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BIOACCUMULATION OF POTENTIALLY TOXIC TRACE ELEMENTS IN BENTHIC ORGANISMS FROM ADMIRALTY BAY, KING GEORGE ISLAND, ANTARCTICA

http://dx.doi.org/10.4322/apa.2014.077

Alessandra Pereira Majer[1,*], Monica Angélica Varella Petti[2], Thais Navajas Corbisier[2], Andreza Portella Ribeiro[1], Carolina Yume Sawamura Theophilo[3], Rubens Cesar Lopes Figueira[1]

[1]Laboratório de Química Inorgânica Marinha – LAQIMAR, Departamento de Oceanografia Física, Química e Geológica, Instituto Oceanográfico, Universidade de São Paulo – USP, Praça do Oceanográfico, 191, Cidade Universitária, CEP 05508-120, São Paulo, SP Brazil
[2]Laboratório de Bentos Antártico, Departamento de Oceanografia Biológica, Instituto Oceanográfico, Universidade de São Paulo – USP, São Paulo, SP, Brazil
[3]Programa de Pós-graduação em Oceanografia, Instituto Oceanográfico, Universidade de São Paulo – USP, São Paulo, SP, Brazil
*e-mail: lhemajer@gmail.com

Abstract: *The bioaccumulation of trace elements is defined as the uptake of a chemical by an organism from the abiotic and/or biotic (food) environment, and is a widely observed and very important process considering the impact assessment of anthropogenic activities. In Antarctica the main local source of metal and metalloid is related to the activities of research stations. In order to verify the contribution of the Comandante Ferraz Brazilian Antarctica Station (EACF- Portuguese acronym, in continuity) in the accumulation of these elements, and to supply baseline values to allow future monitoring, the concentration of Ag, As, Cd, Cu, Ni, Pb and Zn was measured in twelve benthic Antarctic species (Desmarestia sp, Himantothallus grandifolius, Laternula elliptica, Yoldia eightsi, Amphioplus acutus, Bovalia gigantea, Gondogeneia antarctica, Sterechinus neumayeri, Nacella concinna, Paraserolis polita, Parborlasia corrugatus and Glyptonotus antarcticus). A wide variation in metal content was observed depending on the species and the element. These concentrations were usually lower than those of other Antarctic areas, not indicating relevant anthropogenic impacts of EACF. However, considering the serious fire incident that occurred at the end of last summer (February/2012), and that relevant measures of heavy metals (such as Pb, Cd, and Zn) are released in this kind of event, this data, and the associated methodology, attains particular importance, due to their potential to enlighten the extension of this impact, as well as, the success of any recuperation strategy.*

Keywords: Antarctica, bioaccumulation, metal, metalloid

Introduction

The bioaccumulation of trace elements is defined as the uptake of a chemical by an organism from the abiotic and/or biotic (food) environment (Gray, 2002), and is a widely observed process (e.g. Santos *et al.*, 2006; Farías *et al.*, 2007; Gray *et al.*, 2008; Grotti *et al.*, 2008). For metals and metalloids the bioaccumulation may be the result of natural sources, since these elements are constituents of any ecosystem (Grotti *et al.*, 2008). In Antarctica, like other remote regions of the Earth, the natural concentration of metals and metalloids in abiotic matrices (snow, ice, soil, sediment and air) of most areas are generally within or lower than the observed values of other polar areas, being considered as background levels (Sanchez-Hernandez, 2000). However, near the research stations a lower but continuous kind of contamination is observed (Vodopivez & Curtosi, 1998), directly linked with activities such as garbage incineration, use of paints, fuel usage and sewage (Santos *et al.*, 2004). The result is an increased concentration of both organic and inorganic contaminants, and their impacts are obviously linked with the increasing presence of humans (Bargagli *et al.*, 1998). In order to monitor the effects of the activities in the surrounding biota, the potential bioaccumulation of a variety of metals and metalloids (Ag, As, Cd, Cu, Ni, Pb and Zn) was verified for different Antarctic organisms sampled near EACF.

Methodology

Twelve benthic Antarctic species (macroalgae – *Desmarestia* sp, *Himantothallus grandifolius*, bivalves – *Laternula elliptica* and *Yoldia eightsi*, ophiuroid – *Amphioplus acutus*, amphipods – *Bovalia gigantea* and *Gondogeneia antarctica*, sea urchin – *Sterechinus neumayeri*, limpet – *Nacella concinna*, isopods - *Paraserolis polita* and *Glyptonotus antarticus*, nemertean - *Parborlasia corrugatus*) were sampled nearby EACF, located in Admiralty Bay, the largest bay of King George Island. Samples of benthic invertebrates and macroalgae were obtained manually in the intertidal zone, and between depths of 10-20 m onboard the R/B SKUA, using a van Veen grab, a dredge or by Scuba diving, from November/2005 to February/2006, during the austral summer of the 24th Brazilian Antarctic Expedition. Methods followed those of a previous study performed by Corbisier *et al.* (2004).

Silver (Ag), arsenic (As), cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) concentrations on the organisms were obtained by the analytical technique of Inductively Coupled Plasma – Optical Emission Spectrometry (ICP OES). For that, 0.35 g of each dried sample was digested with 4 mL of nitric acid, to which, six hours later, was added 1 mL of hydrogen peroxide. After 18 hours it was disposed in a heating block digester for 3 hours, and the final solution was filtered and diluted to the final volume of 30 mL. The expressed concentrations of elements in the samples represent the mean of three independent determinations. Certified Reference Materials (CRM - Mussel Tissue – NIST-SRM2976) were analyzed in parallel with the trace element determinations, and reagent blanks were run with all sample analyses.

Results

The metal and metalloid concentrations for the several investigated species are summarized in Table 1. The species with the highest metal or metalloid concentration varied according to the analyzed element. The grazer *S. neumayeri* showed the highest concentration for Zn (353.91 µg g^{-1}). High concentrations of Cu were observed for the carnivores *G. antarticus* and *P. polita* (126.18 and 115.71 µg g^{-1} respectively). The suspension feeder *L. elliptica* showed the highest values for Ag and As (1.04 and 45.88 µg g^{-1}, respectively), while for Cd, Ni and Pb the highest values were observed for the carnivore *P. corrugatus* (5.02 µg g^{-1}),

Table 1. Concentration (µg g^{-1} dry wt) of Ag, Cd, Cu, Ni, Pb and Zn in invertebrates sampled in Admiralty Bay, Antarctica. *sample without enough mass for quantification. Data presented as mean ± SD.

Species	Ag	As	Cd	Cu	Ni	Pb	Zn
Desmarestia sp	0.84 ± 0.03	20.96 ± 0.21	0.39 ± 0.01	4.56 ± 0.10	16.66 ± 0.03	4.45 ± 0.16	29.44 ± 0.09
H. grandifolius	0.32 ± 0.03	14.84 ± 0.58	0.25 ± 0.02	3.53 ± 0.04	0.85 ± 0.06	4.55 ± 0.39	21.73 ± 0.15
L. elliptica	1.04 ± 0.05	45.88 ± 1.06	1.07 ± 0.01	26.10 ± 0.52	2.10 ± 0.09	2.10 ± 0.09	53.08 ± 0.58
Y. eightsi	0.51 ± 0.04	36.64 ± 1.47	0.22 ± 0.04	26.29 ± 0.42	0.35 ± 0.07	*	91.81 ± 1.10
S. neumayeri	0.82 ± 0.08	5.03 ± 0.25	0.98 ± 0.02	3.60 ± 0.03	0.62 ± 0.05	8.93 ± 0.91	353.91 ± 7.43
B. gigantea	0.87 ± 0.01	9.83 ± 1.01	2.29 ± 0.01	58.28 ± 0.76	1.77 ± 0.15	4.34 ± 0.52	52.53 ± 0.42
A. acutus	0.21 ± 0.01	5.98 ± 0.04	0.93 ± 0.04	5.19 ± 0.15	1.16 ± 0.03	9.31 ± 0.84	58.61 ± 0.41
N. concinna	0.74 ± 0.01	6.26 ± 0.60	1.76 ± 0.01	3.41 ± 0.02	0.37 ± 0.06	5.92 ± 0.38	53.72 ± 0.32
G. antarctica	0.44 ± 0.02	7.82 ± 0.55	0.53 ± 0.02	40.83 ± 0.20	0.86 ± 0.13	4.26 ± 0.30	52.96 ± 0.11
P. corrugatus	0.74 ± 0.01	18.59 ± 0.61	5.02 ± 0.03	18.51 ± 0.20	0.48 ± 0.09	2.60 ± 0.15	158.57 ± 0.32
G. antarticus	0.99 ± 0.04	9.88 ± 0.34	0.44 ± 0.02	126.18 ± 0.5	0.97 ± 0.19	4.26 ± 0.30	78.19 ± 1.09
P. polita	0.60 ± 0.07	8.39 ± 0.61	1.07 ± 0.04	119.12 ± 0.36	0.78 ± 0.08	8.66 ± 0.22	53.08 ± 0.27

for the macroalgae *Desmarestia* sp (16.66 µg g^{-1}), and for the ophiuroid *A. acutus* (9.31 µg g^{-1}), respectively.

Discussion

Different factors can affect metal bioaccumulation in organisms, such as its environmental bioavailability (Gray, 2002), but also the assimilation efficiency and efflux rate of the studied species (Wang & Ke, 2002). All these factors contribute to the variability of the results, however, comparing the concentration for each species with those in the literature, which for some species is scarce, lower or similar values were observed in our sampling point (Admiralty Bay) than for other Antarctic areas. For instance, the As concentration for *H. grandifolius* in Admiralty Bay was only 13% (112 µg g^{-1}) of those observed by Farías *et al.* (2002) for samples from the Argentinian base at Potter Cove (King George Island), and 16% (91 µg g^{-1}) for those obtained by Runcie & Riddle (2004) for Casey Station, East Antarctica. The same pattern was observed when comparing Cd concentration for *S. neumayeri* and *P. corrugatus* from Terra Nova Bay (Ross Sea–Northern Victoria Land), with our estimates being only 14 and 23%, respectively, of those observed by Dalla Riva *et al.* (2004). Only for Zn, and in this case in a closer sampling point (in front of EACF), our concentrations were slightly smaller than those observed by Santos *et al.* (2006) for *B. gigantea*, *G. antarctica* and *N. concinna*. These results agree with those obtained through sediment analysis for EACF, in which, despite being observed an enrichment of As, there were no indications of relevant anthropogenic impacts (Ribeiro *et al.*, 2011).

Conclusions

These results contribute to the knowledge of the possible impacts of the Comandante Ferraz Brazilian Antarctica Station considering the liberation of metal and metalloids due to their routine activities. The temporal comparisons between this data and those of other monitoring samplings (previous and posterior to 2005/2006) will allow identification of any increment in terms of bioaccumulation in the surrounding biota. Especially, considering the serious fire incident that occurred at EACF at the end of last summer (Feb/2012), and that relevant amounts of heavy metals (such as Pb, Cd, Fe, Mo, and Zn) are released during this kind of occurrence, this data, and the associate methodology, attains particular importance, due to their potential to enlighten the extension of the impacts, as well as, the success of any recuperation strategy.

Acknowledgements

This work integrates the National Institute of Science and Technology Antarctic Environmental Research (INCT-APA) that receives scientific and financial support from the National Council for Research and Development (CNPq process: n° 574018/2008-5) and Carlos Chagas Research Support Foundation of the State of Rio de Janeiro (FAPERJ n° E-16/170.023/2008). The authors also acknowledge the support of the Brazilian Ministries of Science, Technology and Innovation (MCTI), of Environment (MMA) and Inter-Ministry Commission for Sea Resources (CIRM).

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