ARSENIC METABOLISM IN THE MEDITERRANEAN POLYCHAETE *SABELLA SPALLANZANII*

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Abstract
The bioaccumulation and biotransformation of arsenic was investigated in the Mediterranean polychaete *Sabella spallanzanii*. This species is considered an interesting model which concentrates in branchial crowns very elevated levels of dimethylarsinic acid (DMA), a moderately toxic arsenic compound. Organisms were exposed to different arsenic compounds and the total concentrations and chemical speciation were measured. The overall results suggest the ability of *S. spallanzanii* to produce DMA through transformation reactions including both methylation and degradation of other arsenic compounds.
Keywords : Annelida, Bio-accumulation, Chemical Speciation, Metals.

Nearly all marine organisms contain measurable levels of arsenic which is present as organic non toxic compounds. Arsenic concentrations vary widely in different taxa and species-specific characteristics more than environmental factors appear to modulate basal arsenic bioaccumulation in bivalve molluscs and fishes, without a consistent trend by taxonomic group or trophic levels [1]. On the other hand crustaceans seem to exhibit greater As concentrations in temperate or cold regions compared with tropical latitudes [1]. Among polychaetes, some species accumulate elevated levels of this element and also exhibit the presence of moderately toxic arsenic compounds; the natural variability in arsenic total content and speciation of chemical forms among various polychaetes species are not explained in terms of anthropogenic impact, geographic distribution, phylogenetic similarities, trophic habits or ecological features [2]. The Mediterranean fan worm *Sabella spallanzanii* is characterized by marked differences of arsenic concentrations in different tissues, with values ranging between 40 and 60 ppm in body portions and higher than 1000 ppm in the branchial crowns [3]. Arsenic is associated to cytosolic fraction in a soluble form and analyses of chemical speciation revealed the great predominance (more than 85%) of dimethylarsinic acid (DMA), a moderately toxic compound [3]. The presence of DMA in these tissues might suggest both the degradation of more complex arsenic-compounds i.e. arsenobetaine (AsB), arsenocholine (AsC) or arsenosugars (AsS) accumulated from phytoplanctonic algae, or the methylation of inorganic arsenic usually present in abiotic matrices, such as seawater and sediments [2,3]. To obtain further insights on the capability of *S. spallanzanii* to accumulate different forms of arsenic compounds and to operate transformation reactions, organisms were exposed under laboratory conditions to various chemical species of arsenic including arsenate (As^V) (20 μg/L), DMA (60 μg/L), trimethylarsine (TMA) (60 μg/L) and AsB (60 μg/L). After 20 days total arsenic content and chemical speciation were measured in both branchial crowns and body portions and differences among tissues and kind of experiments were compared using ANOVA and SNK *post-hoc* tests.

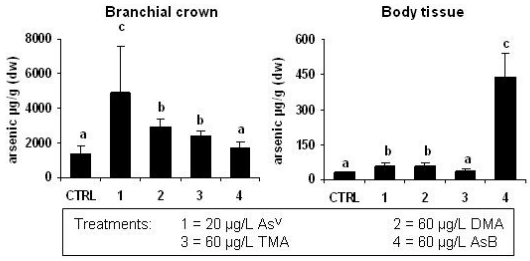

Fig. 1. Total As content (ppm) in branchial crowns and body tissues of organisms exposed to different chemical forms. Letters indicate statistical differences between means of values (p<0.0001).

The highest increases of arsenic content were observed in branchial crowns of organisms treated with arsenate, which can enter the cell through the phosphate carrier system; lower variations were measured with DMA and TMA, while not significant changes of total As occurred after treatments with AsB (Figure 1). In body tissues, exposure to As^V, DMA, TMA confirmed a progressively lower accumulation of total arsenic, while a marked increase was caused by AsB (Figure 1). The basal level of arsenic chemical species in branchial crowns of *S. spallanzanii* were about 1100 ppm for DMA, 6 ppm for TMA, 67 ppm for tetramethylarsonium (TETRA), 58 ppm for AsB and 63 ppm for AsC. Concentrations occurring in the body portions were about 25 ppm for DMA and 5 ppm for AsB.

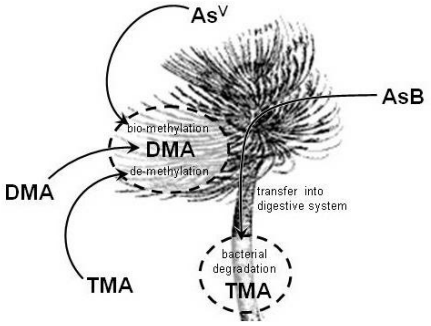

Fig. 2. Arsenic bioaccumulation and biotransformation pathways occurring in the polychaete *Sabella spallanzanii*.

Analyses of chemical speciation of organisms exposed to As^V revealed that inorganic arsenic never occurred in the tissues and the variations of total arsenic were explained almost exclusively by the significant increase of DMA with concentrations always close to 80-90%. Levels of other As compounds remained unchanged during this experiment. Similar trends were obtained after exposures to DMA and TMA when only concentrations of DMA significantly increased in tissues of *S. spallanzanii* while levels of TETRA, AsB, AsC did not change compared to control values. Different results were obtained after exposures to AsB which caused no accumulation of arsenic in branchial crowns and a marked increase in body tissues mostly related to AsB (39 ppm) and especially TMA (222 ppm), not previously detected in any of other experimental conditions. The overall results allowed to hypothesize the mechanisms of arsenic bioaccumulation and biotransformation in *S. spallanzanii* (Figure 2). During all the experiments, DMA was the most accumulated molecule, suggesting that this polychaete species possesses the enzymatic pathways for methylation and de-methylation reactions of inorganic and tri-methylated arsenicals. Only AsB was not accumulated in branchial crowns and not converted to DMA, supporting a microbial pathway for degradation of this molecule, particularly important in body tissues of *S. spallanzanii* for the presence of bacteria associated to digestive tracts [4]. The efficient biotransformation of arsenic would explain the elevated basal levels of DMA typical of *S. spallanzanii* which may represent an adaptive mechanism against predation in more vulnerable tissues.

References

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