



## Research Article

# Bioaccumulation of Heavy Metals in Spotted Babylon Snail (*Babylonia areolata* Link, 1807), Karachi Coast, Pakistan

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## Abstract

**Background and Objective:** The release of metals in the aquatic environment is a great concern to the whole world as it has a great impact on the environment. In the current research, muscle samples were examined to evaluate the heavy metal amounts (Aluminum [Al], Lead [Pb], zinc [Zn], copper [Cu] and cadmium [Cd]). **Materials and Methods:** All samples were divided into two groups according to the weight group A (<5 g) and group B (>5 g) and were explored with the Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). **Results:** The average estimated levels of Al, Pb, Zn, Cu and Cd in the muscle of group A were  $4.71 \pm 1.62$ ,  $0.46 \pm 0.21$ ,  $27.06 \pm 9.24$ ,  $9.40 \pm 1.27$  and  $0.23 \pm 0.05 \mu\text{g g}^{-1}$ , respectively. Moreover, the average amount of the above metals concentrations in muscle for group B were  $10.17 \pm 2.10$ ,  $0.73 \pm 0.20$ ,  $71.09 \pm 23.52$ ,  $11.29 \pm 7.15$  and  $0.32 \pm 0.05 \mu\text{g g}^{-1}$ , respectively. The correlation between the different size groups and metals accumulation in muscle tissues were explored for both groups. **Conclusion:** The analyses indicated that Al, Pb, Zn, Cu and Cd buildups in muscle tissues of *Babylonia areolata* collected from Karachi Fish Harbour Pakistan did not surpass limit values.

**Key words:** Heavy metal accumulation, muscles, *Babylonia areolata*, Karachi Fish Harbour, correlation, metals concentration

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

*Babylonia* has been cultured for consumption, including *B. areolata*, *B. formosae*, *B. zeylanica* and *B. spirata*<sup>1-5</sup>. The release of heavy metals into the aquatic environment is of great concern to the whole world as it has a great impact on the environment due to its toxicity and bioaccumulative behaviour in aquatic organisms<sup>6</sup>. Heavy metals can be accumulated in aquatic organisms and also in the food chain. Heavy metals can accumulate in aquatic and aquatic organisms. The release of heavy and anthropogenic metals can reduce the diversity of marine species that strengthens the marine environment. In addition, people's seafood can be exposed to metals that have a significant impact and risk to their health<sup>7</sup>. Aquatic organisms are exposed to different kinds of contaminants in their environment. The toxicity testing of both heavy and non-heavy metals has been well established in several studies. Various marine organisms such as shells, bivalves, shrimp and gastropods have been used as bioindicators to monitor heavy metal contamination of these substances and the marine environment<sup>8,9</sup>. Heavy metals are considered to be important elements of the marine environment and freshwater and these heavy metals are found in very low-lying areas. The vast majority of heavy metals released from the earth reveal their access to water, such as direct ventilation, weather and damage from rainwater. Many activities such as anthropogenic, domestic, mechanical, agricultural and mining activities and thus increase the levels of heavy metals in marine areas<sup>10-12</sup>. Consuming the polluted fish, shells and other marine organisms affects directly human by deteriorating their health status<sup>13-16</sup>. Levels of heavy metals in marine ecosystems have a serious impact on marine ecosystems and the people who use these pollutants. Many health organizations and institutions, for example, food and drug administration (FDA) have introduced long-standing pressures on the safety of fisheries found in water and polluting resources<sup>17</sup>. In general, metals can be classified as dispensable and non-dispensable metals. The non-dispensable metals (e.g., aluminium (Al), cadmium (Cd) and lead (Pb)) have no proven biological function and their toxicity hikes with increasing concentration. Dispensable metals (e.g., copper (Cu) and zinc (Zn) on the other hand, have a known biological role and toxicity occurs either at metabolic deficiencies or high concentrations<sup>18</sup>. The deficiency of an essential metal can therefore, cause an adverse health effect, whereas its high concentration canal so result in negative impacts which are equivalent to or worse than those caused by non-essential metals<sup>18-20</sup>. Many studies focus on heavy metals in *Babylonia areolata* tissue<sup>8-21-23</sup>. The

most commonly found heavy metals in fish organisms are cadmium, lead, mercury, zinc, copper, nickel, cobalt, molybdenum, chromium and tin. Amongst them, the most frequently studied, concerning fish and other marine organism's deformities, including cadmium, copper, lead, zinc, mercury and chromium. This study observed the muscle sample to evaluate the heavy metal amounts.

## MATERIALS AND METHODS

**Sampling for heavy metals determination:** Spotted Babylon snail (*Babylonia areolata*) were collected from Karachi Fish Harbour, Karachi, Pakistan from 2019-2020. These specimens were packed in clean zipped polythene bags and transported to the research facility of International Center for Chemical and Biological Sciences (ICCBS), University of Karachi, in a piece of ice-filled polystyrene protection box. Samples were cleaned from sticky materials and put in the Industrial Analytical Center (IAC) laboratory freezer at -20°C to decrease organic decay before and during the trial. The specimens were sorted concerning their weight as follows: Group A: <5 g, Group B: >5 g and each group was divided into four classes according to their weight. Samples were clean with distilled water before dissecting to isolate the muscle tissues of *Babylonia areolata* from shells. The muscles were dissected into small pieces with stainless-steel scissors, forceps and honed blades. The muscles were washed with Milli-Q water and dried at 80°C for 12 hrs and ground to a fine powder with mortar and pestle. The dried tissue powder was measured accurately to the closest (1 g) and exchanged for a glass container. About 10 mL of concentrated acid (60% HNO<sub>3</sub>: 70% HClO<sub>4</sub>) were added and kept at room temperature for 12 hrs. The processed specimens were heated gradually to 180°C till the sample volume was diminished to 2-3 mL. Every sample was filtered and made up to 25 mL with Milli-Q water. The heavy metals were estimated by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES Avio™ 500 PerkinElmer USA).

**Calibration:** Calibration of a particular element's concentration at ICP-OES was done by using a set of standards and blanks. In ICP-OES, a matrix-matched solution of 1% nitric acid was used as the calibration solution and calibration concentrations ranged from 0-5 ppm for all analyzed elements. Standards used in preparing the calibration curve include 0.01, 0.05, 0.1, 0.5 and 2 ppm by Petrosyan *et al.*<sup>24</sup> and Hoenig<sup>25</sup>. Standards to prepare the calibration equation had 0, 10, 25, 50, 75 and 100 ppb concentrations. Internal standards were spiked in calibration solution, blanks and

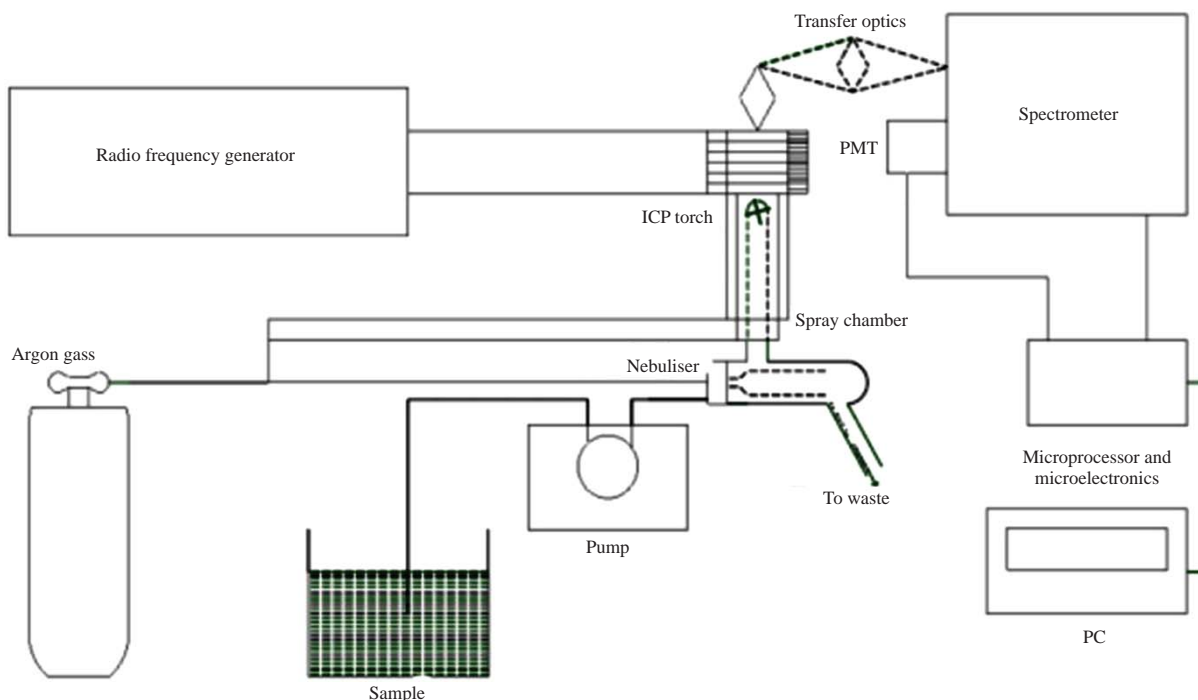


Fig. 1: Schematic diagram of a typical ICP-OES Avio™ 500 PerkinElmer USA system

ICP-OES: Inductively coupled plasma optical emission spectrometry, PMT: Photo-multiplier tube and PC: Personal computer

samples to serve as ionization buffers and monitor effects on analytes during calibration. For ICP-OES, Y and Cs were the internal standards<sup>26</sup>.

**Instrumentation:** ICP-OES Avio™ 500 PerkinElmer USA were used for this analysis. The main parts of the instruments are shown in Fig. 1. The ICP-OES has a carrier gas tube and a torch made of a quartz tube and connected to a radio-frequency (RF) generator. Argon is introduced to the torch and RF is applied to create a magnetic field and produce ions and electrons. The resultant current flow heats the gas so that once sample introduction is done via the nebulizer, it is converted to aerosol and directed to the torch<sup>24-27</sup>. Light emitted by atoms of metals from samples in plasma is converted to quantifiable electrical signals.

Digested samples were filtered, diluted and assayed using the ICP-OES instruments. After analysis, the final concentrations of each element were determined in ppm ( $\text{mg kg}^{-1}$ )<sup>12</sup>:

$$\text{Metal concentration (mg kg}^{-1}\text{)} = \frac{\text{Concentration} \times \text{Volume of sample} \times \text{dilution factor}}{\text{Weight of digested sample}} \times 1000$$

**Statistical analysis:** All heavy concentrations of the metals in *Babylonia areolata* within muscle tissues among the groups

were determined by carrying out analysis of variance (ANOVA) using Tukey's HDS *post hoc* comparison method. The results were assessed on the basis of homogenous groups with a significant level of ( $p < 0.05$ ). The elements which were common in the muscle tissue of *Babylonia areolata* snail were assessed utilizing Pearson's correlation coefficients. Then, the correlation between weight groups and metal accumulation was investigated. Finally, the data collection and statistical calculations were performed using (IBM SPSS software version 24).

## RESULTS AND DISCUSSION

The metal concentrations of Al, Pb, Zn, Cu and Cd in *Babylonia areolata* are shown in Table 1. The mean metal concentration in sample group A (<5 g) was Zn ( $27.06 \pm 9.24$ ), Cu ( $9.40 \pm 1.27$ ), Al ( $4.71 \pm 1.62$ ), Pb ( $0.46 \pm 0.21 \mu\text{g g}^{-1}$ ) and lowest amount was Cd ( $0.23 \pm 0.05 \mu\text{g g}^{-1}$ ). The highest metal concentration in sample group A (<5 g) (IV) was Zn ( $40.20 \pm 0.01 \mu\text{g g}^{-1}$ ) while the lowest was Cd (I) ( $0.15 \pm 0.02 \mu\text{g g}^{-1}$ ). For group B (>5 g) were Zn ( $71.09 \pm 23.52 \mu\text{g g}^{-1}$ ), Cu ( $11.29 \pm 7.15 \mu\text{g g}^{-1}$ ), Al ( $10.17 \pm 2.10 \mu\text{g g}^{-1}$ ), Pb ( $0.73 \pm 0.20 \mu\text{g g}^{-1}$ ) and Cd ( $0.32 \pm 0.05 \mu\text{g g}^{-1}$ ). For group B (>5 g) the highest metal concentration was Zn (IV) ( $96.78 \pm 0.04 \mu\text{g g}^{-1}$ ) while the lowest was Cd (I and IV) ( $0.27 \pm 0.01 \mu\text{g g}^{-1}$ ).

Table 1: Average concentrations of heavy metals ( $\mu\text{g g}^{-1}$  dry weight  $\pm$ SD) in muscles of shells *Babylonia areolata*

	Al	Pb	Zn	Cu	Cd	Weight (g)	Frequency
<b>&lt;5 g</b>							
I	3.56 $\pm$ 0.34	0.23 $\pm$ 0.02	15.20 $\pm$ 0.13	8.24 $\pm$ 0.03	0.15 $\pm$ 0.02	1-2	10
II	2.89 $\pm$ 0.27	0.27 $\pm$ 0.01	22.73 $\pm$ 0.01	8.49 $\pm$ 0.01	0.24 $\pm$ 0.01	2-3	10
III	5.35 $\pm$ 0.13	0.61 $\pm$ 0.12	30.10 $\pm$ 0.12	9.37 $\pm$ 0.12	0.26 $\pm$ 0.01	3-4	10
IV	7.04 $\pm$ 0.10	0.72 $\pm$ 0.12	40.20 $\pm$ 0.01	11.48 $\pm$ 0.09	0.28 $\pm$ 0.02	4-5	10
Mean $\pm$ SD	4.71 $\pm$ 1.62	0.46 $\pm$ 0.21	27.06 $\pm$ 9.24	9.40 $\pm$ 1.27	0.23 $\pm$ 0.05		
<b>&gt;5 g</b>							
I	11.72 $\pm$ 0.59	0.44 $\pm$ 0.13	38.41 $\pm$ 0.04	2.45 $\pm$ 0.02	0.27 $\pm$ 0.01	5-5.5	10
II	8.55 $\pm$ 0.02	0.66 $\pm$ 0.04	59.78 $\pm$ 0.26	6.13 $\pm$ 0.25	0.35 $\pm$ 0.13	5.5-6	10
III	7.70 $\pm$ 0.04	0.89 $\pm$ 0.17	89.74 $\pm$ 0.21	17.39 $\pm$ 0.58	0.38 $\pm$ 0.01	6-6.5	10
IV	12.72 $\pm$ 0.59	0.93 $\pm$ 0.03	96.78 $\pm$ 0.04	19.20 $\pm$ 0.02	0.27 $\pm$ 0.01	6.5-7	10
Mean $\pm$ SD	10.17 $\pm$ 2.10	0.73 $\pm$ 0.20	71.09 $\pm$ 23.52	11.29 $\pm$ 7.15	0.32 $\pm$ 0.05		

Table 2: Pearson correlation coefficients for the relationships between the concentrations of different metals in muscles of shells *Babylonia areolata*

	Al	Pb	Zn	Cu	Cd
<b>&lt;5 g</b>					
Al	1				
Pb	0.958*	1			
Zn	0.905	0.949	1		
Cu	0.947	0.905	0.954*	1	
Cd	0.651	0.809	0.901	0.737	1
<b>&gt;5 g</b>					
Al	1				
Pb	-0.134	1			
Zn	-0.062	-0.996**	1		
Cu	-0.004	-0.975*	0.990**	1	
Cd	-0.983*	0.314	0.244	0.185	1

\*Correlation is significant at the 0.05 level, \*\*Correlation is significant at the 0.01 level

Table 3: Comparison of the metal concentrations ( $\mu\text{g g}^{-1}$ ) in the muscle of *Babylonia areolata*

	Metal concentration ( $\mu\text{g g}^{-1}$ )					References
	Al	Pb	Zn	Cu	Cd	
Group A	4.71 $\pm$ 1.62	0.46 $\pm$ 0.21	27.06 $\pm$ 9.24	9.40 $\pm$ 1.27	0.23 $\pm$ 0.05	
Group B	10.17 $\pm$ 2.10	0.73 $\pm$ 0.20	71.09 $\pm$ 23.52	11.29 $\pm$ 7.15	0.32 $\pm$ 0.05	
<b>International limits and research</b>						
1	-	2	100	30	0.5	Tabrez <i>et al.</i> <sup>28</sup>
2	-	0.5-6	30-100	10-100	1	Barisic <i>et al.</i> <sup>29</sup>
3	13.8	0.12	67.1	3.28	0.189	Barchiesi <i>et al.</i> <sup>30</sup>
4	-	0.2	-	-	0.05	Bosch <i>et al.</i> <sup>31</sup>
5	-	2	50	20	0.2	Tornero and Hanke <sup>32</sup>
6	-	1	75	6	1	Cohen <i>et al.</i> <sup>33</sup>
7	-	0.1	-	10	0.1	Dar <i>et al.</i> <sup>34</sup>
8	-	4-53	70-316	5-7	<1-2	Szefer <i>et al.</i> <sup>35</sup>

Table 2 summarizes the correlation coefficients among the metal levels of the muscle in the snail, significant correlations ( $p < 0.05$ ) and ( $p < 0.01$ ) are in asterisks (\*) and (\*\*), respectively. Seen from the table, the most noticeable correlations were found between the pairs Al-Pb (0.958) and Cu-Zn (0.954) in group A and Al-Cd (-0.983), Pb-Zn (-0.996), Pb-Cu (-0.975) and Zn-Cu (0.990) in group B, respectively.

Table 3 shows the comparison of the metal concentrations ( $\mu\text{g g}^{-1}$ ) in the muscle of *Babylonia areolata*, to international standards and other previous research on the concentrations of heavy metals (Al, Pb, Zn, Cu and Cd) in the

muscle of *Babylonia areolata* collected from Karachi harbour, Al in group A (4.71 $\pm$ 1.62  $\mu\text{g g}^{-1}$ ) and group B (10.17 $\pm$ 2.10  $\mu\text{g g}^{-1}$ ) were below to Barchiesi *et al.*<sup>30</sup> (13.8  $\mu\text{g g}^{-1}$ ).

The Pb in group A (0.46 $\pm$ 0.21  $\mu\text{g g}^{-1}$ ) high than Barchiesi *et al.*<sup>30</sup> (0.12  $\mu\text{g g}^{-1}$ ), Bosch *et al.*<sup>31</sup> (0.2  $\mu\text{g g}^{-1}$ ) and Dar *et al.*<sup>34</sup> (0.1  $\mu\text{g g}^{-1}$ ) and below to Tabrez *et al.*<sup>28</sup> (2  $\mu\text{g g}^{-1}$ ), Barisic *et al.*<sup>29</sup> (0.5-6  $\mu\text{g g}^{-1}$ ), Tornero and Hanke<sup>32</sup> (2  $\mu\text{g g}^{-1}$ ), Cohen *et al.*<sup>33</sup> (1  $\mu\text{g g}^{-1}$ ) and Szefer *et al.*<sup>35</sup> (4-53  $\mu\text{g g}^{-1}$ ). The Pb in group B (0.73 $\pm$ 0.20  $\mu\text{g g}^{-1}$ ), above to Barchiesi *et al.*<sup>30</sup> (0.12  $\mu\text{g g}^{-1}$ ), Bosch *et al.*<sup>31</sup> (0.2  $\mu\text{g g}^{-1}$ ) and Dar *et al.*<sup>34</sup>

(0.1  $\mu\text{g g}^{-1}$ ) and below to other standards Tabrez *et al.*<sup>28</sup> (2  $\mu\text{g g}^{-1}$ ), Barisic *et al.*<sup>29</sup> (0.5-6  $\mu\text{g g}^{-1}$ ), Tornero and Hanke<sup>32</sup> (2  $\mu\text{g g}^{-1}$ ), Cohen *et al.*<sup>33</sup> (1  $\mu\text{g g}^{-1}$ ) and Szefer *et al.*<sup>35</sup> (4-53  $\mu\text{g g}^{-1}$ ).

The Zn in group A ( $27.06 \pm 9.24 \mu\text{g g}^{-1}$ ) below all standards and group B ( $71.09 \pm 23.52 \mu\text{g g}^{-1}$ ) below Tabrez *et al.*<sup>28</sup> (100  $\mu\text{g g}^{-1}$ ) and Cohen *et al.*<sup>33</sup> (75  $\mu\text{g g}^{-1}$ ) and higher than Barchiesi *et al.*<sup>30</sup> (67.1  $\mu\text{g g}^{-1}$ ), Tornero and Hanke<sup>32</sup> (50  $\mu\text{g g}^{-1}$ ) and in the range of Barisic *et al.*<sup>29</sup> (30-100  $\mu\text{g g}^{-1}$ ) and Szefer *et al.*<sup>35</sup> (70-316  $\mu\text{g g}^{-1}$ ).

The Cu in group A ( $9.40 \pm 1.27 \mu\text{g g}^{-1}$ ) below Tabrez *et al.*<sup>28</sup> (30  $\mu\text{g g}^{-1}$ ), Barisic *et al.*<sup>29</sup> (10-100  $\mu\text{g g}^{-1}$ ), Tornero and Hanke<sup>32</sup> (20  $\mu\text{g g}^{-1}$ ), Dar *et al.*<sup>34</sup> (10  $\mu\text{g g}^{-1}$ ) and above to Barchiesi *et al.*<sup>30</sup> (3.28  $\mu\text{g g}^{-1}$ ), Cohen *et al.*<sup>33</sup> (6  $\mu\text{g g}^{-1}$ ) and Szefer *et al.*<sup>35</sup> (5-7  $\mu\text{g g}^{-1}$ ) and for group B ( $11.29 \pm 7.15 \mu\text{g g}^{-1}$ ), were below to Tabrez *et al.*<sup>28</sup> (30  $\mu\text{g g}^{-1}$ ) and Tornero and Hanke<sup>32</sup> and above to Barchiesi *et al.*<sup>30</sup> (3.28  $\mu\text{g g}^{-1}$ ), Cohen *et al.*<sup>33</sup> (6  $\mu\text{g g}^{-1}$ ) and Szefer *et al.*<sup>35</sup> (5-7  $\mu\text{g g}^{-1}$ ) and in the range of Barisic *et al.*<sup>29</sup> 10-100  $\mu\text{g g}^{-1}$ .

The Cd in group A was ( $0.23 \pm 0.05 \mu\text{g g}^{-1}$ ) below to Tabrez *et al.*<sup>28</sup> (0.5  $\mu\text{g g}^{-1}$ ), Barisic *et al.*<sup>29</sup> (1  $\mu\text{g g}^{-1}$ ), Cohen *et al.*<sup>33</sup> (1  $\mu\text{g g}^{-1}$ ) and Szefer *et al.*<sup>35</sup> (<1-2  $\mu\text{g g}^{-1}$ ) and above to Barchiesi *et al.*<sup>30</sup> (0.189  $\mu\text{g g}^{-1}$ ), Bosch *et al.*<sup>31</sup> (0.05  $\mu\text{g g}^{-1}$ ), Tornero and Hanke<sup>32</sup> (0.2  $\mu\text{g g}^{-1}$ ) and Dar *et al.*<sup>34</sup> (0.1  $\mu\text{g g}^{-1}$ ).

Figure 2 shows that Al concentration in the tissue of the Spotted babylon snail, the highest concentrations of Al were in IV followed by I, II and III in group B. The lowest concentrations of Al were in II group A.

Figure 3 compares the concentration of Pb in the tissue of the Spotted babylon snail, the highest concentrations of Pb were in IV followed by III, II and I in group B, respectively. The lowest concentrations of Pb were in I group A.

Figure 4 summarizes the concentration of Zn in the tissue of the Spotted babylon snail, the highest concentrations of Zn were in IV followed by III, II and I in group B. The lowest concentrations of Zn were in I group A.

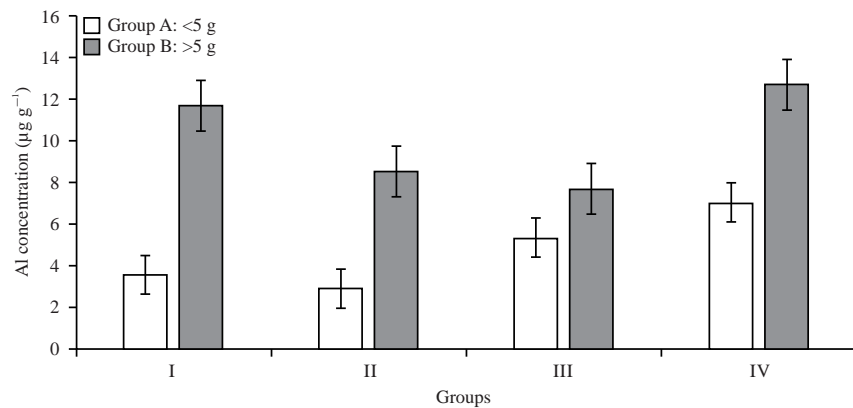


Fig. 2: Aluminum level in spotted babylon snail (*Babylonia areolata*) tissue

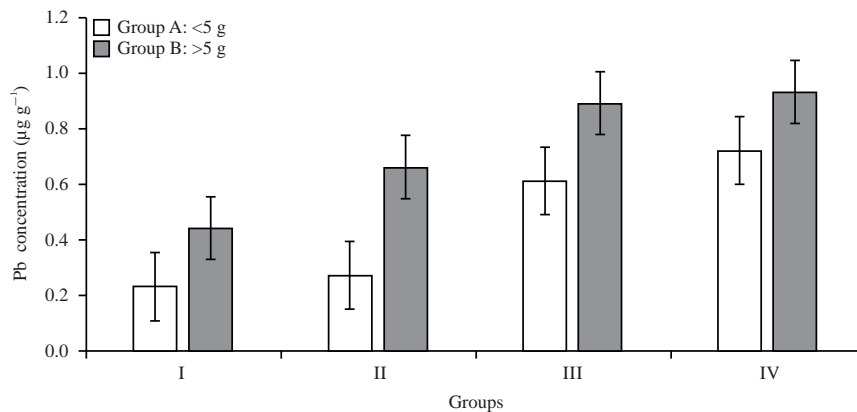


Fig. 3: Lead level in spotted babylon snail (*Babylonia areolata*) tissue

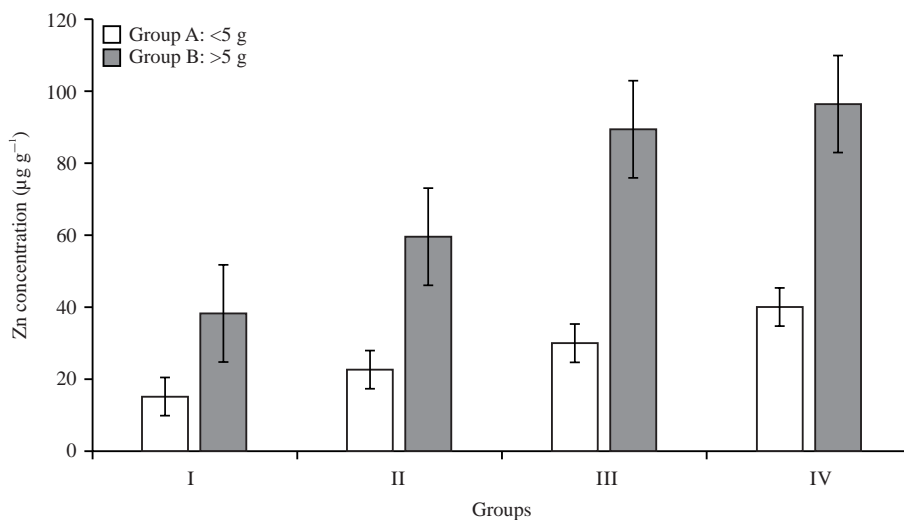


Fig. 4: Zinc level in spotted Babylon snail (*Babylonia areolata*) tissue

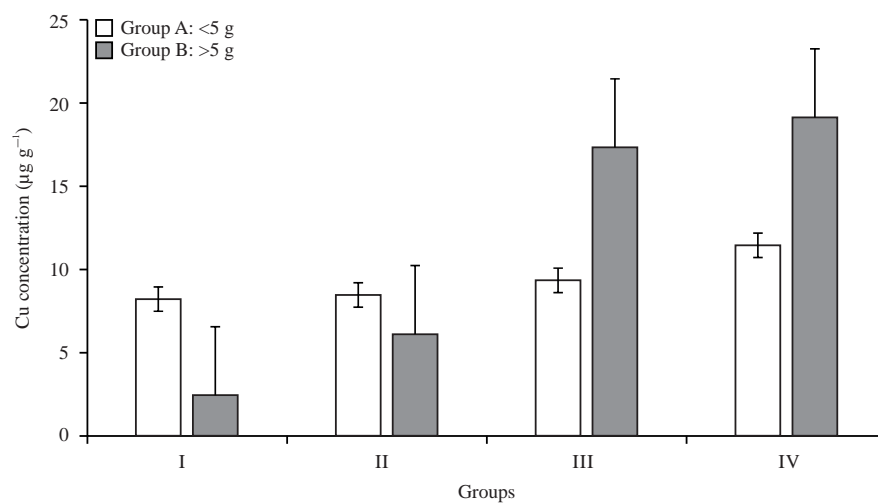


Fig. 5: Copper level in spotted Babylon snail (*Babylonia areolata*) tissue

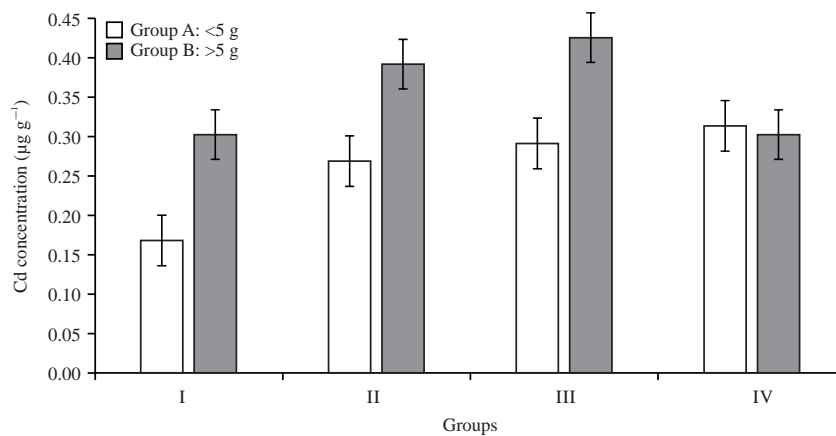


Fig. 6: Cadmium level in spotted Babylon snail (*Babylonia areolata*) tissue

Figure 5 shows that Cu concentration in the tissue of Spotted Babylon snail, the highest concentrations of Cu was in IV and III in group B and the lowest concentrations of Cu were in I group A.

In Fig. 6 the concentrations of Cd in the tissue of the Spotted Babylon snail, the highest concentrations of Cd was in III in group B. The lowest concentrations of Cd were in I group A.

In aquatic organisms, heavy metal concentrations accumulate due to direct consumption of water and food or indirect ingestion of heavy metals through permeable membranes such as the gills or skin. Concentrations of heavy metals within fish organs indicate the volume of heavy metals in their surroundings. It is possible for fish organs to accumulate heavy metals at levels exceeding environmental levels and to produce a toxic effect when uptake exceeds the animal's ability to metabolize, store and detoxify the metals<sup>36</sup>.

Heavy metals like aluminum (Al), cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) have a high level of toxicity and persistence capacity possessing potential for biomagnification, bioaccumulation and incorporation into the food chain after reaching a certain limit in the aquatic environment<sup>6-37-40</sup>. Bioaccumulation and biomagnification denote the processes and pathways of heavy metal pollutants from one trophic level to others in the foodweb<sup>6,41</sup>. Because of this, some snails and other marine organisms have been used as bioindicators such as *Babylonia areolata*<sup>8-21-23</sup>, *Mytilus galloprovincialis*<sup>35-42</sup>, *Pomacea canaliculata*<sup>43</sup>.

Many authors have reported the contamination of aquatic environments with heavy metals, such as Rashed<sup>44</sup>, Osuna-Mascaro *et al.*<sup>45</sup>, Rajeshkumar and Li<sup>36</sup>, Khan *et al.*<sup>46</sup>. Several heavy metals which are harmful to aquatic organisms contaminate water, including lead, mercury, zinc, copper, arsenic, chromium and cadmium. At the highest point of the natural feeding grounds, aquatic organisms (fish, shrimp and crab) accumulate numerous elements from the water<sup>47,48</sup>. In Table 3. The levels of the heavy metal concentrations in the tissue of snails are compared with the international standards for metals compiled by Tabrez *et al.*<sup>28</sup>, Barisic *et al.*<sup>29</sup>, Barchiesi *et al.*<sup>30</sup>, Bosch *et al.*<sup>31</sup>, Tornero and Hanke<sup>32</sup>, Cohen *et al.*<sup>33</sup>, Dar *et al.*<sup>34</sup>. The mean concentrations of the Pb and Cd in groups A and B are higher than those of EU and EC standards. Chemical pollution of water by heavy metals also results in changes in the aquatic environment, often affecting behavioural, physiological and bloodstream patterns, cell structures and ionic balance Hewitt *et al.*<sup>49</sup>, carbohydrate metabolism and liver function of fishes<sup>49,50</sup>. As stated in earlier reports, industrial and domestic effluent are the largest sources of metals that contribute to the steadily increasing

levels of metallic contaminants in aquatic and terrestrial environments around the world<sup>16,51</sup>. The accumulation of Al, Pb, Zn, Cu and Cd in muscle tissues of *Babylonia areolata* was found to be significantly different between small and big snails ( $p < 0.05$ ). Table 2 summarizes the correlation coefficients among the metal levels of the muscle in snail, significant correlations ( $p < 0.05$ ) and ( $p < 0.01$ ) are in asterisks(\*) and (\*\*), respectively. Seen from the table, the most noticeable correlations were found between the pairs Al-Pb (0.958) and Cu-Zn (0.954) in group A and Al-Cd (-0.983), Pb-Zn (-0.996), Pb-Cu (-0.975) and Zn-Cu (0.990) in group B, respectively.

## CONCLUSION

The results of this study show that Al, Pb, Zn, Cu and Cd accumulations of *Babylonia areolata* caught from Karachi Harbour were below the international limits. The present study shows that precautions are needed to be taken to obviate metal pollution in the future. It is thought that intake values may trigger some health problems in case of excessive consumption because these pollutants can be detrimental to the health of the fish population and humans consuming them.

## SIGNIFICANCE STATEMENT

This study discovered that metals accumulations in *Babylonia areolata* collected from Karachi Harbour were below international limits and can be used to determine aquatic pollution.

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