Oceanography/Vol.1/No.3/Fall 2010/6/15-20

Trace metals in the mussel *Donax trunculus* of Annaba estuaries, Algeria

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Abstract

Trace metal concentrations (Pb, Ni, Cu and Zn) in the mussel *Donax trunculus* and the sediments of Annaba estuaries, North-East Algeria were studied. *D. trunculus* is a widely consumed species by local population. Samples were collected from four sites located alongside Annaba coastline, and exposed to different types and degree of urban and industrial pollution. Results have indicated that the concentrations of Pb, Ni, Cu and Zn are higher in sites which are close to Annaba city. On the other hand, metal concentrations are almost similar between males and females, with only few exceptions. Generally, the concentrations of Pb, Ni, Cu and Zn of sediment have followed the same trend as that of *D. trunculus*. This study suggests that the species and the sediment as well might be used for monitoring trace metal pollution in Annaba estuaries. It is also suggested that this species is not recommended for fishing and for human consumption in sites near Annaba city.

Keywords: *Bivalve, Donax trunculus, estuaries, pollution, sediment, traces metals, Introduction*

1. Introduction

Currently the survey of trace metals in bivalves and sediment is more than necessary to evaluate the level of pollution in the estuaries of Annaba coastal water, as it was suggested in the project dealing with trace metal monitoring in animals. The coastline of Annaba (North-East Algeria) is characterized by intense economic, agricultural and tourist activities. As a consequence, Annaba estuaries are the sink receiving the discharges of two main water bodies, The Seybouse and the Mafrag rivers. These water bodies transport the industrial, agricultural and domestic discharges of the catchment area which is greatly urbanized and the local development increased considerably, especially in the last three decades. However, only few works have studied the distribution of trace metals in the decapods Crustaceans (Abdennour et al., 2000; Abdennour et al., 2004), and the bivalves (Drif et al., 2005) in the estuaries of North-East Algeria. As benthic organisms, bivalves show a bigger sensitivity for the metallic pollutants.

Such organisms represent the most reliable tool to monitor pollution by trace metals (Rainbow and Philips, 1993; Bat et al., 1999; Topcuoglu et al., 2002; Rainbow et al., 2004; El-Sikaily et al., 2004; Wang et al., 2005). In addition, sediment has been used for monitoring trace metal levels in many locations of the world under different climatic, environmental and anthropogenic conditions; from the eastern English estuaries (Wright & Manson, 1999), from Turkish Coast of the Black Sea (Topcuoglu et al., 2002), the Italian Venice Lagoon (Belluci et al., 2002), the Russian coastal habitats of the North-western Sea of Japan (Shulkin et al., 2003), the French Atlantic coast at Gironde estuary (Baudrimont et al., 2005), the Spanish southern coast(Saenz et al., 2003; USERO et al., 2005), and the Egyptian South Eastern Mediterranean coast ((Abdallah, 2008).

The objective of this work is to evaluate the distribution of trace metals (Pb, Ni, Cu and Zn) in the bivalve *D. trunculus* of sediments differently subjected to the pollutions through the estuaries of Annaba, and also to study the variations of metal concentrations between males and females. This mussel represents the south-east Mediterranean coast, which has not been given much attention, while it has been exposed to different types and degrees of pollution in the last decades.

2. Materials and Methods

The four sites are situated along the coast of Annaba on an inshore line of about 20 Km (Figure 1): Bettah (site 1) is rather under the direct influence of the contributions of Mafrag estuary, relatively non polluted; Seybouse (site 4) receives direct industrial and urban discharges; Chatt (site 2) and Sidi Salem (site 3) are submitted indirectly to the influences of the discharges of Mafrag and Seybouse, respectively. In addition, site 3 directly receives the untreated sewer from the city of Annaba throughout the year.

However, the estuary of Mafrag is made of the unification of two permanent minor rivers, EL-Kebir and Bounamoussa (Figure 1).

The species concerned in this work is the bivalve Donax trunculus Linnaeus, 1758. It is collected during the month of July 2005, by local fisherman, from Annaba coastline with an average air temperature of 35 °C (Figure 1). The selected dimensions cover the individuals present in the 4 sites, having a length between 28-30mm. Such dimensions are found in the market and they are the more consumed by local populations.

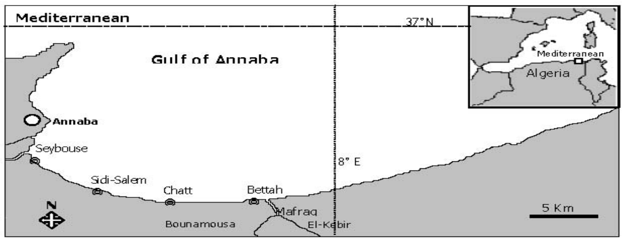

Fig 1. Geographic Map of Annaba Coastline Showing the Sampling Sites.

The individuals were immediately transported in container to the laboratory, cleaned by sea water, and then grouped to males and females. The collected superficial sediments of the same sites have been divided into three replicates, filtered with a sieve of 80 µm, and dried before being analysed. The dry weight of tissues and the sediments have been digested by concentrated nitric acid and sulphuric acid, before measuring the concentrations of Pb, Ni, Cu and Zn, by using the flame atomic absorption spectrophotometer (A-6601F).

The mean metal concentrations of the different populations of *D. trunculus* have been compared with Student t-test and the one way analysis of variance ANOVA. The significant differences at $p<0.05$ have been considered.

3. Results

3.1 Donax trunculus

Pb: Site 4 recorded the most elevated concentrations, followed by site 3. Significant differences between site 1-3, site 1-4, site 2-3, site 2-4 and site 3-4 have been recorded among males and females. Concerning sex, there was no significant difference between males and females (Figure 2).

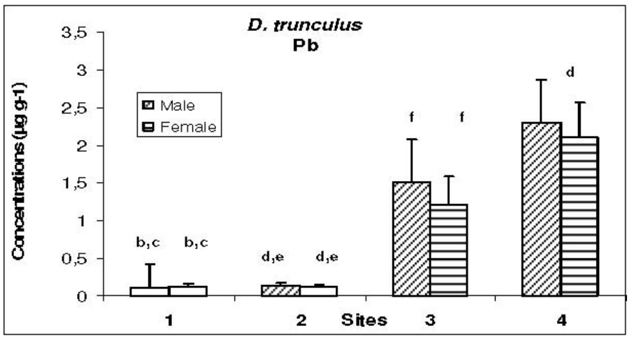

Fig 2. Mean Total Body Cconcentrations (±SD) of Pb (µg g^{-1} dry weight) in *D. trunculus*. a: S1 vs. S2; b: S1 vs. S3; c: S1 vs. S4; d: S2 vs. S3; e: S2 vs. S4; 1: Male vs. Female.

Ni: The concentrations of the Ni in the *D. trunculus* were higher in site 4, followed by site 3, with significant differences between sites as those of Pb. Besides, only one significant difference has been observed between the two sexes and that in site where Ni concentration has been raised more among males (Figure 3).

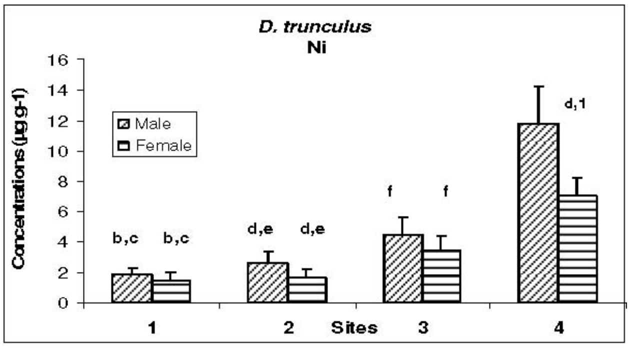

Fig 3. Mean total body concentration (±SD) of Ni (µg g-1 dry weight) in *D. trunculus* Statistical comparison as in Figure 2.

Cu: The concentration has increased from site 1 and reached its maximum in site 4. The most elevated rates have been found at site 4 among males, and at site 3 among females, with the total absence of significant differences between the two sexes (Figure 4).

Zn: The concentrations of Zn in *D. trunculus* are by downward order (site 4 < site 3 < Site 2 and site 1), accompanied by only one significant difference between the two sexes at site 2 (Figure 5).

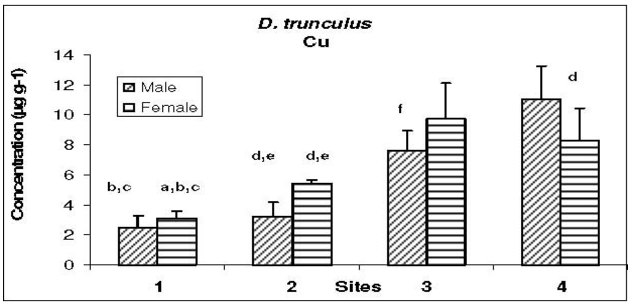

Fig 4. Mean total body concentration (±SD) of Cu (µg g^{-1} dry weight) in *D. trunculus*. Statistical comparison as in Figure 2.

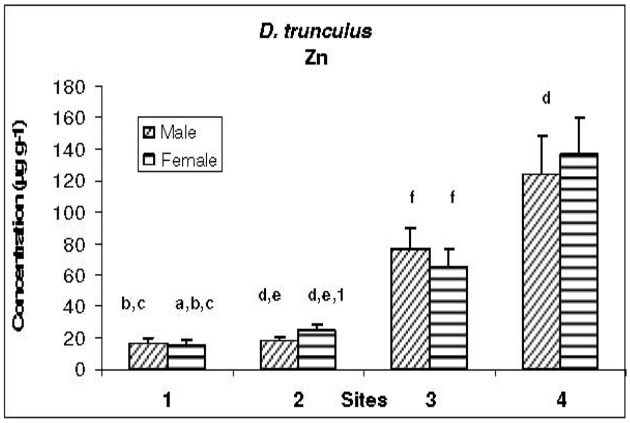

Fig 5. Mean total body concentration (±SD) of Zn (µg g^{-1} dry weight) in *D. trunculus*. Statistical comparison as in Figure 2.

3.2 Sediment

Generally, the levels of the Pb, Ni, Cu and Zn in the sediment followed the same trend as that of *D. trunculus*, with the exception of the Cu in site 1 and 2. However, site 4 showed the most elevated levels for all metals, followed by site 3 (Figures 6, 7).

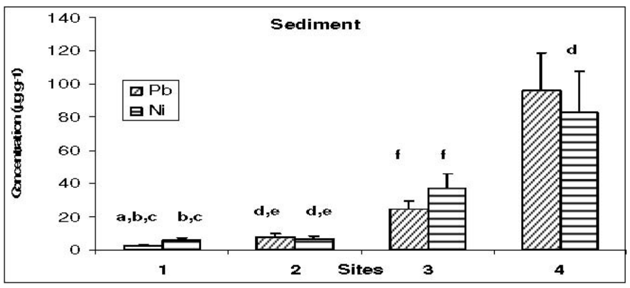

Fig 6. Mean concentrations of Pb and Ni (µg g^{-1} dry weight) in the sediment. Statistical comparison as in Figure 2.

Significant differences were observed between the four sites of Pb, Ni, Cu and Zn, except those of sites 1and 2 for Ni and Zn, and sites 1 and 2 and sites 3 and 4 for Cu, where the concentrations were closer.

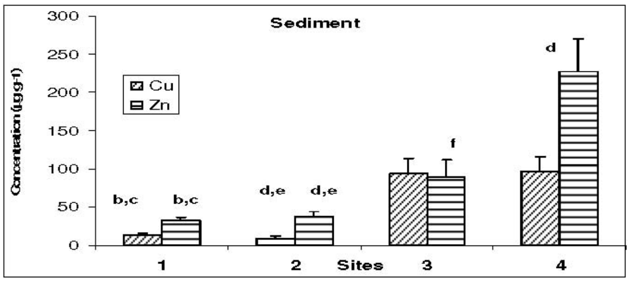

Fig 7. Mean concentration of Cu and Zn (µg g^{-1} dry weight) in the sediment. Statistical comparison as in Figure 2.

4. Discussion

Annaba estuaries are being subjected to heavy urban and industrial discharges due to the intense human activities (Khelifi- touhami et al., 2006). The estuaries are used as sources of food, especially fish and bivalves. The mussel *D. trunculus* is being consumed by local population during the four seasons of the year. However, fishing marine organisms are not well subjected for analysing their pollutant contents, particularly trace metals. The levels of trace metals in the studied estuaries have showed wide variations through the investigated sites, which represent the different exposure to pollutants. Metal concentrations in *D. trunculus* were in increasing order from the relatively unpolluted site, going through the moderately, then the highly polluted stations. It is interesting to note that the four studied sites are situated between two big water bodies, the Mafrag in the east and the Seybouse in the west. Though, site 1 and 2 are influenced mainly by the Mafrag estuary, whereas site 3 and 4 are influenced by Seybouse River. If we looked to the contents of discharges of each water body, we could explain why trace metal concentrations have varied between sites.

Accordingly, in wet seasons, we could see the influence of these rivers on the estuaries from the space, where Mafrag region is muddy yellowish, whereas the Seybouse region is brownish carrying huge quantities of pollutants. Yet, the water flux from both water bodies decreases significantly in July-September period. In addition to receiving industrial and urban effluents indirectly from Seybouse River, site 3 also receives the city centre sewer throughout the year. Consequently, black debris of organic matter was found inside shells of animals collected from this last site. Although metal concentrations were higher in site 3, but were still lower than those of site 4. It has been reported that organic matter complexes trace metals, reducing however, their bioavailability to living organisms (Rainbow, 1997). Previously, Abdennour et al. (2000) mentioned the role played by organic materials in determining the trace metal contents of the decapods Paelemonetes varians collected in summer from a semi-closed brackish water lagoon rich in sewage and situated 200 m to the east of site 3.

Salts are known also to complex trace metals, leading to their precipitations in the sediments (Rainbow, 1997). The bivalve *D. trunculus* is a sediment inhabiting species and is in direct contact with the precipitated metals. In the actual results, however, the concentrations of trace metals in *D. trunculus* correlate with those of the sediments, increasing from the east to the west. That is to say, metal contents in this species reflect to some extent those exist in the sediments. Compared to the semi-closed brackish water lagoon (Abdennour et al., 2004), the concentration of Zn in the sediment of site 3 is higher, whereas that of Cu is almost the same. Previous reports, however, have recorded such relations between trace metal concentrations in mussels and those of the sediments (Usero et al., 2005; Shulkin et al., 2003).

Apparently, metal concentrations in mussels were related to those of the sediments in the Turkish Coast of the Black Sea (Topcuoglu et al., 2002), and in the coastal habitats of the north-western Sea of Japan, which has a broad range of contamination due to urban sewage (Shulkin et al., 2003). Also the contaminated sites were found to be rich in trace metal contents compared to other non contaminated sources (Wright & Manson, 1999; Shulkin et al., 2003; Usero et al., 2005). If the non essential metals, Pb and Ni, are considered as net pollutants, part of the essential metals, Zn and Cu, are known to play physiological roles in animal tissues (White & Rainbow, 1985).

Sex however, has affected trace metal concentrations only in two sites, one is highly polluted and another is moderately. If the high Zn level in females could be related to the reproductive activity which starts from April till September, it is difficult to find an explanation of Ni elevation in males. It has been reported that the metal accumulation in mussels might be affected by reproductive cycle (Coimbra & Carraca, 1990), or it varied significantly between males and females (Lima, 1997). Contrary, Cu concentration of Perna perna was found not to be related to sex in summer period (Rezende & Lacerda, 1986). Other studies have reported that sex has not affected Pb levels in P. perna (Rezende & Lacerda, 1986). Finally, it is important to note that sample collections were made in July where temperature was the highest during the year 2005. These thermal conditions affect the animal growth rate. For that reason, rapid growth rate dilute body metal contents, on one hand, and take up much metals from the medium, on the other hand (White & Rainbow,1984).

5. Acknowledgements

This work was kindly supported by CREAD, Ministry of Territory Management and Environment; project code 1.564, Ref 130/DIR/2004.

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