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Estimation of mercury background values in sediment and biota of the Bijagós archipelago, Guinea-Bissau



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ABSTRACT

This work evaluates the mercury (Hg) contamination status (sediments and biota) of the Bijagós archipelago, off the coast of Guinea-Bissau. Sediments exhibited very low concentrations ($<1\text{--}12\text{ ng g}^{-1}$), pointing to negligible sources of anthropogenic Hg in the region. Nevertheless, Hg is well correlated to the fine fraction, aluminium, and loss on ignition, indicating the effect of grain size and organic matter content on the presence of Hg in sediments. Mercury in the bivalves *Tagelus adansonii* and *Senilia senilis* did not vary considerably among sites, ranging within narrow intervals ($0.09\text{--}0.12$ and $0.12\text{--}0.14\text{ }\mu\text{g g}^{-1}$ (dry weight), respectively). Divergent substrate preferences/feeding tactics may justify slight differences between species. The value 11 ng g^{-1} is proposed as the sediment background concentration for this West-African coastal region, and concentrations within the interval $8\text{--}10\text{ ng g}^{-1}$ (wet weight) may be considered as reference range for *S. senilis* and *T. adansonii* in future monitoring studies.

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The awareness of ecosystem degradation in various regions of the planet led to the development of environmental quality guidelines and monitoring programs to assess the environmental status of different types of habitats. The establishment of concentrations of hazardous materials is crucial to distinguish between anthropogenic-influenced values and natural levels (OSPAR, 2005). Mercury (Hg) is recognized as one of the most hazardous elements, due to the acute toxicity of all its chemical forms, persistence, bioaccumulation and biomagnification properties (Boening, 2000; Coelho et al., 2013). Accordingly, mercury is considered a priority by several environmental protection agencies and directives worldwide, with several guidelines regarding its concentration in sediments and biota. Lithology may influence the sediment elemental composition of low impacted systems, which implies that background values may vary at regional scale (Mil-Homens et al., 2014). Compared to other areas of the world, and due to insipient industrial activities, West African aquatic systems generally present low concentrations of metallic contaminants (Biney et al., 1994), although some contamination hotspots in highly populated areas have

been identified (Gnandi et al., 2011; Diop et al., 2015; Kouassi et al., 2015). Documenting mercury values in abiotic and biota matrixes of low industrialized regions of Africa provides a better understanding of the regional variation in background levels. The use of biota, namely bivalve mollusks, has become a widely accepted methodology for assessing contaminant bioavailability (Boening, 1999; Zuykov et al., 2013; Coelho et al., 2014), as most of them are benthonic filter feeders and therefore are well-suited to reflect temporal and spatial variability of contaminants in dissolved and particulate fractions of aquatic systems.

The Bijagós archipelago, in Guinea-Bissau, West Africa has 88 islands and islets, a total area of 2624 km^2 and ca. 30,000 inhabitants that are distributed over 26 inhabited islands. Wildlife in the extensive mangroves, sand banks, intertidal areas, shallow waters and forests led to the establishment of two national parks (João Vieira-Poilão and Orango) and of a Community Based Marine Protected Area (Urok) in the archipelago. The economy of the region is based on agriculture and harvesting of fish, crustaceans and bivalves. This work aims to evaluate the mercury concentration in sediments and in two bivalve species, *Tagelus adansonii* and *Senilia senilis* in this UNESCO Biosphere Reserve. These two species are widespread and an important component of the diet

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of several human communities in the archipelago. Sampling of surface sediments and bivalves was carried out during February–March 2015 in four intertidal sites in three islands of the Bijagós archipelago: Bubaque, João Vieira and Imbone, part of the Orango National Park (hereafter referred to as Orango, Fig. 1). In these areas, sediment samples were collected in the intertidal zone along transects perpendicular to the coastline up to the low tide mark. Samples included a mixture of sediments up to 20 cm depth, which were air-dried and subsequently stored in plastic containers until laboratory analysis. Specimens of *T. adansonii* and *S. senilis* were collected by hand in sediments during low tide, left to dehydrate overnight in sea water and stored in ethanol 99% for transportation. Prior to analysis, ethanol was discarded and samples thoroughly rinsed with ultra-pure water, freeze-dried at $-50\text{ }^{\circ}\text{C}$ and 0.06 bars, and homogenized for analysis. Samples consisted of the entire soft tissue (edible portion). Sediment samples were wet sieved (after a 6 hour immersion in a 3% sodium pyrophosphate solution) to separate the fine fraction ($<63\text{ }\mu\text{m}$) and expressed as a weight proportion of the total. The organic matter content of the sediment samples was estimated through the weight loss on ignition (LOI) at $450\text{ }^{\circ}\text{C}$ during three hours. Sediment and biological samples were analyzed for total mercury by thermal decomposition atomic absorption spectrometry with gold amalgamation, using a LECO AMA-254 (Advanced Mercury Analyser). This method requires no sample pre-treatment, given that dried and homogenized samples are placed into a pre-cleaned combustion boat and inserted in a quartz combustion catalytic tube. The sample is heated in an oxygen atmosphere, the resulting mercury vapour is collected in a gold amalgamator, subsequently released to a heated cuvette and then quantified by atomic absorption spectroscopy using a silicon UV diode detector (Costley et al., 2000). The limit of detection of this methodology is 0.01 ng absolute mercury. Analytical quality control was performed through the daily use of the certified reference materials

(CRMs) MESS-3 (for sediments) and TORT-2 (Lobster hepatopancreas) for biota. All values obtained for the CRMs analysis were inside the respective confidence intervals, with recovery efficiencies ranging from 100 to 102% (MESS-3: $102 \pm 8\%$, $n = 18$; TORT-2: $100 \pm 7\%$, $n = 51$). Sediment Al content was quantified after microwave-assisted digestion (CEM MARS 5; ramping heating until $180\text{ }^{\circ}\text{C}$ at 1600 W for 5 min and 10 min at 1600 W and a constant temperature of $180\text{ }^{\circ}\text{C}$). Briefly, about 200 mg of sample were digested with 9 mL of HNO_3 and 3 mL of HF in Teflon vessels. After microwave digestion, the vessels were placed in a plate heater, the contents evaporated to near dryness, re-dissolved with HCl 1:1, re-evaporated, the residues dissolved in HNO_3 1:5 and heated for 30 min at $150\text{ }^{\circ}\text{C}$. Aluminium (Al) and lithium (Li) were determined by inductively coupled plasma optical emission spectroscopy (ICP-OES, Horiba Jobin Yvon Activa M). The analytical control of the methodology was carried out by parallel digestion of the CRM MESS-3, with extraction efficiency between 85 and 94%. All analyses were always performed in triplicate and a maximum coefficient of variation of 10% adopted as acceptance criteria.

Mercury concentrations in sediments were normalised to Li according to OSPAR Guidelines (OSPAR, 2008), according to the following equation:

$$C_{ss} = C_M * (N_{ss} - N_x) / (N_M - N_x)$$

where, C_{ss} is the Li-normalised Hg value, C_M the measured Hg concentration, N_{ss} the pivot value for Li (7), N_x the reference value for Li (52) and N_M the measured Li concentration. The pivot and reference values for Li were obtained from OSPAR (2008).

The fine fraction ($\% <63\text{ }\mu\text{m}$) of analyzed sediments differed statistically among sampling sites (ANOVA $F_{3,55} = 10.71$, $p < 0.05$, Table 1) with samples from Orango and Bubaque1 showing a significantly larger

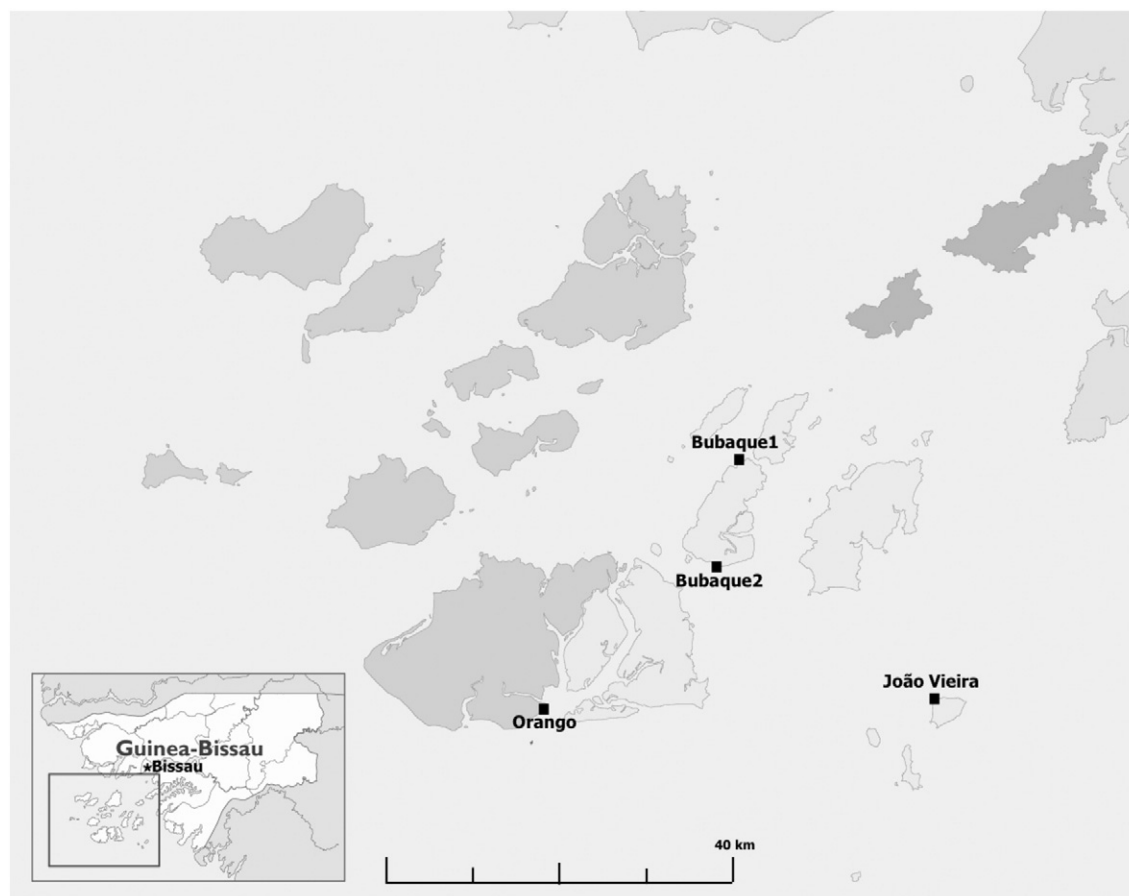


Fig. 1. Schematic representation of the Bijagós archipelago, with the sampling sites indicated.

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