Shyam Janakiraman (from Chennai, India)

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"Treatment of waters contaminated with volatile organic compounds in constructed wetlands"

Summary

For industrial areas such as Leuna, close to Leipzig, Germany, there is a growing environmental concern regarding the contamination of benzene and MTBE in ground water. These contaminations were caused by leakages during storage and filling at refineries. There was also an accidental spillage of ammonia from an ammonium production site that also penetrated into the ground water. Hence, there was an urgent need for development of effective remediation technologies. With this objective, the removal of the organic pollutants namely benzene and MTBE and inorganic pollutant such as ammonium in the groundwater were carried out using experimental constructed wetlands as one possible prospective remediation technology.

In order to ensure a better oxygen transport into the wetland for transformation/degradation of these contaminants, one experimental horizontal subsurface-flow constructed wetland was subjected to a tidal outflow regime where the contaminated groundwater was pumped or filled in the wetland up to a defined depth and drained at different intervals of time. This was intended to cause a faster aerobic degradation/transformation of the contaminants by various oxidation processes. Further experimental wetlands (without tidal outflow regime and an unplanted control) were run and their treatment results were compared among them.

Experimental investigations were carried out by taking samples of the pore water along the flow path and at different depths of the experimental wetlands.

Field studies showed that in comparison to the other experimental wetlands in the wetland with tidal outflow regime, the upper zones of the soil matrix were enriched with oxygen and higher decrease in contaminant concentrations (benzene and ammonium) obtained. A change in the physico-chemical parameters shown by an increase in redox potential, lowering of Fe(II) concentration and accumulation of nitrate indicated higher removal potential as well. For MTBE, there was no significant decrease obtained. This could be due to the chemical structure which makes it difficult to degrade the pollutant and also due to a longer time frame needed for microbes, capable to degrade MTBE, to grow.

For all contaminants, previous studies showed that seasonal variation also played a vital role concerning degradation rates. The same trend could be seen for the wetland subjected to tidal outflow regime comparing spring and summer.

The loss of water from plants by transpiration and by evaporation of the water in wetlands was dependent on sampling temperature and transpiration rates of plants and played a vital role to estimate the contaminant loads (inflow and outflow) and their removal rates respectively.

In order to determine the efficiency of the tidal outflow regime process, the total mass of benzene and MTBE present in the outflow were calculated and they showed that with increase in the number of tides, their masses in the outflow reduced and were found to be lower in comparison to a wetland not subjected to tidal outflow. However, investigations need to be done to decide if a longer or shorter time frame between two successive tides would result in similar or even higher effectiveness and thus cause the contaminant loading to decrease further.

In general the results of this work confirm the concept of Vymazal and Masa (2003) that the treatment efficiency of horizontal subsurface-flow wetlands can be improved by a very simple operation mode which needs no significant additional external energy. Nevertheless, further investigations have to be done to clarify to which extent the tidal outflow regime can be modified to get even higher removal rates due to the stimulation of microbial activities.

Shyam Janakiraman and Eva Seeger(4 February 2009)