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Effect of Sulphate Concentration on Phosphate Mobilization from Lake Sediment - An Experimental Study

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Sulphate load to the lake water has in some cases caused phosphate mobilization from lake sediment and increased algal growth. The basic chemical mechanism behind this is the formation of iron sulphide, which blocks the normal binding of phosphate to ferric substances in aerobic conditions. However, this is a complicated phenomenon and therefore every lake has to be studied as individual cases.

Lake Sulkavanjärvi, situated in Siilinjärvi, Eastern Finland, showed some signs of increased trend of lake water phosphate in 2011 and 2012. At the same time sulphate concentration in hypolimnion varied between 15-25 mg/L. The release of phosphate from Lake Sulkavanjärvi sediment was tested in laboratory experiments. Lake Kolmisoppi, which situates upwards in the watershed, has been noticed to suffer from eutrification due to sulphate load from the mining industry (Saarijärvi et al. 2013).

The test was done with PMEU technology (Hakalehto and Heitto 2012) which allows the controlling of e.g. oxygen concentration during the experiment. PMEU technology has been widely used besides in environmental research (e.g. Hakalehto et al. 2011; Pitkänen et al. 2009; Hakalehto 2015), also in health care and biorefinery technology. Surface sediment from Lake Sulkavanjärvi was put in sample syringes (Fig. 1) and anoxic conditions were implemented with nitrogen gas. Lake water of known sulphate concentration was added to the syringe. The PMEU apparatus was kept in 4 °C in a cold room, so the experimental conditions were very much like near the sediment surface.

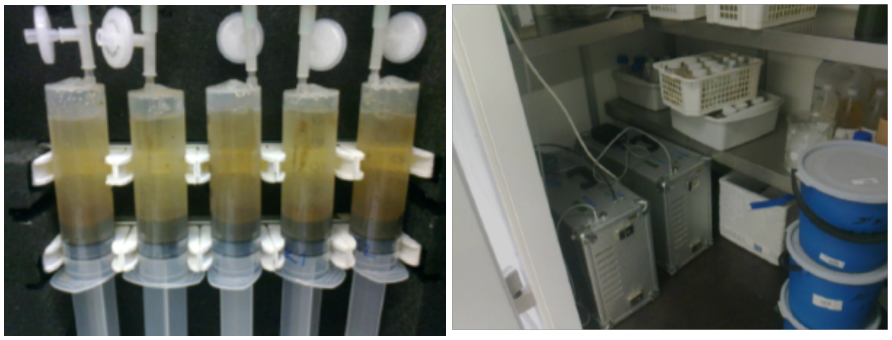

Figure 1. PMEU sample syringes with surface sediment and lake water (left) and test run conducted in a cold room (right).

Two experiments were carried out. The first experiment lasted almost two months (26.6.-22.8.2012) with three different sulphate concentrations (8, 31 and 96 mg/L). In the second experiment (6.9.-14.10.) three sulphate concentrations within a narrower range were used (15, 46 and 73 mg/L). In the first experiment phosphate concentration increased very quickly in syringe with highest sulphate concentration and after two weeks the phosphate concentration was about 4-fold compared to the other syringes. There was no big difference between the released phosphate concentrations in the two lower sulphate concentrations. In the second experiment increasing the sulphate concentration from 16 mg/L to 46 mg/L caused about 2-fold

increase in the liberated phosphate concentration. With sulphate concentration of 73 mg/L, very high phosphate concentrations were achieved (Fig. 2).

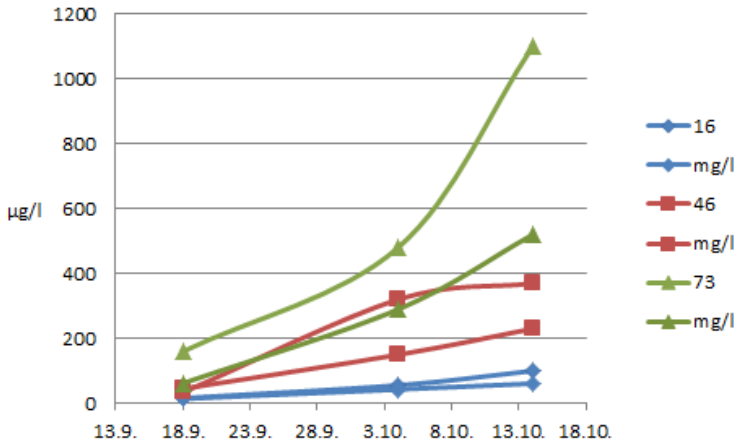

Figure 2. Phosphate concentrations (µg/L) in experiment 2 in different initial sulphate concentrations (16, 46, and 73 mg/L) during the experiment.

The experiment showed clearly that the sediment of Lake Sulkavanjärvi possesses a risk for eutrophication with quite low sulphate concentrations (30-40 mg/L). During recent years the sulphate concentrations of hypolimnion have been during late summer under 30 mg/L. Hypolimnion phosphorus concentrations have been have been in August 2011-2014 higher than earlier, but algal growth has been quite stable. PMEU technology worked out very well in this lake sediment simulation, e.g. small volume of sample syringe makes keeping of anoxic conditions in a long experiment economically feasible.

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