CONSTRUCTED PEAT/WETLAND TREATMENT SYSTEMS FOR HEAVY METAL REMOVAL

by

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Abstract. The use of peat/wetland treatment systems for heavy metal removal has increased significantly over the past ten years. Many of the projects incorporate a constructed peat/wetland treatment system as an integral part of a reclamation and/or restoration operation. Most of the wastewaters have a moderate pH (5 to 6) with a relatively low metals concentration, therefore, are conducive to metals removal utilizing a peat/wetland treatment system. A constructed peat/wetland treatment system was designed based on the data gathered from a wetland treatment demonstration project. The constructed system is designed to incorporate subsurface flow (SSW) to enhance sulfate reduction for metals removal. The heavy metal removal is a function of the peat organic availability, hydraulic conductivity, nutrient concentration and absorption capacity. The project is anticipated to have an efficiency of greater than 90% of heavy metal removal. The efficiences of heavy metal removal are generally regulated by the characteristics of the peat such as pH, organic content, fiber characteristics, hydraulic conductivity, flow patterns, residence time and sulfate and organic availability. There are a number of possible mechanisms for metal retention and/or removal by the peat including absorption on cation exchange sites, precipitation by sulfate reduction and complexation with soil organic matter. The heavy metal removal through the use of peat/-wetland treatment system has shown excellent results in removing of heavy metals. The use of a passive peat/wetland treatment system requires little or no operational maintenance. The use of a constructed wetland system will provide the dynamics of a heavy metal removal from wastewater.

Introduction

A full scale constructed peat/wetland treatment demonstration project for a taconite mining operation was designed and will be operated for removal of heavy metals. The system was constructed for multiple cells to incorporate various flow regime and vegetative types. The system was constructed to incorporate both surface water flow (SW) and subsurface flow (SSW). This will incorporate the potential for anaerobic conditions to develop and/or encourage sulfate reduction activities. Flow regime within each cell were varied to evaluate the efficiency of removal which may occur during different flows.

Treatment considerations for heavy metal removal efficiency is generally based on the characteristics of the peat such as pH, organic content, fiber characteristics,

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hydraulic conductivity, flow patterns, water level, residence times, sulfates and organic availability.

There are a number of possible mechanisms for metal retention and/or removal by peat. These include absorption, cation exchange, precipitation by sulfate-reduction and complexation of soil organic matter. In addition, the dynamics of the physical/chemical and biological components of the peat/wetland systems utilize removal of suspended materials, biological uptake, microbial oxidation and absorption mechanisms. Under anaerobic conditions, metal sulfide formation is one of the most effected metal retention mechanisms as it forms an insoluble metal precipitants. Sulfide production is limited by the quantity of available sulfates and simple/available organics that are the materials necessary for sulfate reduction activities.

Peat materials used for the peat/wetland treatment system will require a high hydraulic conductivity and available organic content. This provides for uniform contact between the organic absorption sites on the peat and the seep waters. The design criteria established for the peat used in the treatment system includes:

- o Hydraulic conductivity greater than 1.3 meters per day
- o Fibrous peat with irregular length and split fibers
- o Fiber decomposition/little or no fiber disassociation
- o Organic content of over 90% by dry weight
- o High cation exchange capacity

A number of peat samples were examined for their fiber content, peat composition and physical characteristics. To obtain the most effective peat material, a combination of reed sedge peat mixed with the process screenings from a peat mining operation provides the best media. The peat media selected includes two parts of process screening and one part reed sedge peat. The two materials are mixed on-site prior to placement in the peat/wetland treatment system.

The peat was placed loosely within the wetland on the upstream and downstream side of a till berm. The loose placement is an attempt to maintain an adequate hydraulic conductivity by minimizing compaction of the peat. The peat mixture and berms create a water pool to approximate 1 foot in depth.

Peat with a pH less than 5 generally have a low buffering capacity and exhibit poor efficiency in metal removal. The best metal removal efficiency is with pHs of 6 to 8 for aerobic conditions and under anaerobic conditions the pH must remain above 5 to have effective sulfate reduction.

Good heavy metal removal requires peat with a high or available organic content. The most effective peat has an organic content or more than 90%. Chemical/physical conditions include absorption, cation exchange, direct organic chemical action and ceolation.

Simple organic compounds are vital for anaerobic activities involving sulfate reduction. The organic material is one of the primary materials for reduction reactions for effective metal removal. The most effective organics are simple forms to enable the organics to degrade during redox reactions. A peat/wetland treatment system with a standing vegetative crop provides additional organics by degradation and detritus formation. Maximization of vegetative growth on a peat/wetland treatment system will increase the available organics and thus extend the absorption life of the peat.

The peat selected for the peat/wetland treatment system and has a high fiber content with minimal decomposition, high hydraulic conductivity water holding capacity. This enables the maximum surface area contact in the peat and the water to be treated. Subsurface flows will be encouraged through the system to sustain good water movement while providing a maximum amount of peat surface area. Flow patterns include surface sheet flow and subsurface flow. The water in the pool behind the earthen dike can allow for dispersed flow and saturation of the peat, encourage the flow and increased retention time within each segment.

A typical section of peat/wetland treatment system is illustrated in Figure 1. The peat/wetland treatment system is constructed to treat seep flows such that metal removal will meet the water quality standard established by the regulatory agency. Figure 2 is a cross-section of the berm that illustrates the surface and subsurface flow.

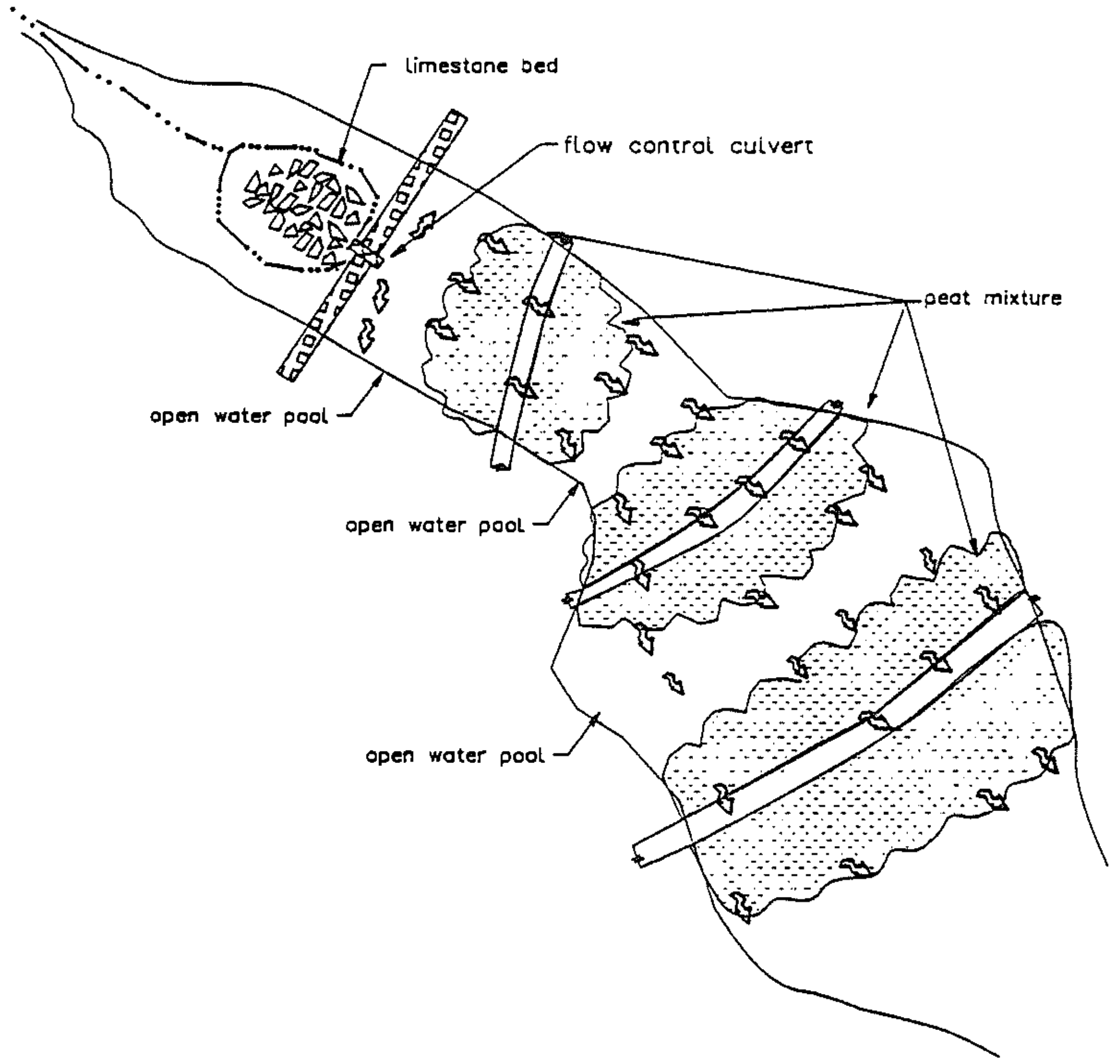
Conclusion

The use of the peat/wetland treatment system has shown excellent results for heavy metal removal. The use of the passive peat/wetland system requires little or no operational maintenance with the exception of the replacement spent peat once it becomes ineffective for metal removal. The peat wetland system provides for an enhancement of existing wetland with an improved vegetative diversity and habitat and enables the development of a dynamic ecosystem for a high-quality wetland and effective treatment system.

Metal removal by peat is a complex phenomenon which includes a series of physical and chemical process such as absorption, ion exchange and chelation. Additional biological, chemical and physical mechanisms also exhibit the function to reduce the total amount of metals removed in the peat/wetland treatment. These processes included filtration of suspended metals, bio-accumulation of metal and removal of metals by sulfide precipitation caused by a microbial reduction of sulfates.

The efficiencies of heavy metal removal are generally regulated by the characteristics of the peat such as pH, organic content, fiber characteristics, hydraulic conductivity, flow patterns, residence time and sulfate and organic availability. There are a number of possible mechanisms for metal retention and/or removal by the peat including absorption on cation exchange sites, precipitation by sulfate reduction and complexation with soil organic matter.

The heavy metal removal through the use of peat/wetland treatment systems has shown excellent results. The use of a passive peat/wetland treatment system requires little or no operational maintenance. The use of a constructed wetland system will provide the dynamics of a heavy metal removal from wastewater.



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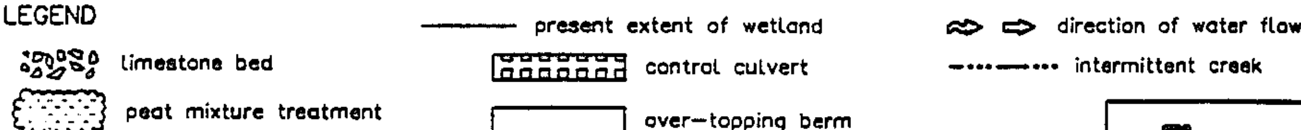
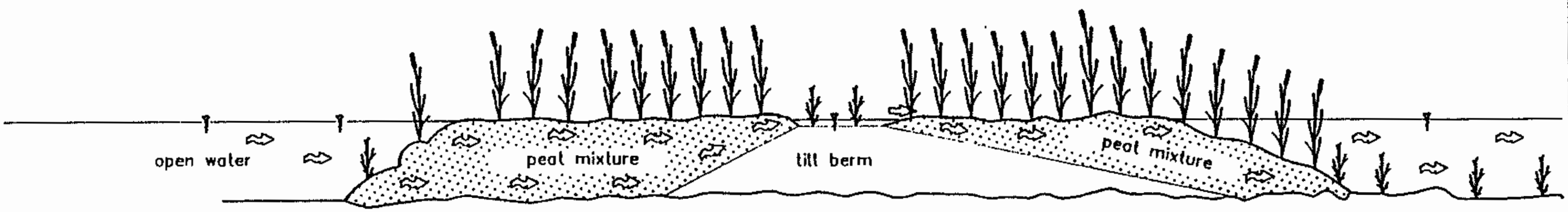


Figure 1

TYPICAL PEAT/WETLAND TREATMENT SYSTEM

CONSTRUCTED WETLANDS FOR HEAVY METAL REMOVAL



TYPICAL PEAT/ WETLAND TREATMENT BERM

CONSTRUCTED WETLANDS FOR HEAVY METAL REMOVAL

Figure 2