# POLLUTION

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**Nguyen T.T.N.[1] *, Volkova I.V.[2]**

[1, 2] Astrakhan State Technical University, Astrakhan, Russia;
[1] Vietnam Maritime University, Hai Phong, Vietnam

* Correspodning author (nguyenthuynhung.ast[at]gmail.com)

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# MERCURY CONTENT IN BIVALVES AT THE ESTUARY AREA OF THE RED RIVER (VIETNAM)

Research article

**Abstract**

This article evaluates the content of mercury in various tissues (gills, mantle, hepatopancreas, and body "foot") in four species of bivalves in the estuary area of the Red River in Vietnam. In this article, the authors determine the dependencies of the mercury content in the tissues of mollusks on the indicators of the length and mass of tissues and on the content of the pollutant in dissolved, suspended forms and in bottom sediments. The content of mercury in the tissues of mollusks varies from 30.5±1.2 to 415.8±6.3 ng/g. The highest content of the toxicant was observed in the hepatopancreas of *Austriella corrugate*, while the lowest was seen in the "foot" of *Lutraria rhynchaena*. Close, reliable, positive correlations between the concentration of mercury in the tissues of mollusks and the contents of its suspended form in the bottom water layer and in bottom sediments ($r$ from 0.68 to 0.92, $p < 0.05$) were observed. Bivalves can be used as one of the objects of biomonitoring when studying the distribution of mercury in the estuary area of the Red River.

**Keywords:** Mercury, estuary area of the Red River, bivalve, biological accumulation coefficient.

**Нгуен Т.Т.Н.[1] *, Волкова И.В.[2]**

[1, 2] Астраханский государственный технический университет, Астрахань, Россия;
[1] Вьетнамский морский университет, Хайфон, Вьетнам

* Корреспондирующий автора (nguyenthuynhung.ast[at]gmail.com)

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# СОДЕРЖАНИЕ РТУТИ В ДВУСТВОРЧАТЫХ МОЛЛЮСКАХ В УСТЬЕВОЙ ОБЛАСТИ РЕКИ КРАСНАЯ (ВЬЕТНАМ)

Научная статья

**Аннотация**

В работе проведена оценка содержания ртути в различных тканях (жабры, мантия, гепатопанкреас и тело «нога») у 4 видов двустворчатых моллюсков в устьевой области реки Красная Вьетнама. Даны зависимости содержания ртути в тканях моллюсков от длины и массы тела и от содержания полютанта в растворенной, взвешенной формах и в донных отложениях. Содержание ртути в тканях моллюсков меняется от 30.5±1.2 до 415.8±6.3 нг/г с.м. Наибольшее содержание токсиканта отмечено в гепатопанкреасе *Austriella corrugate*, наименьшее – в «ноге» *Lutraria rhynchaena*. Отмечены тесные достоверные положительные корреляционные связи между концентрациями ртути в тканях моллюсков и содержаниями её взвешенной формы в придонном слое воды и в донных отложениях (r от 0,68 до 0,92, $p<0,05$). Двустворчатые моллюски можно использовать как один из объектов биомониторинга при изучении распределения ртути в устьевой области реки Красная.

**Ключевые слова:** ртуть, устьевая область реки Красная, двустворчатые моллюски, коэффициент биологического накопления.

## 1. Introduction

It is known that bivalve mollusks are one of the important functional links of the hydro-ecosystem. They play a special role in the migration and transformation of trace elements since such mollusks represent the largest organisms of macrozoobenthos, through which flows of trace elements pass with their subsequent deposition in bottom sediments [1], [2].

The research of Linnik P.N. (2010) showed that some ecological groups of bivalves living in certain environmental conditions are capable of concentrating trace elements up to 10 times higher than their content in the environment; i.e., they are biofilters [3].

To assess the migration and transformation of mercury in the system "bottom sediments - macrozoobenthos - water phase" of the estuary area of the Red River, as well as the ability and accumulation method of mercury in the body of aquatic organisms, the content and characteristics of the mercury accumulation in the tissues of the dominant and minor species of bivalve *Meretrix lyrata*, *Anadara granosa*, *Austriella corrugate*, and *Lutraria rhynchaena* should be considered.

The aim of the research is to establish the mercury levels in the tissues of the main species of bivalves in the estuary area of the Red River and analyze its correlation with mercury concentration in water and sediments. Objectives: to study the content of mercury in various tissues (gills, mantle, hepatopancreas, and foot) of bivalves; to analyze the correlation between the concentration of Hg in water, sediments, and in tissues of bivalves; and to compare the ability of biological accumulation of metal by these mollusks.

## 2. Methods

The collection of material (mollusks) was carried out at 4 stations (Figure 1). At each station, 14 samples were selected, with 20 mollusks per sample. For the experiment, we used mollusks that were 3 years old. The studies were carried out during the main hydrological seasons of 2014 - 2019.

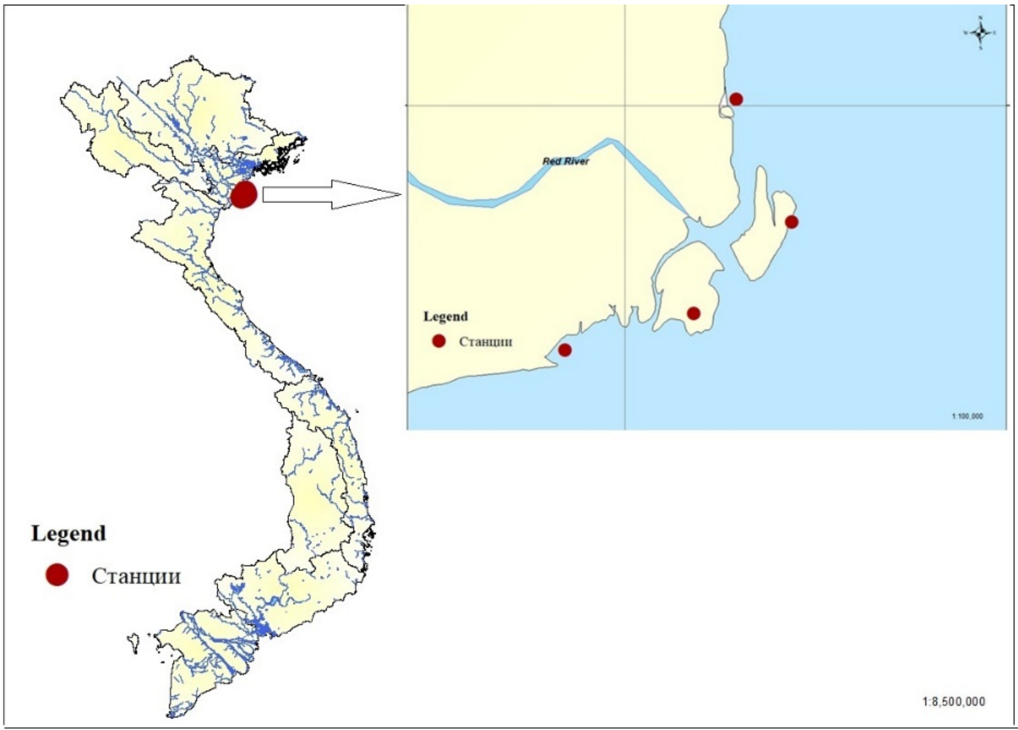


Figure 1 – Map - scheme of the research stations location in the estuary area of the Red River

Samples of mollusks were frozen at -15°C, and biometric analysis was performed under laboratory conditions. Various tissues were dried at room temperature and packed in plastic bags.

The mass concentration measurement of total mercury in the samples was carried out by the method of flameless atomic absorption. Atomization of the Hg contained in the sample was carried out in a two-section pyrolyzer of the PIRO-915+ attachment at a temperature of +560°C with its subsequent determination on an RA-915+ mercury analyzer [4], [5].

Statistical processing of the results was carried out using the STATGRAPHICS Centurion XVIII program. The results were presented as average values and their errors (x ± mx). Comparison of the average value was assessed by ANOVA analysis methods and LSD tests with significance level $\alpha = 0.05$.

To assess the degree of accumulation of metals in the tissues of mollusks in relation to the content of these elements in the environment, the coefficient of biological accumulation (Kd) was calculated [1], [6]:

$$K_d = \frac{C_t}{C_s} \tag{1}$$

- Ct – the concentration of heavy metal (HM) in the tissues of aquatic organisms (mg/kg dry tissue)
- Cs – concentration of HM in the environment (in water and bottom sediments) (mg/l).

## 3. Results and discussion

The results of ANOVA analysis and LSD tests (α=0.05) showed that the mercury accumulation in 4 species of mollusks and in their different tissues have significant differences (Table 1).

Table 1 – Mercury content in bivalves tissues

| Form | Length, mm | Mass, g | Mercury content, ng/g | | | | |
|---|---|---|---|---|---|---|---|
| | | | Gills | Mantle | Hepatopancreas | Foot | Average |
| *Meretrix lyrata* | 40.4±2.6 | 14.4±0.3 | 69,8±17,1$^{a}$ | 71,6±16,7$^{a}$ | 76,5±15,9$^{a}$ | 66,1±18,8$^{a}$ | 70.9±17.1 |
| *Anadara granosa* | 36.8±1.6 | 14.2±0.2 | 105,6±3,1$^{a}$ | 112,7±4,7$^{b}$ | 135,3±7,9$^{c}$ | 103,2±3,4$^{a}$ | 114.2±4 |
| *Austriella corrugate* | 63.5±3.2 | 85.3±1.1 | 408,2±6,5$^{b}$ | 450,8±8,8$^{c}$ | 468,9±7$^{d}$ | 335±10,7$^{a}$ | 415.8±6.3 |
| *Lutraria rhynchaena* | 82.7±1.5 | 67.8±0.3 | 24,6±1,4$^{b}$ | 37,2±1,1$^{c}$ | 37,5±1,3$^{c}$ | 22,5±1,3$^{a}$ | 30.5±1.2 |

*Note: a, b, c, d - the differences were significant (α = 0.05).*

In the estuary area of the Red River, the maximum average values of mercury content (415.8±6.3 ng/g) were observed in *Austriella corrugate*, and the minimum average values (30.5±1.2 and 70.9±17.1 ng/g) were observed in *Lutraria rhynchaena* and *Meretrix lyrata*, respectively.

In addition to interspecific differences, all the studied species of mollusks showed a high variation of mercury content between organs. From the data in Table 1, it can be seen that the highest values of mercury content were observed in the hepatopancreas, and the lowest levels were in the foot.

For *Meretrix lyrata*, the mercury concentration in the mantle, gills, foot, and hepatopancreas do not have significant differences (with significance level α=0.05).

For *Anadara granosa*, the mercury content was without significant difference and range in the foot (103.2 ± 3.4 ng/g) and gills (105.6 ± 3.1 ng/g). The metal content in the hepatopancreas was the highest at a level of 135.3±7.9 ng/g.

For *Austriella corrugate*, the lowest mercury content was also found in the foot (335 ± 10.7 ng/g) and was higher in the gills, mantle, and hepatopancreas (408,2±6,5; 450,8±8,8; and 468,9±7 ng/g; respectively).

For *Lutraria rhynchaena*, the mercury concentration in the mantle and the hepatopancreas was the same, but it was more than in the gills (24.6±1.4 ng/g) and foot (22.5±1.3 ng/g).

The distribution of mercury between organs and tissues turned out to be unequal: “foot” < gills < mantle < hepatopancreas.

The difference in the accumulation of mercury in the organs and tissues of mollusks is explained by the differences in the accumulating capacity and the level of metabolic activity of tissues [7]. The gills are respiratory organs and filtration centers. During filtration, the gill petals of mollusks actively move and are washed by a large volume of water, which contains $Hg^{2+}$ ions. Thus, mercury can quickly interact with cell membranes and penetrate inside them. These reasons explain the increased mercury content in the gills compared to its content in the body. The research of Kupina N.M. (2015) noted that, in the body of aquatic animals, the accumulation of many toxicants proportionally depends on the content of lipids in them [8]. Therefore, the deposition of lipids in the hepatopancreas explains the maximum content of mercury in this organ.

For three of four species of mollusks inhabiting the estuary area of the Red River, a reliable, close, positive dependence of the mercury content on bodyweight and length was revealed (Table 2).

Table 2 – Pair correlation coefficient of mercury content and body weight of bivalves

| Form | n | $r_m$ | p | $r_n$ | p |
|---|---|---|---|---|---|
| *Meretrix lyrata* | 20 | 0,83 | <0.05 | 0.84 | <0.05 |
| *Anadara granosa* | 20 | 0.46 | 0.04 | 0.93 | <0.05 |
| *Austriella corrugate* | 20 | 0.84 | <0.05 | 0.89 | <0.05 |
| *Lutraria rhynchaena* | 20 | 0.82 | <0.05 | 0.96 | <0.05 |

However, the accumulation of mercury in the tissues and organs of mollusks is determined not only by the filtration activity and the level of metabolism of the mollusk but also by the metal content in the environment and the degree of bioavailability of its ions in the research area. According to the results of statistical analysis, linear relationships were revealed between the mercury content in mollusks and the suspended form of the bottom layer of water (Figure 2) and bottom sediments (Figure 3).

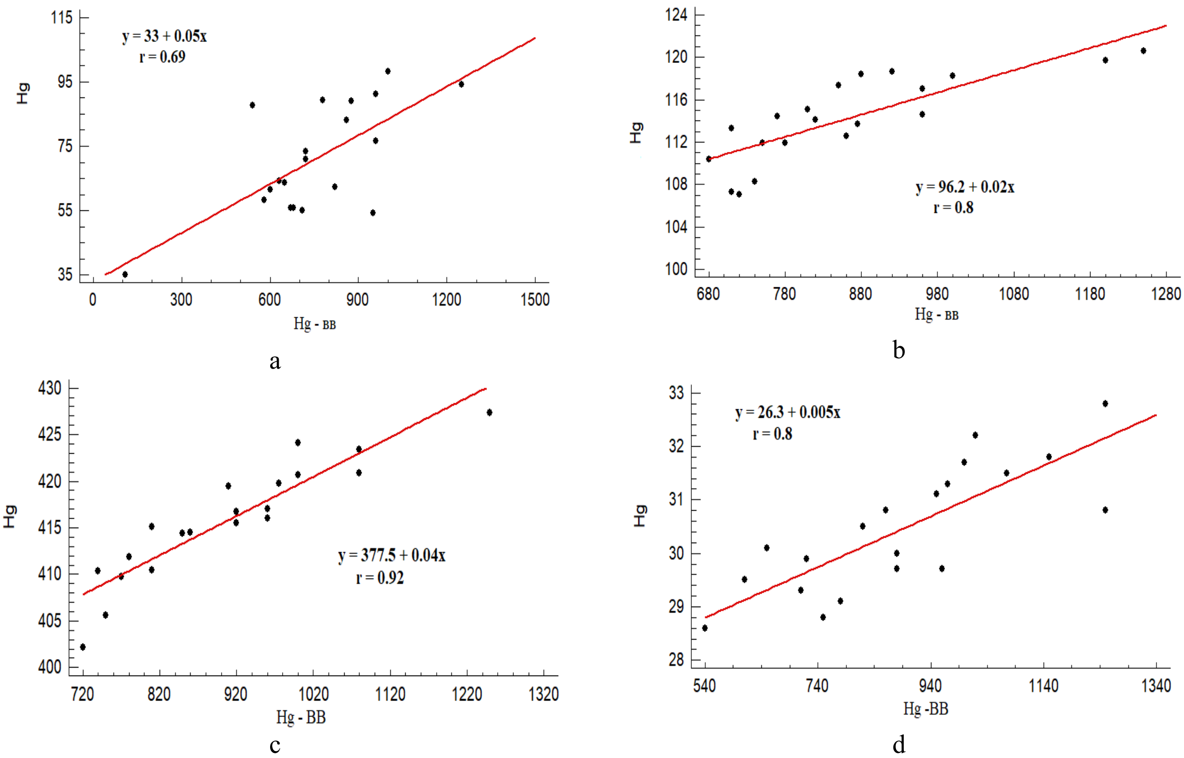


Figure 2 – Dependences of the mercury content in the tissues of molluscs on its concentration in the suspended form in the bottom layer of water: a. *Meretrix lyrata*, b. *Anadara granosa*, c. *Austriella corrugate* and *Lutraria rhynchaena*

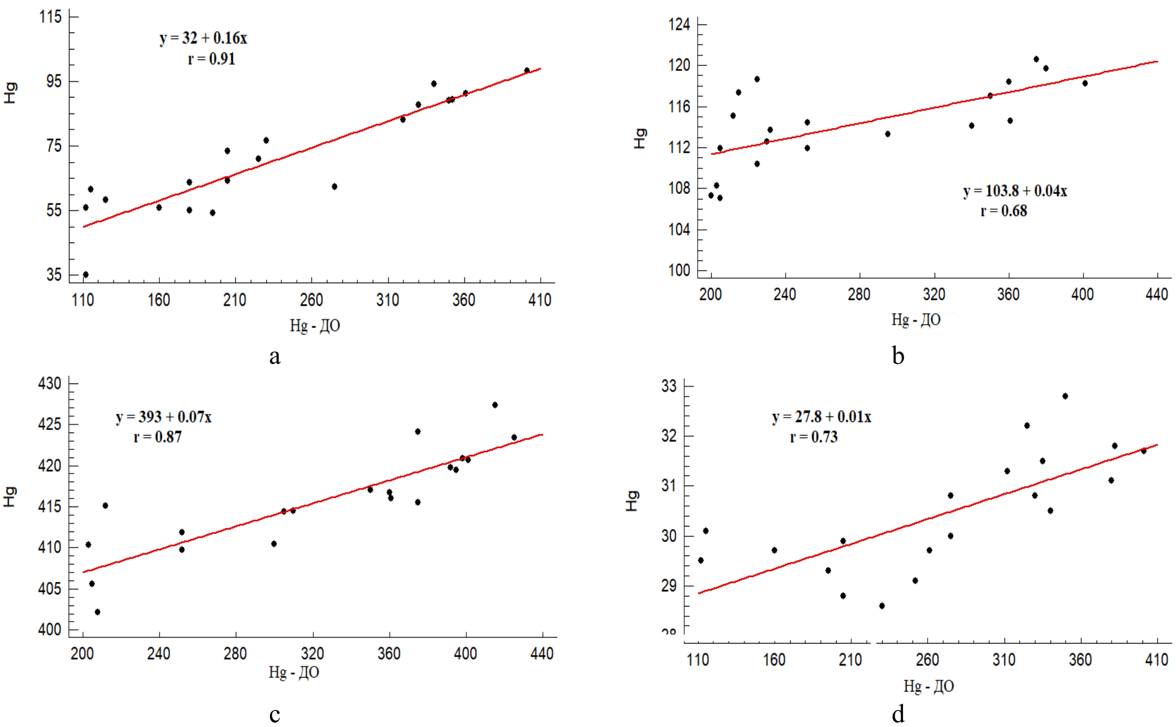


Figure 3 – Dependences of the mercury content in the tissues of molluscs on its concentration in bottom sediments: a. *Meretrix lyrata*, b. *Anadara granosa*, c. *Austriella corrugate* and *Lutraria rhynchaena*

No statistically significant relationships were found between the content of the dissolved form of mercury in water and its concentration in the tissues of mollusks. This phenomenon allows us to conclude that the absorption of mercury into suspended substances and the accumulation of bottom sediments have a predominant effect on its accumulation in mollusks.

To determine the degree of accumulation of mercury by mollusks, the authors calculated the coefficients of biological accumulation (Table 3):

Table 3 – Accumulation coefficient values for some tissues of bivalve molluscs

| Form of molluscs | Tissues of mooluscs | Bioaccumulation factor for water $Kd_{(water)}$ | Bioaccumulation factor for water bottom sediments $Kd_{(bs)}$ |
|---|---|---|---|
| *Meretrix lyrata* | Gills | 110.2 | 0.4 |
| | Mantle | 111.1 | 0.41 |
| | Hepatopancreas | 116.3 | 0.44 |
| | Foot | 107.7 | 0.38 |
| *Anadara granosa* | Gills | 119.8 | 0.61 |
| | Mantle | 127.8 | 0.65 |
| | Hepatopancreas | 153.5 | 0.78 |
| | Foot | 117 | 0.59 |
| *Austriella corrugate* | Gills | 462.9 | 2.34 |
| | Mantle | 511.3 | 2.59 |
| | Hepatopancreas | 531.7 | 2.69 |
| | Foot | 379.9 | 1.92 |
| *Lutraria rhynchaena* | Gills | 27.9 | 0.14 |
| | Mantle | 42.2 | 0.21 |
| | Hepatopancreas | 42.5 | 0.22 |
| | Foot | 25.5 | 0.13 |

Table 3 shows that mercury accumulates unequally in different tissues. The highest Kd value (water and bottom sediments) for all species of mollusks was observed in the hepatopancreas, while the lowest was observed in the foot: Kd (g-p) > Kd (m) > Kd (l) > Kd (foot)

The data obtained (Table 3) indicate the coefficient $Kd_{(water)} > 2$ for all investigated tissues of mollusks. Such tissues and organs are macro-concentrators. Therefore, they have a high bioavailability of mercury. The hepatopancreas *Austriella corrugate* ($Kd_{(water)} = 531.7$) has the highest concentrating ability.

3 out of 4 species of mollusks act as deconcentrators ($Kd_{(bs)} <1$). The tissues and organs of *Austriella corrugate* have the highest concentrating ability, in which the "foot" is a micro-concentrator ($1 < Kd_{(bs)} <2$), and other organs are macro-concentrators ($Kd_{(bs)} > 2$); i.e., this species of mollusk is capable of accumulating mercury not only from the water phase but from bottom sediments.

## 4. Conclusion

Thus, analyzing the data obtained, we can determine the following conclusions:

1. Mercury was found in all studied tissues of bivalves. The highest concentration of the toxicant was observed in the hepatopancreas of *Austriella corrugate*, while the lowest was observed in the "foot" of *Lutraria rhynchaena*.
2. A direct close correlation was observed between the mass and length of the body of mollusks and the average content of mercury. In this connection, the individual indicators of the age of bivalves can be used as one of the parameters of biomonitoring when studying the distribution of mercury in the estuary area of the Red River.
3. Identified positive dependencies of the concentration of mercury in the tissues of mollusks on its suspended form in the bottom layer of water and in bottom sediments exist.
4. The highest accumulation in water and bottom sediments for all species of mollusks was observed for the hepatopancreas, while the lowest was observed for the foot. Per the coefficients of biological accumulation, calculated relative to the mercury content in bottom sediments, the "foot" is a micro-concentrator ($1 < Kd_{(bs)} <2$), and other organs are macro-concentrators ($Kd_{(bs)} > 2$). Regarding the mercury content in the bottom layer of water, all the studied species of mollusks were assigned to the group of macro-concentrators.

**Conflict of Interest**

None declared.

**Конфликт интересов**

Не указан.

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