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Heavy metals in the mountain streams

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Introduction

A heavy metal representing a subset of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanoids, and actinides. There have been proposed many different definitions of the term "heavy metals". Some of them were based on density, some on atomic number or atomic weight. Also some definitions were founded on toxicity or other chemical properties. The elements in heavy metals group are miscellaneous. But latest times, the occurrence of heavy metals were dramatically changed in the nature. In many places the concentration of heavy metals was increased. It was caused by thoughtless human activity, i.e. toxic pollution as consequence of mining natural resources. It was confirmed, high concentration of these elements in nature has serious impact on the living organisms, so it is still necessary to study this theme, and of course find the solutions which can help to eliminate them from nature. In contrast to the High Tatra streams, very little published information are available on the biota and chemical properties of the streams in the West Tatra. In view of the need to increase our knowledge in this area, the Institute of Fishery Research and Hydrobiology organized a limnological investigation of the West Tatra lakes in 1988-1990.

Short description of heavy metals

Living organisms require varying amounts of "heavy metals." Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans. Other heavy metals such as mercury, plutonium, and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of animals can cause serious illness.

Motivations for controlling heavy metal concentrations in gas streams are diverse. Some of them are dangerous to health or to the environment (e.g. Hg, Cd, As, Pb, Cr), some may cause corrosion (e.g. Zn, Pb), some are harmful in other ways (e.g. arsenic may pollute catalysts). Within the European community the 13 elements of highest concern are As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Tl, the emissions of which are regulated in waste incinerators. Some of these elements are actually necessary for humans in minute amounts (Co, Cu, Cr, Ni) while others are carcinogenic or toxic, affecting, among others, the central nervous system (Hg, Pb, As), the kidneys or liver (Hg, Pb, Cd, Cu) or skin, bones, or teeth (Ni, Cd, Cu, Cr).

Sources of heavy metals

Heavy metal pollution can arise from many sources. But most commonly comes from the purification of metals, e.g. the smelting of copper, mining of gold and the preparation of nuclear fuels. The primary source of chromium and cadmium is the electroplating. Heavy metals can create a lot of complex compound with other elements, so heavy metals pollutants can lay invisible and dormant. One of the properties of these compounds is that heavy metals do not decay and thus pose a different kind of challenge for remediation.

Heavy metals comes to the our environment as a subpart of combustion gas emised by the thermal power plants, blast furnaces and some others industrial operations; garbage disposal plant; manufacturing wastes from mining and industry; Plumbum in old pipes and paints.

Secondary source of heavy metals can be also some plants and sea animals. If there is contaminated water, marine animals accumulate toxical elements. Consuming these animals can introduce a serious danger for human organism.

Bacteria perform many important processes in stream ecosystems. They break down both dissolved and particulate organic matter (Suberkropp 1998), and are mediators in many biogeochemical pathways, such as the oxidation and reduction of N, S and Fe. Bacteria can be consumed by higher trophic levels and enter aquatic food wels through the microbial loop (Meyer 1994). Thus, bacterial processes warrant measurement and understanding in streams under anthropogenic stress.

The substratum in mountain streams typically is composed of gravels, cobbles, and boulders that support epilithic bacteria in close association with other biota, especially algae, as a biofilm. Bacterial productivity covaries with algal abundance and productivity in some streams (Kaplan and Bott 1998, Romani and Sabater 1999), but not in others (Findlay *et al.* 1993, Sobczak and Burton 1989).

The measurement of abiotic variables (concentrations of metals and nutriens) is described in detail by Niyogi *et al.* (1999). A path analysis (Schumacher and Lomax 1996) was also done for each bacterial process to test an overall model of direct and indirect effects of streams as predicted by previous studies (Rudd *et al.* 1998, Kaplan and Bott 1989, Sobczak 1996).

Benthic invertebrates have been increasingly used in freshwater monitoring programmes, due to its large species richness covering all types of fresh water habitats. Benthos can be used for different monitoring topics, such as eutrophication, acidification, changes in habitat structure and species diversity and toxicity. In streams ecosystems aquatic invertebrates is an important energy link, constituting a number of species with different ecological traits and limits (Koskenniemi 2000).

Trace metal studies on biota partly focus on analysing the bioavailability of metals as an aspect of biomonitoring (Hare and Tessier 1996, Hare and Campbell 1992, Iivonen *et al.* 1992, Yan *et al.* 1989, Yan *et al.* 1990, Young and Harvey 1991).

Bentic fauna is one of the biological quality elements of the EU Water Framework Directive.

The characteristics of benthic invertebrate fauna are as follows:

- The taxonomic composition and abundance correspond totally or nearly totally to the undisturbed conditions.
- The ratio of disturbance sensitive taxa to intensitive shows no signs of alteration from undisturbed levels.
- The level of diversity of inevertebrate taxa shows no sign of alteration from undisturbed levels (Tolonen *et al.* 2001).

The development of field sampling designs that employ multiple reference and polluted sites has been proposed as an alternative to the traditional upstream vs. downstream approach used in most biomonitoring studies. Spatially extensive monitoring programs can characterize ecological conditions within an ecoregion and provide the necessary background information to evaluate future changes in water quality. The organisms living in this system are only exposed to atmospherically transported pollution levels during all their life. The oxygen concentration is a well-known and important ecological factor in the water biota. Variations in the oxygen concentration will greatly influence the occurrence of animal species. Water pollution often results in a reduced oxygen content of the water (Mannk 1965). Some information about the environmental needs of these species is given in the literature.

Differences among metal categories were highly significant for most measures of macroinvertebrate abundance and all measures of species richness. We observed the greatest effects on several species of heptageniid mayflies (Ephemeroptera: Heptageniidae), which were highly sensitive to heavy metals and were reduced by > 75% at moderately polluted stations (Clements *et al.* 2000). Prey communities at the upstream reference station were dominated by metal-sensitive mayflies (Ephemeroptera) and black flies (Diptera: Simuliidae), whereas those at the downstream polluted station were dominated by metal-tolerant chironomids (Diptera: Chironomidae) and caddisfiies (Trichoptera). Molluscs react on changes in life conditions of their habitats very sensitively (Iles and Rasmussen 2005). At the beginning of second half 20th century worked on several authors. In the research of tatra continued Zelinka (1953), Obr (1955), Ertlová (1964).

The Nemouridae fauna of Slovak streams has been studied by (Krno and Šporka 2003, Krno 2004). The origin and spreading of mayflies in High Tatra in the various types of streams and influence of environmental factor was discused in Derka (2005). Benthic macroinvertebrate communities reflects the relative degree of degradation from contaminants is a fundamental assumption in stream biomonitoring studies (Cairns and Pratt 1993). Previous studies have shown that mayflies are highly sensitive to heavy metals and are usually the first group eliminated from metal-polluted streams (Clements 1994, Clements and Kiffney 1995). Heavy metal concentration was the most important predictor of benthic community structure at these sites. Because of the ubiquitous distribution of heavy-metal pollution in the High Tatras ecoregion, we conclude that potential effects of heavy metals should be considered when investigating large-scale spatial patterns of benthic macroinvertebrate communities in mountain streams. Sediments represent an important sink for heavy metals and other contaminants in aquatic systems. Levels of heavy metals in sediments are often several orders of magnitude greater than those in overlying water. Because of their close association with sediments, benthic invertebrates readily accumulate metals from contaminated sediments (Tatem 1986, Hare *et al.* 1989) and therefore represent an important link to higher trophic levels.

Fish are a very important part of the biocenosis in a lake. Fish has an important role in the food web of the stream, but additionally it is the most interesting part of biocenosis for human consumption. Therefore it is quite natural, that fish fauna is also one of the biological quality elements should be performed. Especially important is analysis of possible sliming of gill nets, as well as the blooming of algae (Sladeček 1973).

Information on the toxicity of metals to fish has been summarized by Duodoroff and Katz 1950, McKee and Wolf 1963, Rudolfs *et al.* 1950, and others. Higher concentrations were not used with insects because fish seem to be more sensitive to metals.

Although most metals show little tendency to biomagnify up food chains, concentrations in fish can reach harmful levels owing to reduced prey diversity and increased consumption of contaminated prey (Dallinger *et al.* 1987). Several investigators have shown that feeding habits of fish at impacted sites may be modified to include tolerant prey types (Jefree and Williams 1980, Clements and Livingston 1983, Livingston 1984). In streams polluted by mining effluents, Jefree and Williams (1980) reported that fish switched from pollution-sensitive to pollution-tolerant prey types.

The levels and the cellular distribution of heavy metals, and the extent by which the metals binds to metallothionein (MT) in brown trout (*Salmo trutta*) and European eel (*Anguilla anguilla*), were analyzed in order to assess the natural conditions of MT and heavy metals in these two fish species. There were no differences in heavy metals and MT concentrations between males and females of brown trout in a nonreproductive status and between adult brown trout individuals. Brown trout presented higher Cu content than European. The cellular distribution of Cu was also different between the two fish species; while in brown trout most of the Cu was in the noncytosolic fraction, Cu was mainly located in the cytosol. However, the cellular distribution of Zn, Cd, and Pb was similar in the two fish species(Linde *et al.* 1999).

Aluminium and low pH is a very toxic combination (McDonald and Wood 1993) and acidification has been reported to increase slime excretion in the gills (McDonald 1983) causing physiological disturbances and even large fish kills. Increased concentration of iron caused gill damages in brown trout (*Salmo trutta*) (Peuranen *et al.* 1994).

Conclusion

Heavy metal pollutants have received widespread attention as they have a long record of anthropogenic emission, are potentially toxic and are persistent with a tendency to bind to aerosols as well as to particulates in soils, sediment and water. In recent years, we have seen a rapid increase of systematic trace metal studies in streams. Such studies are urgently needed because different biota provides different insights into metal bioavailability in freshwater (Luoma 1983, Bryan and Langston 1992). Some important aspects necessary to achieve a synthesis are provided by the following papers.

This article dealt with heavy metals and they impact to the living environment. Many researches remitted how dangerous effect they can have to the human and animals. The concentration of heavy metals in some place is still increasing and we need to perform active retaliations to stop them spreading. In fact there is no natural way how to eliminate them from nature. For example, once they get to the mountain stream, heavy metals can spread in the world by food chain in cycle invertebrate -> fishes -> humans. One of the possible solutions how to decrease they concentration in world, is restrict to use them in the maximal possible way. So do not use Cadmium in batteries, eliminate mining of ore with using the mercury, replace all old roofs and pipes made from lead by other nature friendly materials, etc.. Another possible way could be using some microorganisms which are able to absorb some heavy metals such as mercury. Plants which exhibit hyper accumulation can be used to remove heavy metals from soils by concentrating them in their bio matter. Some treatment of mining tailings has occurred where the vegetation is then incinerated to recover the heavy metals.

We still need to fight for cleaner living environment, and maybe this small review of current state of art in heavy metals pollution will help with this not easy task.

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