Treatment of contaminated dredged sediment by using a membrane bioreactor

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Introduction: Every year more than 40 million tons of sediment have to be dredged in Germany to guarantee the prescribed depth of waterways (rivers, canals, harbors and marine waterways). Most of the material is relocated within the same water body, however in some cases its further transportation and treatment is inevitable. The dredged sediment is then classified as waste and its handling is regulated by the legislative directives, depending on the content of certain pollutants [1, 2].
The aim of the presented work was to compare several methods for the treatment of contaminated sediment dredged from Finow Canal, Germany. As a consequence of industrial activities in the last century, this sediment is heavily polluted by contaminants from metal and petroleum processing, especially heavy metals (up to 4 g/kgdry solids Cu and Zn), petroleum hydrocarbons (up to 2 g/ kgdry solids) and polycyclic aromatic hydrocarbons [3].

Methods: In total five processes for the treatment of the sediment were tested: Wet oxidation, aeration with the addition of activated sludge, chemical leaching by a complexing agent, chemical leaching by acidification and bioleaching by using sulfur oxidizing bacteria. Treatment efficiency of all processes was compared and technical and economic aspects were discussed.
Wet oxidation was performed by using the LOPROX® technology from Bayer (20 bar, 200°C).
The two other processes - aeration with the addition of common bacteria from activated sludge and chemical leaching by complexing agent (nitrilotriacetic acid, NTA) - were tested using similar set-ups. Based on the results of small scale tests in 250 ml flasks, both processes were tested in larger scale, using a membrane bioreactor (MBR) with a volume of approx. 60 litres. In the first set-up, the sediment was first mixed with activated sludge (10 % of the suspended solids) and the solid and liquid phase were continuously separated by a membrane. The heavy metals were removed from the permeate using a cation exchanger and the liquid phase was subsequently recycled back to the bioreactor (Fig 1.).

The fourth and fifth treatment processes were only tested in the small scale. The former included the acidification of the sediment to pH 1.7-2.8 by 1 mol/L sulfuric acid, the latter comprised the acidic leaching with the addition of sulfur oxidizing bacteria (*Acidithiobacillus Ferrivorans*).

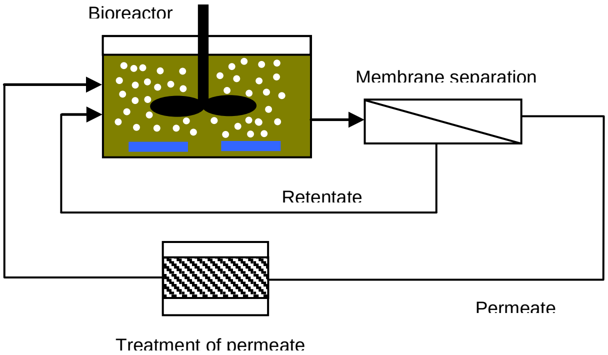

Fig. 1: Schematic of the MBR pilot plant

Results: The treatment by wet oxidation exhibited the best results in terms of the removal efficiency. Most organic pollutants were mineralized so that their concentration was below detection limit. The heavy metals were solubilized and after three washing+centrifugation steps their concentration in the solid phase decreased by 70-98 % compared to the original value. Thanks to this, the limits of the LAGA technical guideline [4] enabling limited utilization were fulfilled with the exception of mercury.
The removal rate of organic pollutants after 6 weeks of operation of the MBR with the addition of activated sludge was between 10 to 65 %, removal of heavy metals between 0 to 20 %. During the second MBR experiment the leaching efficiency of heavy metals was supported by addition of 1 mmol/L NTA. This lead to increased removal of heavy metals from the solid phase (up to 88 %).
The results of the acidic leaching by sulfuric acid showed that the efficiency of transfer of the heavy metals into the liquid phase was both pH and time dependent. After the addition of the sulfur oxidizing bacteria (bioleaching) the leaching efficiency of most

metals was higher compared to mere acidification to the same pH value.

In general the treatment efficiencies towards heavy metals for the five processes can be arranged from best to worst as follows: wet oxidation > chemical leaching with NTA > bioleaching > acidic leaching > aeration with activated sludge.

The operational and capital costs were calculated for three processes with best treatment efficiency. The costs were assessed as follows: wet oxidation 360 EUR/tsusp. solids, chemical leaching with NTA 274 EUR/tsusp. solids and bioleaching 446 EUR/tsusp. solids

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