Why testing stones in mesocosms?

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1. Introduction

Slag material from copper production (iron silicate) has been used as armour stones in rivers, channels and harbors in Germany for many years. However, nowadays the ecological effects of metals leaching from these stones are discussed. Within a large research activity of the German Federal Institute of Hydrology (BfG), Aurubis (copper producer and recycler), Peute Baustoff and Fraunhofer IME, the potential leaching of metals and subsequent effects on ecosystems were analysed by different experimental and monitoring approaches, e.g. in the outdoor mesocosm study presented here. The aim of the study was to derive the amount of crushed stone fines or armour stones without ecologically adverse effects on the algae, plants and invertebrate community in the mesocosms over one year of exposure.

2. Materials and methods

The study was conducted in 25 stainless steel enclosures of 2 m^3 volume, installed in a large artificial pond on the test site of the Mesocosm GmbH with an established aquatic community. Five enclosures served as controls including 25 g/L basanite crushed stone fines and 100 g/L basanite armour stones as natural reference material. In eight enclosures 3.25, 6.25, 12.5 and 25 g/L iron silicate crushed fine stones (two replicates) and in 12 enclosures 12.5, 25, 50 and 100 g/L iron silicate armour stones (three replicates) were introduced. In each enclosure the appropriate amount of basanite stone fines and stones were added to achieve the same amount stone fines and stones in all enclosures including the controls. During the study the concentrations of metals in the water and the sediment were monitored while metals in biota were measured at the end of the study after one year of exposure. For the effect assessment the development of the populations of algae (phytoplankton and periphyton), macrophytes, zooplankton and macroinvertebrates was monitored and tested for statistically significant differences compared to the basanite only control systems.

3. Results

Cu, Ni, Zn, Mn and Fe concentration in the water increased, related to the amount of introduced iron silicate, The maximum Cu concentrations found at the highest stone treatment level were 14 µg/L in March 2010 while the highest concentration in the crushed fines enclosures were found to be close to 13 µg/L 7 days after introduction of the test items. After one year of exposure, Cu concentration in the water decreased down to 3 and 5 µg/L in in highest crushed fines and stone treatment level, respectively.

No dose related increase of metals could be found in the sediment.

In biota Cu concentration increased up to a factor of 5 compared to the controls while other metals showed usually no or a smaller increase in biota. No indication of biomagnification in the food chain was found.

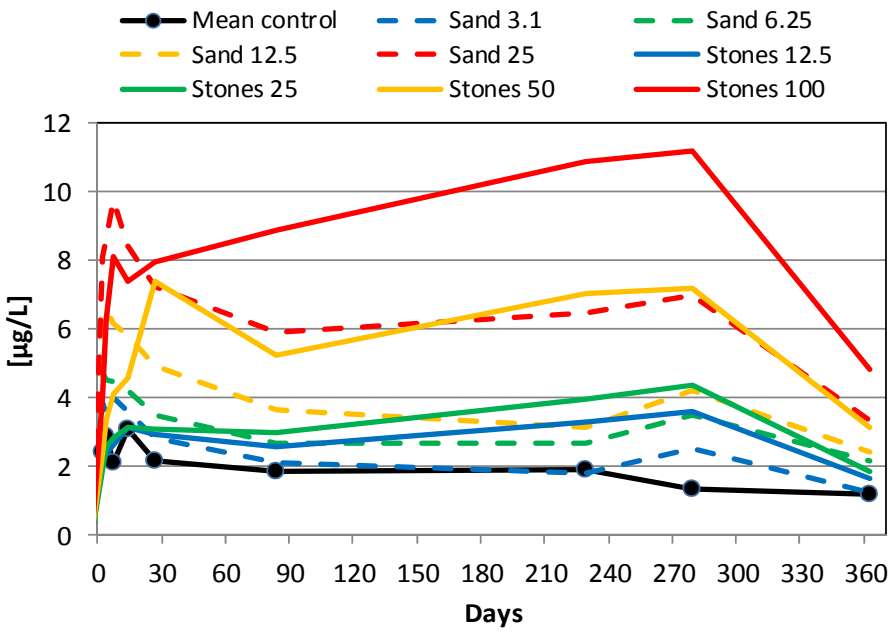

Fig. 1. Dynamics of dissolved copper in the enclosure water (0.45 µm filtered). Means per treatment levels are shown.

Up to 12.5 g crushed fines / L or 50 g stones / L no long-term or pronounced effects on the communities were observed. At 25 g crushed fines / L or 100 g stones / L, effects on algae, macrophytes and insects over more than 8 weeks or at the end of the study could not be excluded.

Table 1: Dynamics of dissolved copper in the enclosure water (0.45 µm filtered). Means per treatment levels are shown. Classification of effects, modified from [1]. 1: no effect, 2: slight or temporary effects, statistically significant only on single sampling dates, 3: pronounced but temporary effect (< 8 weeks), 5A: effect over more than 8 weeks but no effect at the end of the study, 5B effect over 8 and until the end of the study, +: in-crease in abundance

	Sand					Stones			
g test material/L	3.1	6.3	12.5	25		12.5	25	50	100
mass ratio	1:320	1:160	1:80	1:40		1:80	1:40	1:20	1:10
Phytoplankton (pigments)	2	2	2	3		2	2	3	5A+
Phytoplankton (cell counts)	2	2	2	5B		2	2	2	5B+
Periphyton (pigments)	2	2	2	2		2	2	3	5B+
Makrophytes	1	1	1	5B		1	1	1	5B
Total primary production	1	1	1	2		1	2	2	5A+
Zooplankton	1	1	1	3		1	1	1	3
Makrozoobenthos	1	1	1	5A		1	1	1	3+
Insect emergence	1	1	1	2		1	1	2+	5B+
Total assessment	2	2	2	5B		2	2	3	5B

4. Conclusions

Due to the absence of any persistent and pronounced effects on the community in the enclosures the 12.5 g sand/L (1:80) and the 50 g stones/L (1:20) are considered ecologically acceptable amounts of iron silicate in this study.

5. References

[1] De Jong F.M.W., Brock T.C.M., Foekema E.M., Leeuwangh P. (2008): Guidance for summarizing and evaluating aquatic micro- and mesocosm studies. RIVM Report 601506009/2008. A guidance document of the Dutch Platform for the Assessment of Higher Tier Studies. RIVM, Bilthoven, The Netherlands. www.rivm.nl/bibliotheek/601506009/pdf.

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