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Concentrations of arsenic in freshwater, estuarine and mangrove clams from the Mekong and Red R. deltas

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ABSTRACT. During 2017-2018 arsenic concentrations in soft tissues of economically important bivalves from the Mekong and the Red R. Deltas were estimated. Freshwater, estuarine and mangroves species in 10 genera from 11 sites were analyzed. Arsenic levels in both freshwater and estuarine clams were below the permissible limits for hazardous substances in fish and fishery products for recommendation of FAO. In the contrary, in mangrove clams *Geloina* increased levels of As were found. Target hazard quotients and target cancer risk of As was calculated. Arsenic concentrations in the tissues of the *Geloina* are estimated to pose a rather high total cancer risk to consumers.

Keywords: bivalve mollusks, mangrove clams, great river deltas, arsenic contamination, permissible limits, target hazard quotients, target cancer risk.

1. Introduction

Arsenic is considered one of the most significant hazards in the environment which acute dosages of 15 mg per kg of body weight can lead to death (Nga et al., 2001). This metalloid which enters the body with drinking water and food is associated with cancer of skin and organs, as well as other diseases (Chen et al., 1988; Tsai et al., 1998). Arsenic concentrations are typically very low in natural waters - from 0.1–2 μg /L in rivers to 15 μg /L in seawater (Nga, 2008), and less than 10 μg /L in groundwater of most areas (Welch et al., 1999). In great rivers deltas of some Southeast Asian countries natural contamination of alluvium and groundwater by inorganic arsenic is an emerging issue. Deltas of the Mekong and the Red R. have young sedimentary deposits of Holocene and Pleistocene age contaminated with As (Berg et al., 2001 and others). That is why surface and especially ground freshwaters of these regions are often far from upper limit of arsenic concentration recommended by WHO for drinking water - 10 μg /L (Berg et al., 2007; Nga, 2008). In the Vietnamese Mekong delta 40% of the tube-wells had arsenic levels 100 μg/L (Trang et al., 2005) with registered maximum 845 μg/L (Berg et al., 2007), while chronic levels of even 50 μg /L can cause health problems after 10–15 years of exposure (Smith et al., 2000).

In comparison with highly toxic inorganic As, coming in with drinking water, As consummated with seafood is less harmful to health because of prevalence of less toxic organic form. Both forms of As accumulate in hydrobionts through the food web. Taking into consideration growing concern about the occurrence of arsenic in aquatic ecosystems of the Vietnamese great deltas and high economic importance of freshwater and estuarine clams in the country comprehensive biogeochemical study was undertaken during 2017-2018.

2. Material and methods

We examined levels of seven heavy metals and metalloid As in different bivalve species from 11 sites of the Mekong Delta and 6 sites of the Red R. Delta including its ancient part in Quang Ninh Province in

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April and September 2017, and in September 2018. Mollusks of 12 species were collected in Hau and Tien channels of the Mekong and in small tributary of the Red R. delta under freshwater condition, in brackish coastal waters and estuaries of Red R., Ba Lai R., Cai Lon R. (Mekong Delta), in the Quang Ninh (Red R. Delta) and Kien Luong (Mekong Delta) mangroves. The most popular estuarine and mangrove clams were purchased in local markets as well in case of reliable information about their origin. Soft tissues of representatives of 10 genera in 5 families were analyzed employing standard methods: *Scabies, Contradens, Ensidens, Pilsbryoconcha, Hyriopsis* (Unionidae), *Anadara* (Arcidae), *Perna, Mytilopsis* (Mytilidae), *Corbicula, Geloina* (Cyrenidae), *Meretrix* (Veneridae).

The molluscs collected were kept for 48 hours in water from the lakes studied and then separated into size-age groups of 2–10 specimens and prepared to obtain 2,5 g wet weights for each group. Then, mollusk soft tissues were oven-dried at a temperature of 85 º C. The prepared weights were mineralized with a highly purified HNO_3 in a MARS 5 microwave. Arsenic concentrations were measured by flame atomic absorption spectrometry using Shimadzu AA–6800 device for cuvet variant. The measurement accuracy of As concentrations was controlled using standard samples. Contamination of reagents was controlled by analyzing blank control samples.

As these clams with the exception of *Mytilopsis* sp. are used for human consumption, comparison As concentrations in studied clams with international standards in mollusks/shellfish compiled by the Food and Agricultural Organization (FAO) of the United Nations (0.5 – 25 μg /g dry weight) has been made.

3. Results and discussion

The study showed that As levels in both freshwater and estuarine clams from the Mekong and Red R. deltas were most often in the range of 3-13, never reaching 15 μg /g dry weight, which was below the permissible limits for hazardous substances in fish and fishery products for recommendation of FAO. That is in congruence with literature data on bivalves from Vietnam (Wagner and Boman, 2003; Tu et al., 2010 and others) as well as with our previous communication on trace elements in the *Corbicula* (Prozorova et al., 2018). In the contrast with those mollusks mangrove clams of the genus *Geloina* from both deltas are persistently characterized by increased concentrations of As (20-28 μg /g dry weight). We associate this with high salinity (15-20‰) and temperature of water and mud (up to 35-40˚C) because of strong insulation in shallow mangrove habitats. Nevertheless, in accordance with US Food and Drug Administration (US FDA) guidelines, *Geloina* clams fit in limits for human consumption (86 μg /g dry weight) as other studied bivalves.

To evaluate potential human risks associated with consumption of the *Geloina*, concentrations of inorganic As should be firstly taken into account. Although, total As concentrations are both high and highly variable in seafood, inorganic As concentrations are uniformly low, as estimated from 2-3 % of total As in estuarine mollusks (Schoof and Yager, 2007) to 6-22% in oysters and mussels from the USA seacoast (Valette-Silver et al., 1999), and 13.5% in *Meretrix lusoria* from Taiwan (Liu et al., 2007). Following the most popular recommendations (Macintosh et al., 1996; Han et al., 1998; 2000) we assumed inorganic As in bivalves as 10% of total As to calculate the target hazard quotients and target cancer risk of As using formula by Tu with coauthors (Tu et al., 2010). Basing that algorithm, among studied bivalves arsenic concentrations in the tissues of the *Geloina* clams from mangroves were estimated to pose a rather high total cancer risk to consumers.

4. Conclusions

Thus, in economically important mangrove clams *Geloina* from the Mekong and the Red R. Deltas increased levels of As were found, which often exceeding permissible limits for hazardous substances in fish and fishery products for recommendation of FAO. Arsenic concentrations in the tissues of the *Geloina* are estimated to pose a rather high total cancer risk to consumers. Taking into consideration revealed problem, further detailed study on the concentration and speciation of As in these and other mangrove molluscs should be conducted in the nearest future.

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