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Effects of season and altitude on copper and zinc concentrations in benthos (Chironomids and Gammarids) and sediment

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Abstract: Concentration of heavy metals in aquatic ecosystems is considered as an important environmental issue. In this study, the Namrood River located in Firoozkooh (Tehran province, Iran) was assessed for the existence of heavy metals. The Namrood River is situated by the main road being by pollutants from tourism and recreational centers, gas stations, sewage of villages, agricultural wastewater and fish culture effluent. The water is extremely contaminated in some parts and possibly contains heavy metals. In the present study, two stations up- and downstream were determined to sample the sediments and Chironomidae and *Gammarus pluex* in both cold and warm seasons of the year (middle of March and middle of August). The copper and zinc were measured in sediment and benthos. The results showed that copper and zinc concentrations ranged 0.170-0.966 and 0.187-3.846 ppm, respectively. Sediments of the upstream station had the highest copper concentration among the samples in both cold and warm seasons of the year.

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Introduction

Heavy metals are one of the components of the earth crust. They are a group of elements with atomic weights of 63.546 – 200.59 whose special weight is more than 6 g/cm^3. They exist in the Biospher following to natural source or anthropogenic ones (Javanshir and Shapoori, 2011). Selecting biological indices is considered as one of the most important biological assessments which is used to determine the qualities of the water bodies. Biological indices may be live organisms, which are able to live and survive according to their adaptations in various environments (Pennak, 1979). Otherwise, they cannot survive and are eliminated from the ecosystem (Wright, 1995). Macrobenthic animals may be used in indices that are used to monitor the sewage entering aquatic ecosystems. Their biomass and species diversity is lower than those of planktons due to their longer lifetime. Therefore, benthic macrofauna can reflect effects of all kinds of wastewater and sewage (Hilsenhoff, 1981). Even frequent sampling (once or twice per months) shows significant changes of water status.

The Namrood River is located in southern part of Alborz Mountain in northern Iran. It is a permanent river thus benthic animals may have a complete life history. The River covers a catchment area of about 51 Km^2, whilst melting of snow, originating from mountains, constitutes the main source of water. The present study aimed to investigate heavy metal contamination of two Namrood River habitants, Chironomids and Gammarids.

Materials and Methods

Sampling was carried out in summer (mid-June to mid-September) and winter (mid-November to mid-February) in upstream (2101m) and downstream (1819m from sea level). In each station three points on a transect across the river were determined (two on the shallow and one on the central deep part of

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river). Samples were collected once per month. Benthos and sediment were sampled using surber and Ekman grab, respectively. All samples were fixed with 4% formaldehyde and kept in glass bottles of 200 ml and kept <16°C. Tissue and sediment samples were prepared in laboratory following a protocol from Moopan (1999). The benthos were identified using the keys from Pennak (1978). Heavy metals concentrations were measured using atomic absorption method. The samples were dried in an oven of 60 °C for 24 h. Then, the particles smaller than 63 µm were separated using a sieve and the extraction was separated in a 200 ml glass bottle using Watmann 0.45 µm filter paper. Data were analyzed one-way ANOVA followed by the Duncan multiple range test. All statistical analyses were performed using SPSS 15 (SPSS Inc.).

Results

Copper concentration of sediment, Chironomids and Gammarids suggest different concentrations from up to downstream which may differ among seasons (Fig. 1). Winter concentrations of copper in sediments were significantly different (P<0.05) between upstream (0.927 μg^{-1}) to downstream (0.827 μg^{-1}). Also, there was a significant difference between up- and downstream in summer (0.966 μg^{-1} and 0.701 μg^{-1}, P<0.05). However, there was no significant difference in zinc of sediment among sampling stations and seasons (Fig. 2). The lowest concentration of copper in Chironomids bodies was measured in upstream and during the winter (i.e. 0.17 μg^{-1}) but in other cases no significant differences were observed (Fig. 1). Gammarids were totally absent in upstream station contrarily to chironomid which were present in all seasons and stations. There was no difference in concentration of copper among seasons (0.469 μg^{-1} compared to 0.492 μg^{-1}). Concentration of zinc in Gammarids, which were present in downstream show significant differences when winter is compared to summer (0.18 vs 1.61 μg^{-1}).

Copper concentrations accumulated in macrobenthos were less than those of the sediments

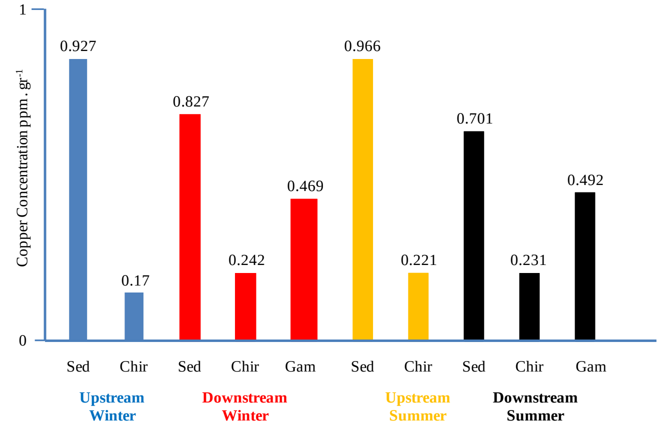

Figure 1. The average concentration of copper in up- and downstream, sediment and benthos. Sed: Sediment; Chiro; *Chironomus*; Gamm: *Gammarus*.

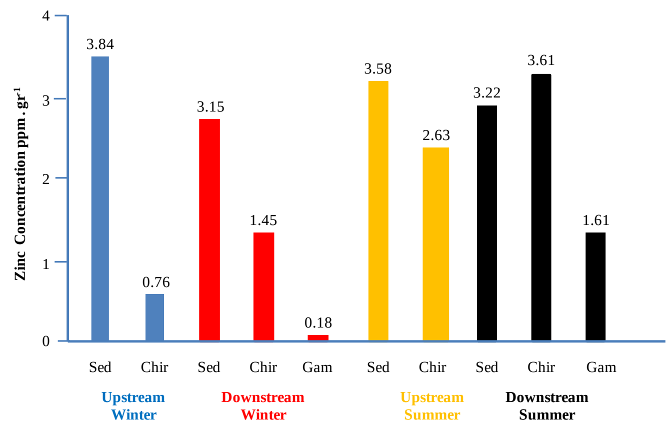

Figure 2. The average concentration of zinc in up- and downstream, sediment and benthos. Sed: Sediment; Chiro; *Chironomus*; Gamm: *Gammarus*.

in stations and differences were significant (P<0.05). The concentrations of copper at up and down stream stations in summer and winter do not show any differences. Concentration of copper in Chironomids of upstream was more than those of downstream ones (P<0.05). The amount of copper accumulated in Gammarids does not show a significant difference in winter and summer.

Zinc concentration shows fewer concentrations at downstream stations than the upstream ones. Among benthic animals, downstream Chironimids contained more zinc concentrations compared to upstream ones (P<0.05), but no significant differences was detected between seasons. Figure 2 suggests that, zinc concentration of the upstream Chironomids in the summer was more than that of the winter. Such trend also can be seen in downstream station (P<0.05).

The amount of zinc accumulation in Gammarus had a significant difference in summer compared to winter ($P<0.05$).

Discussion

The comparison of two main results about copper and zinc observed concentrations in up and down stream in all sampling seasons suggest that the amount of copper in sediments were higher than that of benthos, Chironomid and Gammarid. The exception may be observed in Chironomids of downstream and in summer. At the end of summer and beginning of the fall an important amount of leaves were transferred to the river from the catchment basin. As the river originates from mountains one may suggest that the population of shredders is limited by humic and dead leaf. That is why in upstream Gammarids were totally absent.

In the case of copper concentration in body, Gammarids showed higher concentrations than Chironomids. Chironomid may feed on plankton and fine particulate organic materials (FPOM) (strayer, 2006; Faria et al., 2007). In our study the low concentrations of copper in chironomid bodies may be due to low quantities of this metal in their food which is benthic algae (such as *Chantransia* sp.). The bioaccumulation of copper in these algae may be less than autumnal leaves due to their short life span (Tachet, 2002). This is not the case for other metal bioaccumulation such as zinc in this study. Measurements suggest that the concentration of zinc in chironomids was higher than gammarids. It is possible that natural sources of zinc were transferred from upstream to downstream. Chiromimids are filter feeders (feed on plankton and FPOM) and thus may assimilate more zinc content than Gammarids (shredders of dead leaves). Zinc had a constant concentration in sediments (upstream vs downstream, $P>0.5$). Other studies have shown that heavy metals are absorbed in different concentrations due to their concentration in ambient water (Volk et al., 1997; Townsend, 1989; Vanni et al., 2001; Javanshir et al., 2011). In conclusion, the present study showed differences between zinc concentrations in summer and winter both of them in downstream station. This can be in addition to food, stemmed from differences of solubility of this metal in cold and warm waters (Javanshir et al., 2011).

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