kilograms. AT represents the averaging time of exposure for non-carcinogenic effects, calculated as 365 days per year multiplied by the number of exposure years.

$$HI = \Sigma HQ \qquad (2)$$

HI represents the cumulative sum of THQs for substances impacting the same target organ or organ system. Hence, the THQ for each parameter are aggregated to determine the overall exposure.

3. RESULTS AND DISCUSSION

Table 1 provides an analysis of the concentrations of three heavy metals Ni, Cu, and Mn in two species of gastropods: *T. duplicata* and *C. obtusa*. The results indicate that both species have relatively low concentrations of Ni and Cu. Specifically, *T. duplicata* exhibits a mean Ni concentration of 2.22 mg/kg and Cu at 2.20 mg/kg, while *C. obtusa* shows slightly higher mean concentrations of 2.34 mg/kg for Ni and 2.27 mg/kg for Cu. In contrast, Mn levels are significantly higher in both species. *T. duplicata* has a notably higher mean concentration of 82.61 mg/kg, compared to *C. obtusa*, which has a mean concentration of 51.11 mg/kg. Additionally, the data reveal substantial variability in Mn levels, particularly in *C. obtusa*, as reflected by the larger standard deviation. The findings indicated these snails (*T. duplicata* and *C. obtusa)* throughout the study area were contaminated with heavy metals, possibly due to factors such as agriculture activities, industrial discharge, mining activities, or other environmental influences (Krishnan et al., 2022).

Table 1: Concentration of Heavy metals in gastropods

Heavy Metals	Gastropods	Heavy metal concentration (mg/kg)		
		Min	Max	Mean ± SD
Ni	*T. duplicata*	1.84	2.91	2.22 ± 0.27
	C. obtusa	1.63	4.47	2.34 ± 0.74
Cu	*T. duplicata*	1.53	2.80	2.20 ± 0.37
	C. obtusa	1.64	3.36	2.27 ± 0.50
Mn	*T. duplicata*	68.48	112.52	82.61 ± 12.12
	C. obtusa	28.35	95.69	51.11 ± 21.21

The analysis of heavy metal concentrations in both gastropods *T. duplicata* and *C. obtusa* reveals relatively differences in the accumulation of Ni, Cu, and Mn between these species. While the levels of Ni and Cu are relatively low, the elevated

concentrations of Mn, particularly in *T. duplicata*, highlight potential environmental and health concerns. These findings are crucial when considering the broader implications for human health, especially in communities that rely on these species as a food source. Heavy metals such as Ni, Cu, and Mn are known to accumulate in marine organisms, which can lead to biomagnification as they move up the food chain (Pund, 2023). Although Cu is an essential trace element necessary for human health, excessive intake can lead to gastrointestinal distress and liver damage (Taylor et al.,2020). Ni, on the other hand, has no known biological function in humans, and prolonged exposure is associated with allergic reactions, respiratory issues, and an increased risk of certain cancers (Genchi et al., 2020). Mn, despite being vital for the functioning of several enzymes (Chen et al., 2018), can also pose risks when consumed in large quantities. Chronic exposure to high levels of Mn can lead to neurological effects, including a condition known as manganism, which resembles Parkinson's disease (Kim et al.,2022). The significantly higher concentration of Mn found in *T. duplicata* (mean of 82.61 mg/kg) compared to *C. obtusa* (mean of 51.11 mg/kg) suggests that consumption of these gastropods, particularly *T. duplicata*, could pose a risk of Mn overexposure.

The Independant t-test analysis of heavy metal concentrations in the gastropods *T. duplicata* and *C. obtusa* reveals that there is no significant difference in the levels of Ni, Cu, and Mn between the two species. This observation is based on data collected from 15 samples of each gastropod species, ensuring a robust dataset for comparison. The mean concentrations of Ni and Cu are quite similar between the species, with *T. duplicata* showing slightly lower levels for both metals compared to *C. obtusa*. Even though *T. duplicata* has a higher mean concentration of Mn than *C. obtusa*, the difference is not statistically significant.

The lack of significant differences in heavy metal concentrations between the two gastropod species could be attributed to several factors. First, both *T. duplicata* and *C. obtusa* might inhabit similar ecological niches or regions where they are exposed to comparable environmental conditions and sources of heavy metal contamination (ref). The uniformity in their diets and feeding behaviors could also lead to similar bioaccumulation patterns (Bienfang et al, 2013). Additionally, the physiological mechanisms for metal uptake and detoxification in these gastropods might be alike, resulting in comparable levels of metal accumulation.

3.2. Health Risk Assessment

The Target Hazard Quotient (THQ) and Hazard Index (HI) are crucial indicators used to assess the potential health risks associated with consuming contaminated food, such as snails, by comparing the exposure level to a reference dose. In this study, the THQ and HI values for the snails T. duplicata and C. obtusa were both calculated to be less than 1. This outcome is significant as it suggests that the levels of heavy metals present in these snails do not pose a significant risk of adverse health effects to the population consuming them. Specifically, a THQ or HI value below 1 indicates that the exposure to heavy metals through the consumption of these snails is within safe limits set by health guidelines and does not exceed the threshold that could lead to potential health concerns. Given these findings, it can be concluded that the snails grown in the selected study area are safe for consumption. This is reassuring for the local population, as it suggests that regular consumption of these snails does not contribute to a significant risk of toxicity from heavy metals such as Ni, Cu, and Mn. However, it is essential to maintain ongoing monitoring to ensure that these levels remain safe, as environmental conditions and contamination sources can change over time (Mitra et al., 2022). These results also highlight the effectiveness of current environmental management practices in the study area, which seem to have successfully kept heavy metal contamination within safe limits for human consumption.

Table 2 THQ and HI of heavy metal from *T. duplicata* and *C. obtusa*

Type of snails	**THQ**			**HI**
	Nikel (Ni)	Copper (Cu)	Manganese (Mn)	
T. duplicata	0.0345	0.0171	0.1836	0.2352
C. obtusa	0.0364	0.0177	0.1158	0.1699

4. CONCLUSION

This study presented data specifically on the concentrations of heavy metals in *T. duplicata* and *C. obtusa*, respectively. The results show that there is an accumulation of heavy metals in these intertidal gastropods. In both *T. duplicata* and *C. obtusa*, the highest concentration of heavy metals was found to be Mn, followed by Ni and Cu. The Target Hazard Quotient (THQ) and Hazard Index (HI) calculated for the snails *T. duplicata* and *C. obtusa* were less than 1, indicating no significant adverse health effects for the population consuming these snails in the study areas.

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