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Trace Metals in Mussels *Mytilus galloprovincialis* from Dakar Coast (Senegal)

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Abstract

Mussel samples from the Dakar coast (Senegal) were analysed using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). Microwave acid digestion was also employed for metals (Mn, Pb, Cd, As) determination. Dakar coast usually receives numerous domestic and industrial discharges without prior treatment. The contents of Arsenic were, in all cases, higher than other metals. However, the bivalve molluscs present themselves as effective bio-monitors when assessing marine aquatic pollution by contaminants in the Dakar coast. The ANOVA analysis allows concluding that significant differences were found between mussels from different sampling points. In all cases, the February samples have in all cases a higher content than those collected in October.

Keywords

Mytilus galloprovinciali, Trace Element, Dakar Coast, Pollution

1. Introduction

The global environment has suffered in recent years significant damage, due to the strong growth of industrial and human activities.

In Senegal, metals are the main pollutant of aquatic ecosystems. In water, they are hydrolysed and are absorbed by the shells that accumulate them [1].

Mytilus galloprovincialis is an unsegmented soft bivalve mollusc. It is surrounded by a mantle of two large lobes that surround the body and secrete the bivalve limestone shell [2]. The mussel is a sessile, suspensivorous species and can filter up to 100 to 200 liters of water a day. It can sort the nature and size of the particles entering the palloid cavity [3]. It feeds on phytoplankton and organic debris. It absorbs many substances during its existence and can give indications on the state of pollution of the environment [4] [5].

The analysis of its flesh can provide information on the degree of pollution of water by heavy metals [6]. These seafood products, which are likely to end up in food, become a source of contamination for humans [7]. It is therefore important to control the levels of certain metals present in the environment to prevent possible contamination of the population.

The main objective of this work is to evaluate the content of metals (Mn, Pb, Cd, As) in mussel samples from the Dakar coast. These results provide essential information to assess the pollution status of study area and to evaluate the impact of different human activities on the marine environment.

2. Material and Methods

The study area is characterized by intensive fish activity and several swimming zones; however, also receives both domestic and industrial wastes from the Dakar city and the surrounding industrial areas. In **Figure 1** are shown the sampling points in the corresponding localities.

The locality of Mbao (**M1**) is located next to the African Society of Petroleum Refining (SAR) and the power station (Cap des Biches). The municipality of Hann (**M2**) houses a textile factory, as well as factories processing marine products and the east channel draining wastewater to the sea. The Soumbedioune beach (**M3**) is a place of landing of fishery products and receives numerous urban water discharges through the western channel or channel IV. The Port of Dakar (**M4**) is currently active with frequent transshipment of oil. From there depart the pipelines that supply various oil companies of the capital.

About fifty specimens of *Mytilus galloprovincialis* were collected in each sampling position indicated (**Figure 1**) during the period between February 2018 and October 2018. They were stored in polyethylene bottles containing water from the collection site. In the laboratory, animal tissues are separated from the shells and lyophilized to constant weight. After this, the samples were ground by means of a mechanical ball-mill and then they were sieved using a nylon fiber sieve in order to separate the fraction with particle size lower than 70 µm. Powdered samples were stored at room temperature in stoppered glass bottles in a desiccator.

The mineralization of the solid samples for trace metals determination was performed by acid digestion using a microwave procedure. A portion of dry mussel samples (about 0.15 g) was weighted and placed in the PFA vessel of the Parr reactor and 4 mL of nitric acid (65%) were added. The vessel was closed and heated in the microwave oven during 2 minutes at 450 W of power. After cooling, the reactor was opened and 1 mL of hydrogen peroxide (30%) was added to complete the sample decomposition by heating again during 1 minute at the same power. Finally, the resultant solution was quantitatively transferred into a 25 mL volumetric flask and diluted to volume with ultrapure water. The

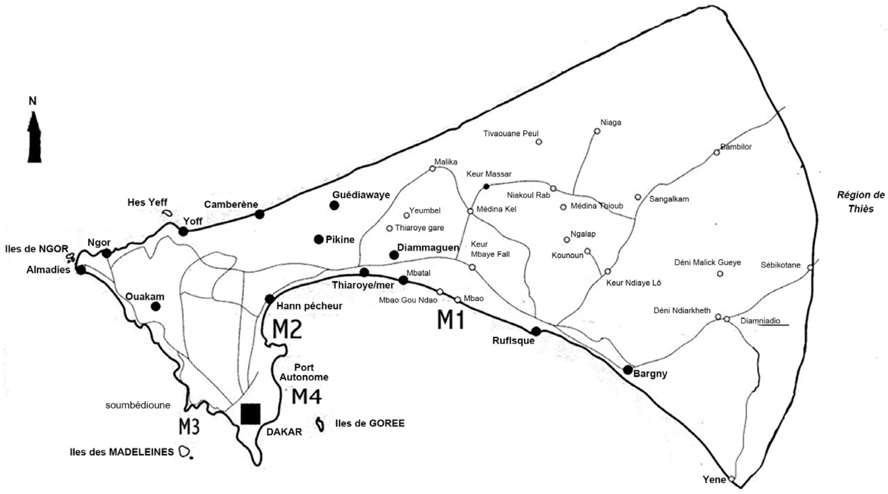

Figure 1. Location of sampling points in the Dakar coast.

final solution was stored, at 4˚C, in stoppered glass bottles until analysis by ICP-MS. The corresponding blank solution was prepared in a similar way but without any sample added.

3. Results and Discussion

During the sampling, pH, temperature and conductivity were measured for the different samples studied. Table 1 presented the main results obtained.

The temperature measured in samples from the Dakar coast varies between 26.4˚C and 30.7˚C, which is in line with European water standards. The neutrality of the sampling medium was noted, given the pH values obtained (7.05 - 7.63), while the relatively high values of the conductivity (1424 - 1820 µS/cm) indicate the highly mineralized nature of the coastal waters from the city of Dakar. The preliminary results, from the introduction of the presence of mineral pollutants, can be easily associated with significant acidity. The measured parameters were followed by qualitative assays of the metal ions likely to be present in the samples. According to our means of analysis, we focused on four metallic elements (Mn, Pb, Cd, As). The results of the assay revealed the presence of these metals in the mussels studied. The elements were then chosen for the continuation of the study.

In the present study, four metallic elements were analysed in wild mussels *Mytilus galloprovincialis*: manganese (Mn), lead (Pb), cadmium (Cd), arsenic (As). The analytical results obtained for metals studied are summarized in Table 2 and all of them are expressed in µg/g dry weight.

The results obtained in the mussel samples from the Dakar coast showed different concentration values. The mussels collected at the level of the Port of Dakar generally have higher levels of Arsenic than mussels at other sites (Figure 2). This trend is also visible with lead (Pb), cadmium (Cd) and manganese (Mn). According to the results obtained, arsenic (As) had the highest levels. These site-specific differences in the contents were analysed in the tissues of the mussels

Table 1. Parameters (pH, temperature and conductivity) found in mussel samples.

Parameters	M1	M2	M3	M4
		February 2018		
pH	7.63	7.05	7.24	7.40
Temperature (˚C)	30.1	29.5	26.4	30.7
Conductivity (µS/cm)	1820	1569	1432	1730
		October 2018		
pH	7.60	7.2	7.26	7.36
Temperature (˚C)	29.9	30	25.8	30.2
Conductivity (µS/cm)	1818	1558	1424	1732

Table 2. Metal content in mussels using the collected along Dakar coast.

Sampling points	Mn (µg/g)	Pb (µg/g)	Cd (µg/g)	As (µg/g)
		February 2018		
M1	2.19 ± 0.44	1.78 ± 0.52	1.22 ± 0.15	4.22 ± 0.32
M2	1.52 ± 0.21	2.28 ± 0.77	1.98 ± 0.04	3.22 ± 0.26
M3	4.28 ± 0.39	2.29 ± 0.52	1.87 ± 0.22	8.22 ± 0.38
M4	5.92 ± 0.49	5.43 ± 0.13	7.06 ± 0.18	11.22 ± 0.78
		October 2018		
M1	2.02 ± 0.56	0.91 ± 0.33	1.01 ± 0.14	3.60 ± 0.29
M2	1.24 ± 0.32	1.10 ± 0.61	1.20 ± 0.21	2.85 ± 0.22
M3	3.58± 0.79	1.24 ± 0.34	1.31 ± 0.17	7.34 ± 0.43
M4	5.22 ± 0.87	2.52 ± 0.45	6.86 ± 0.26	10.23 ± 0.7

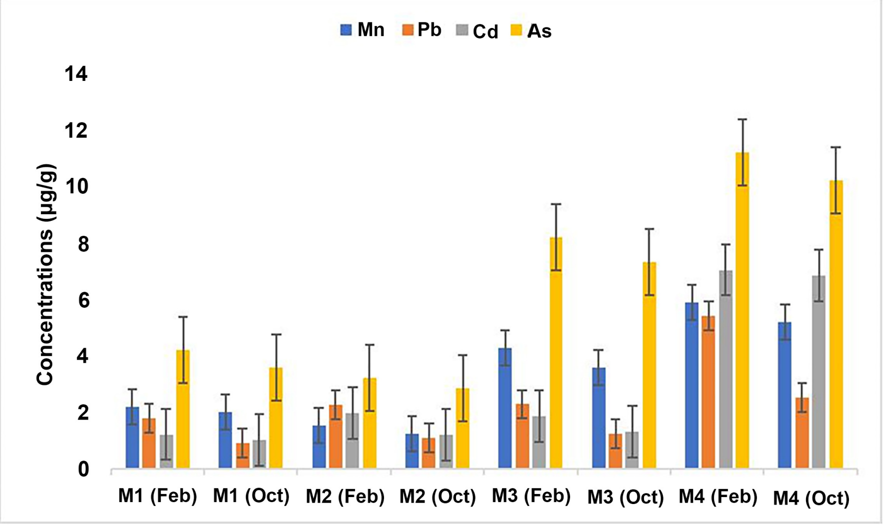

Figure 2. Element concentrations (Mn, Pb, Cd, As) in mussels samples taken in February 2018 and October 2018, as determined using ICP-MS analysis.

can be explained by the differences in the environmental conditions of these sites suggested by Ndiaye *et al.*, 2015 [8]. The conditions in the beaches of Hann, Mbao and Soumbedioune are more dynamic and difficult for the mussels, because they live in rocks exposed to extreme weather conditions, unlike the mussels of the Port of Dakar which are always submerged. This can lead to a more active metabolism in natural mussels and thus a more vigorous accumulation of elements. Another possible reason is the different composition of the mussel feed at the different sites, resulting in different absorption of the elements. Mussels that grow on the floating pier of the Dakar coast are exposed to large tidal currents entering and exiting the coast several times a day, and tidal-dependent waters may differ in the composition of mussel-based foods. It is therefore reasonable to conclude that anthropogenic activities are responsible for the input of metals into the mussels of the Dakar coast with high levels of arsenic (As) found in the mussels following all the sites in the region.

Arsenic (As), a naturally occurring element, is a global contaminant found in rocks, soil, water, air and food. Arsenic is a highly toxic and carcinogenic element for humans. Humans can be exposed to arsenic through ingestion of food and drinking water, but for most people the main source of exposure is diet, mainly fish and seafood [9]. Arsenic concentration in this study ranged between 3.22 et 11.22 µg/g dry weight in wild mussels from Dakar coast. According to Bulgarian Food Codex and Montenegrin Food regulation [10]. The Food and Drug Administration of the United States guidelines 86 mg/kg dry weight for Arsenic in shellfish. In the literature Arsenic concentration in the mussels is found to be between 2.64 - 30 mg/kg dry weight [11] [12].

Cadmium is found in marine waters mostly in the dissolved form, distributed in the marine environment at low concentration and mussel accumulate Cd effectively and may act as poison to humans [13]. Cd levels in analysed marine shells were between 1.22 to 7.06 µg/g dry weight. The maximum Cd level permitted for mollusks is 1 mg/kg according to the European Community [14] and Bulgarian Food Regulation [15]. The present Cd values did not exceed the MPLs set by those health organization. Therefore, there was no apparent Cd risk of consuming molluscan shellfish.

This essential element occurs naturally in many food sources. Exposure to high levels of Mn may lead to adverse neurological effects [16]. Therefore the amount of this element is controlled and information related with recommended intake can be found: the United State Environmental Protection Agency (US EPA) report a non-cancerogenic of 0.14 mg/kg of body weight from diet, in Canada TDI values are 0.136 mg/kg Mn for infants and toddlers, 0.122 mg/kg for children, 0.142 mg/kg for teenagers and 0.156 mg/kg for adults. There are no fixed values for manganese according to Bulgarian Food Codex [10]. For an adult weighing 60 kg, the manganese content is 8.4 mg/kg body weight day. The manganese contents in the mussels analysed ranged between 1.52 and 5.92 µg/g (**Table 2**).

Based on consumption of 125 - 250 g of molluscan shellfishes from Bulgarian Black Sea coastal area on a weekly basis, the human body receives 0.40 and 0.80 mg Mn/person/week for average and high-level molluscan shellfish consumers. These values are below or near the ones stated in the literature: Albanian coast −1.64 mg/week and 3.28 mg/week, respectively; Croatian coast—0.13 mg/week and 0.26 mg/week [17] [18].

The International Agency for Research on Cancer (IARC) classified inorganic Pb as probably carcinogenic to humans [19]. This element is highly toxic and is accumulated in human body in soft tissues, bones and teeth. Its concentration in various food matrixes is strictly regulating. In current study the concentration of Pb was under LOD for some samples up to 0.332 mg/kg for the farmed mussel from the northern region. The maximum concentration of Pb is within the MPLs suggested by the EC [14] (1.50 mg/kg) and USFDA/CFSAN [11] (1.70 mg/kg). Finally, the present Pb ranges are within the legal limits of Pb (1.5 mg/kg) as compiled by Bulgarian Food Codex [10].

Lead concentration in mussels and rape whelks varies in the literature. The European Food Safety Authority (EFSA) concluded that Pb has the most harmful effect on the central nervous system of young children and on the cardiovascular system of adults, and identified three reference dietary intake values, 0.63 µg/kg/day for nephrotoxic effects in adults, 1.50 µg/kg/day for cardiovascular effects in adults and 0.50 µg/kg/day for neuro-developmental effects in children [20]. In the case of farmed mussels from the Dakar region in which the highest Pb concentrations (5.43 µg/kg) were measured around the port of Dakar. The Pearson correlation shows that most of the four metals studied have significant correlation coefficients (**Table 3**).

The overall results presented in **Table 1** are summarized in the box diagram of **Figure 3**, where there are significant differences between mussel samples taken

Table 3. Pearson correlations between the metals analysed.

	Correlations				
		Mn	**Pb**	**Cd**	**As**
Mn	Correlation de Pearson	1	0.737*	0.828*	0.997**
	Sig. (bilateral)		0.037	0.011	0.000
	N	8	8	8	8
Pb	Correlation de Pearson	0.737*	1	0.810*	0.723*
	Sig. (bilateral)	0.037		0.015	0.043
	N	8	8	8	8
Cd	Correlation de Pearson	0.828*	0.810*	1	0.828*
	Sig. (bilateral)	0.011	0.015		0.011
	N	8	8	8	8
As	Correlation de Pearson	0.997**	0.723*	0.828*	1
	Sig. (bilateral)	0.000	0.043	0.011	
	N	8	8	8	8

*. The correlation is significant at the 0.05 level (bilateral). **. The correlation is significant at the 0.01 (bilateral).

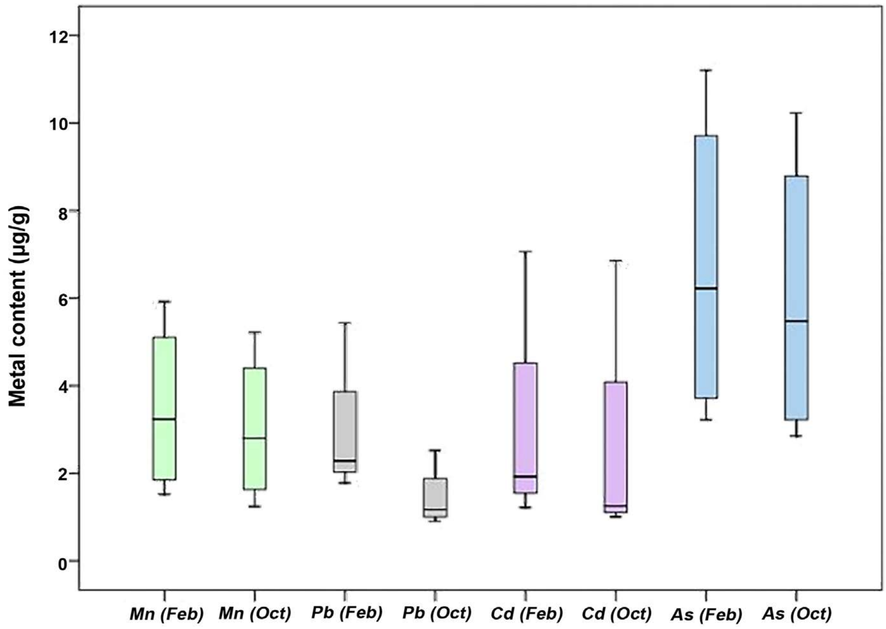

Figure 3. Box diagrams to see the difference of each metal between the two samplings.

in February and October. In fact, the percentiles between 25% and 75% are not coincidental in any cases. It seems that the February samples have in all cases a higher content than those collected in October.

4. Conclusion

The metals content (Mn, Pb, Cd, As) was measured in the mussels (*Mytilus galloprovincialis*) at different sites. The results indicate that mussels accumulate much more arsenic (As) than other metals. However, the highest arsenic levels were noted around the Port of Dakar near the port's multipurpose ore loading facilities, where large quantities of these metal ores are loaded. This provided reasonable indications of marine pollution caused by spills during loading. Our current study confirms that bivalve molluscs are good indicators for assessing marine aquatic pollution, particularly when searching for trace elements. The mussel monitoring program in the Dakar region will continue and the results of our study will serve as guidelines for further sampling, as well as a basis for estimating future trends. The ANOVA analysis allows concluding that significant differences were found between mussel samples taken in February and October. In all cases, the February samples have in all cases a higher content than those collected in October.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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