The Retention of Fe and Mn in Wetlands in Post Brown-Coal Mining Area

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Abstract

Several hundreds km^2 of landscape in Northwestern Bohemia (Czech Republic) have been converted into open-cast mines, spoil heaps and other vegetation free, drained areas since 1960. After finished mining, the area was mostly restored in agriculture land and forest. Costs and effect of small created wetlands on retention of Fe and Mn have been studied on selected sites of a large spoil heap (volume c. 3 000 million m^3, area 2000 ha). The small wetlands, made by explosives and by dredging, are able to accumulate up to 1 kg of iron and manganese per m^2 per year. Although they are low cost and highly efficient in mass retention and cooling effect, wetlands cover less than 2% of land restored after open cast mining. Due to their important role in landscape functioning, wetlands are recommended for restoration provided that the static of spoil heaps is not endangered.

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In the Czech Republic, large areas were strongly damaged by open cast mining, which brought about drainage of landscape and disruption of water cycle accompanied by decrease of underground water table. The mine-water (AMD) is influenced by mineralization of substrate, so it is usually enriched with dissolved solids, pH is extremely low and concentration of heavy metals is high.

The Great Podkrušnohorská Dump is composed mostly from cypris clay, which determines quality of water flowing out of the dump.

Table 1. **Concentration of dissolved solids in water in out of the dump and dump's springs (Vymazal 2001)**

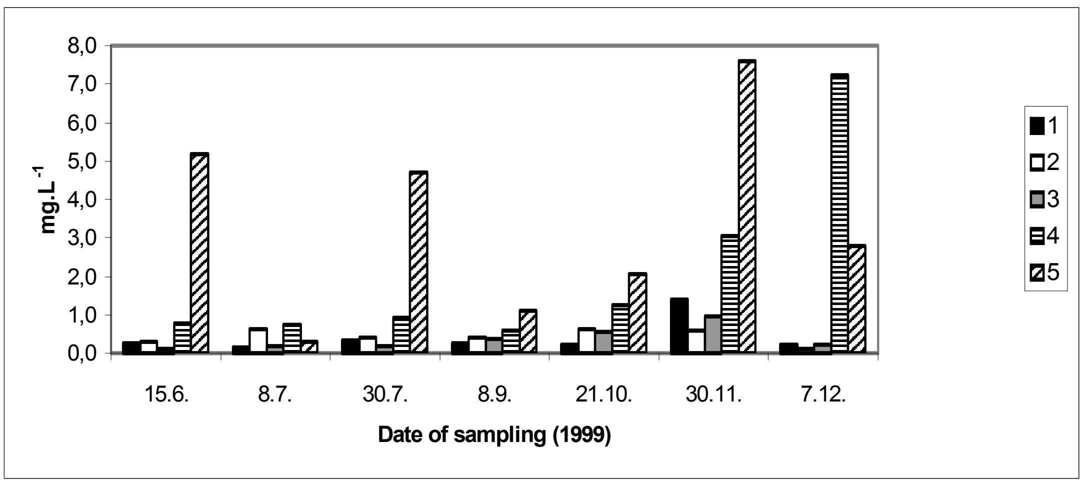
Parameter	Unit	The most common values in the dump (springs)	Common surface water in the Czech Republic
pH		6.5 – 7.5	6.5 – 8.5
Alkalinity	mmol.l^{-1}	20 – 25	0.5 – 3
NH_4 – N	mg.l^{-1}	2 – 10	0.05 – 0.5
NO_3 – N	mg.l^{-1}	0 – 0.3	0 – 5
P_{total} (TP)	mg.l^{-1}	0.03 – 0.05	0.05 – 0.4
Na^+	mg.l^{-1}	800 – 1200	2 – 50
K^+	mg.l^{-1}	16 – 18	1 – 35
Ca^{2+}	mg.l^{-1}	420 – 450	10 – 200
Mg^{2+}	mg.l^{-1}	250 – 320	5 – 50
Cl^-	mg.l^{-1}	3.5 – 5	3 – 50
SO_4^{2-}	mg.l^{-1}	4 500 – 5500	20 – 200
HCO_3^-	mg.l^{-1}	1 100 – 1200	50 – 200
Fe_{total}	mg.l^{-1}	7 – 11	0.01 – 0.5
Mn_{total}	mg.l^{-1}	3 – 6	0.05 – 0.5

The amount of dissolved solids in Velka Podkrusnohorska Dump is very high. The common value in the Czech Republic is in range 0.05 – 0.5 g.l^{-1} (Frouz, Popperl, Přikryl 1999), whereas dump's springs contain 8 –15 g.l^{-1}. Concentrations, especially heavy metals and sulphates dominate, but nitrate and phosphates values are very low. Due to realtively high concentration of HCO_3^- and neutral or even alkaline reaction, the water differs from a typical acid-mine drainage water (AMD).

High concentrations of Mn and Fe in water result in formation of toxic precipitates in neutral and low pH. Small wetlands with *Carex* and *Juncus* plants were built for better sedimentation of Fe and Mn precipitates which are formed at pH above 9.5. The water level in these new created wetlands must be minimum 2 cm high, then the hydrogencarbonate (HCO_3^-) precipitates and dolomitic limestone is formed. Content of NH_4^+ is quite high too, but the form of nitrogen is unstable due to high value of pH.

Two different types of localities were chosen, one (a) with high undergound water level (Pavel, Pool II, Crusta-wetlands) and the other (b) which is drained by a straight and deep channel (Silver Brook, Panský Pond).

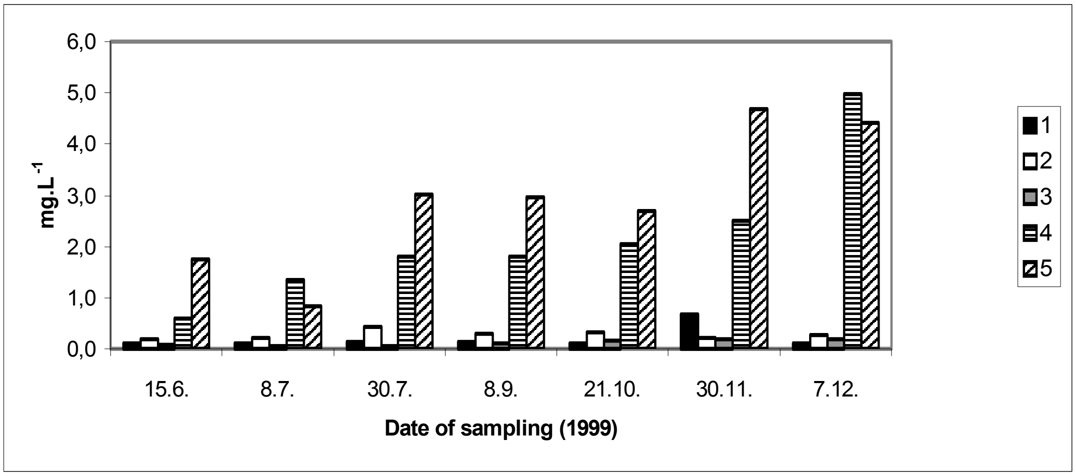
Figure 1: Concentrations of Fe in five experimental localities



1- Pavel 4- Silver Brook
2- Pool II. 5- Pansky Pond
3 - Crusta-wetland

More significant differences among localities a) and b) were found for Mn, see (Fig. 2.) The concentrations of Mn are higher in water from the newly created localities without wetlands than in localities with wetlands left to natural succession.

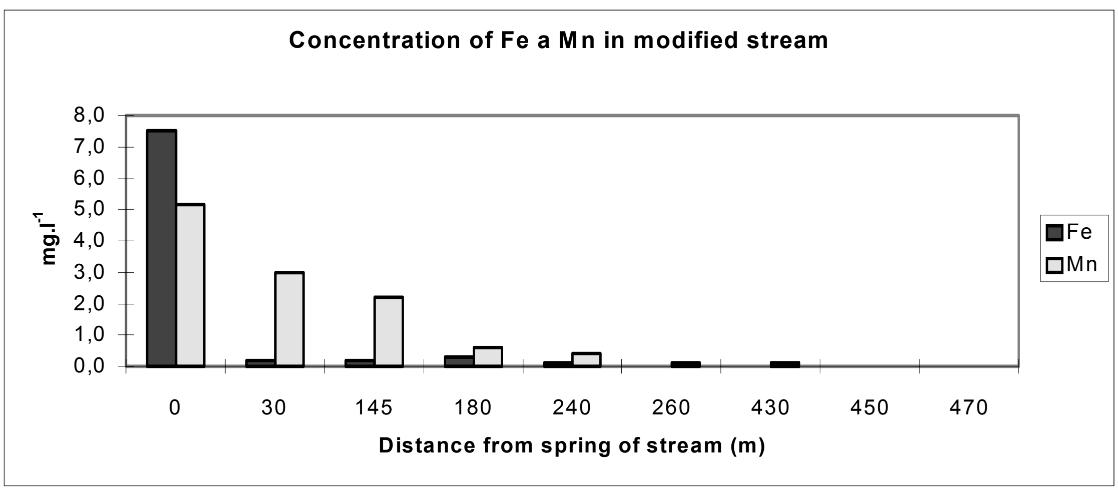
Figure 2: Concentrations of Mn in five experimental localities Spring area "Anita"



Length of this stream is 470 m, flow rate 4l.s^{-1}, iron and manganese concentrations in the spring are 7.5 and 5 mg/l. Small pool was created in spring area and stream channel was extended. Iron sedimentation is more intensive in the first part of modified stream, the wetland appeared there was 200 m^2 large. The whole area for iron precipitation is about 3000 m^2. The value of sedimentation during year is about 0,3 kg Fe per m^2. The second large wetland appeared 150 m far from the spring under man-made cascade. Very shallow layer and precipitation of manganese about 0.3 kg m^{-2} per year are typical for this place, which is 800 m^2 large.

Manganese and carbonate precipitate after decrease of iron concentration and create hard carbonate layers (crusta- wetlands).

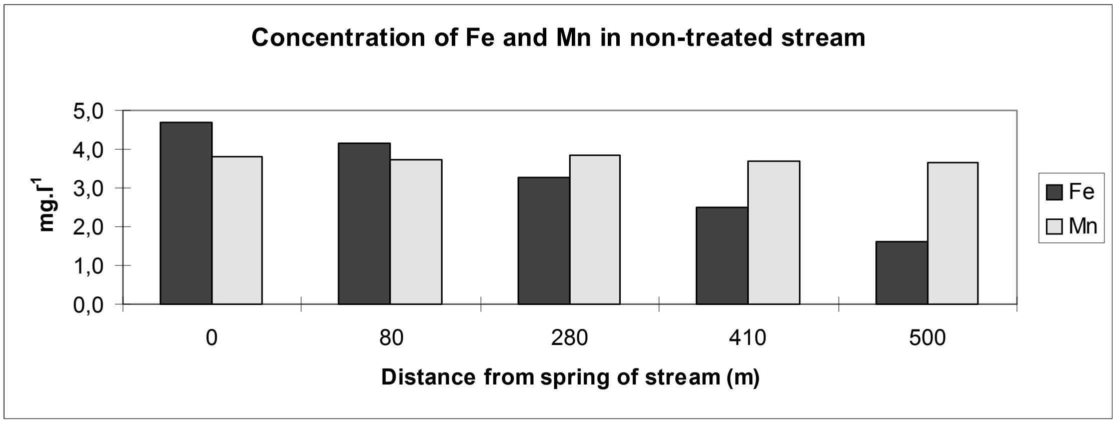
Figure 3: Concentrations of Mn and Fe in spring "Anita"



"Silver Brook"

Silver stream is 500 m long and flow 1.5 l.s^{-1}. Concentration of iron in the spring is about 4.63 mg.l^{-1} a Mn 3.7 mg.l^{-1}. The locality is drained by straight and deep channel without pools and wetlands. Whereas iron precipitates along the whole length of the stream (0.2 kg/m^2. year), Mn does not precipitate, its concentration stays constant due to relaitvely low pH (Fig. 4). Retention of Fe is about 227.44 kg per year and Mn 163.23 kg per year. The iron precipitations occur along the entire length of the stream.

Figure 4: Concentrations of Mn and Fe in locality "Silver Brook"



Conclusion

Positive effect of wetlands to iron and manganese concentration is apparent in our results. The precipitation and post-sedimentation of iron and manganese in hydrated oxides with any back-release were sped up in all experimental wetlands. Dále až věta: On the contrary, the amount of manganese in water channels without wetlands does not changed along streams. Decrease of iron concentration is gradual and red-brown particles are transported slowly downstream.

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