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Geomembrane in artificial marshes and intermittent filters used for wastewater treatment

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ABSTRACT : Millions of homes, small businesses, rural schools and agricultural facilities in rural areas in the world must provide their own waste disposal systems. Natural treatment methods, such as multi-celled wetlands (artificial marshes) (AM), recirculating sand filters (RSF) or intermittent sand filters (ISF) can provide a cost-effective, environmentally friendly alternatives to mechanical treatment methods. It is increasingly difficult to finance energy intensive mechanical wastewater treatment systems and many are turning to simple systems such as artificial marshes and intermittent filters. Installing a geomembrane to control seepage flow of the wastewater in the ground, to act as a barrier to groundwater infiltration into the marsh has many advantages on sites that have shallow soil cover, inadequate permeability, high groundwater, and limited land area. Using an installation built in 1998, it will be shown that tending the plants doing phytoremediation and using a synthetic geomembrane as the liner is very attractive solution to wastewater treatment in rural areas.

1 INTRODUCTION

1.1 *Général*

General Artificial marshes installed as early as 1980 are still functioning properly today. Marshes of dimensions 0.6 to 0.9 m deep and 3 to 35 m length are being planted to further cleanse the effluent from generators of small wastewater flows. The selected plant species are selected for their removal capacity of absorbing toxic metals and convert them into gases and release them into the atmosphere. Also, they can accumulate and break down organic compounds. This concept is known as phytoremediation. To protect the ground water, many regulatory agencies required that each marsh be lined with a geomembrane.

Intermittent sand filters (ISF) consist of a 0.6 m deep cell filled with carefully graded sand. They are viable alternative to conventional methods when site conditions are not conducive for proper treatment and disposal of wastewater through trenches. The surface of the bed is intermittently dosed with effluent that percolates through the granular layer. ISF are typically built below grade in excavations 1 m deep and lined with an impermeable geomembrane.

Figure-1: an artificial marsh lined with a geomembrane

1.2 *Artificial marshes*

No one is suggesting that the plant kingdom isn't doing its faire share. All those leafy creatures are photosynthesizing their virtual hearts out producing the oxygen that keeps the rest of us going. But the plant word can become an industrial partner, one that can clean up our mess.

The concept is known as phytoremediation, phyto being the Greek word for plant, and remediation being the process of correcting a problem. Phytoremediation basically uses human and animal waste as a food supply for plants and their root-associated microbes, thus purifying the wastewater effluents through the marsh filters. Microbes, thriving on in an area known as rhizospere, utilizing biochemical oxygen as a source of energy and food. Now artificial marshes are being planted to further cleanse the effluent from sewage treatment plants or to make the water draining from abandoned mines less lethally acidic.

Selected species are being planted on land that has been contaminated with one or more heavy metals since they can accumulated the metals. Metals are not the only contaminants that plants can help clean up. They can accumulate or break down organic. Plants are using inorganic compounds, such as nitrates, phosphates, potassium, magnesium, as a fertilizer for growing new plant tissue. Poplars, and a number of other plants, planted in strips will stop plumes of underground water contaminated with petroleum.

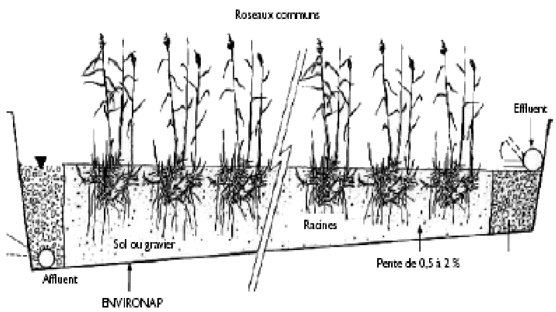

Figure-2: schematic of an artificial marshe

For septic tank overload, wetland systems can come to the rescued. At Indian Creek Nature Center, Cedar Rapids, Iowa, the waste stream first goes to a conventional septic system, but the effluent goes through two basins filled with pea gravel. Water does not reach the surface, but wetland plants extend their roots into the dirty water. The combined surface area of the gravel and the root systems of the plants provides a substrate for the bacteria that break down the sewage. The first basin is planted with cattails and bulrushes while arum, blue and yellow iris, water plantain, cardinal flower, great blue lobelia, ironweed, swamp milkweed and sweet and marsh blazing-star liatris are planted in the second basin. (Wastewater Problem? Just Plant a Marsh, John P. Wiley, Smiththsonian magazine, July 1997).

Figure-2: photograph of a marsh

1.3 *Intermittent Sand Filter*

Intermittent Sand Filters (ISF) remove contaminants in wastewater through physical, chemical, and biological treatment processes. Although the physical and chemical processes play an important role in the removal of many particles, the biological processes play the most important role in sand filters. ISF have a 61 cm deep filter beds of carefully graded media. Sand is a commonly used medium and the surface of the bed is intermittently dosed with effluent that percolates in a single pass through the sand to the bottom of the filter. After being collected in the underdrain, the treated effluent is transported to a line for further treatment or disposal as shown in Figure-4.

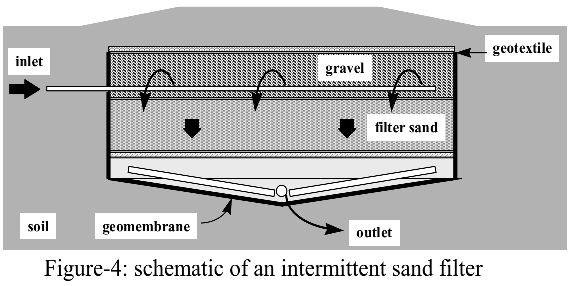

Figure-4: schematic of an intermittent sand filter

ISFs are typically built below grade in excavations 1 to 1.3 meters deep and lined with a geomembrane where required. The underdrain is surrounded by a layer of graded gravel and crushed rock with the upstream end brought to the surface and vented. Pea gravel is placed ontop of the graded gravel, and sand is laid on top of the pea gravel. Another layer of graded gravel is laid down, with the distribution pipes running through it. A flushing valve is located at the end of each distribution lateral. Lightweight filter fabric, a geotextile, is placed over the final course of rock to keep silt from moving into the sand while allowing air and water to pass through. The top of the filter is then backfilled with loamy sand that may be planted with grass. A cross section of a buried ISF, usually designed for single facility, is shown schematically in Figure-5.

Many advantages are related to ISF : it produce a high quality effluent, drainfields can be small and shallow, it has a low energy requirements, no chemical are required, the construction cost are moderate and it can be installed to blend into the surrounding landscape.

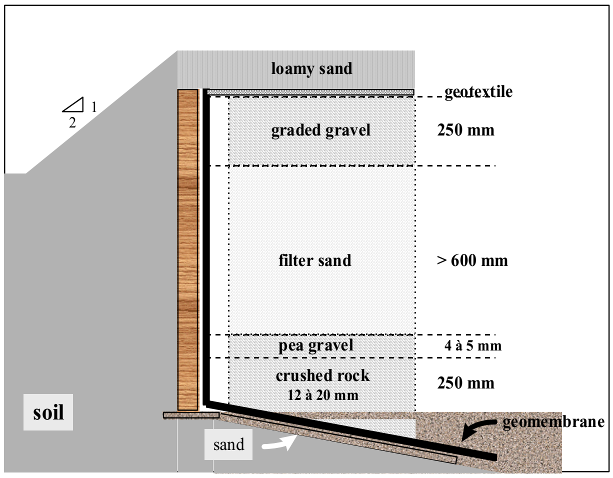

Figure-5: components of an intermittent sand filter

Sand filters produce a high quality effluent with typical concentrations of 5 mg/L or less of biochemical oxygen demand (BOD) and suspended solids (SS), as well as nitrification of 80% or more of applied ammonia. Also significant fecal coliform bacteria reductions can be achieved. Its performance is typically higher in areas where the climate is warmer compared to areas that have colder climates.

The daily operation and maintenance of large filter systems is generally minimal and they can perform for extended periods of time.

An assessment conducted in 1985 by US EPA of ISF systems revealed that sand filters are a viable low-cost alternative to conventional methods when site conditions are not conductive for proper treatment and disposal of wastewater through percolative beds/trenches. They have been serving subdivisions,, mobile home park, rural schools, small communities, other generators of small wastewater flows and on sites that have shallow soil cover, inadequate permeability, high groundwater, and limited land area.

2 CASE STUDY OF AN ARTIFICIAL MARSH

2.1 *Historic*

A group of farmers in Charlevoix district, Quebec, Canada, forced by a new provincial regulation to treat their animal wastes, invested in setting up a large manure treatment facility to produce compost. The compost will be composed of chicken, cow and pig manure, wood chips from saw mills, ash and organic mud from paper mills, and municipal green wastes.

Residues are delivered on a compost plate-form constructed on clayed sol and the resulting leachate is directed into a multicelled wetlands lined with a modified bituminous geomembrane for biological treatment before being release to the environment. The lining of the basins with a geomembrane to control seepage flow of the wastewater in the ground, was required from the very large permeability of the in situ soil.

2.2 *the marsh system characteristics*

The marsh is composed of many basins. The leachate is first send to a sedimentation basin of 7710 m3 capacity to trap solid in suspension. Then the sedimentation basin effluent is send to a second basin, an anaerobic artificial swamp, to favor organic degradation prior to entering the multicelled marshes.
Two marshes have been constructed using a geomembrane as the impermeable liner as shown on Figure-6. Marsh is composed of cells of approximate dimensions 1.2 m deep, 36 m length and 10 m width. These cells are being planted by reeds as shown on Figure-7 to further cleanse the effluent. Because of their removal capacity to break down organic compounds and their resistance to the expected nordic climate, distaff was selected in this project.

Figure-6: bituminous geomembrane installation

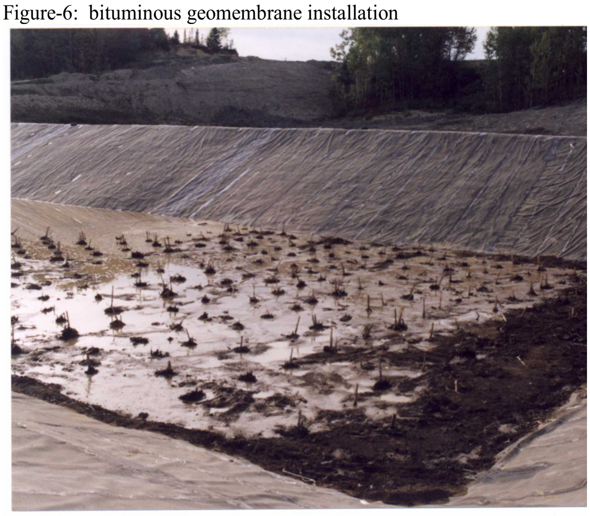

Figure-7: view of a planted cell of the marsh

The effluent from the planted cells is send to a serie of cells with flotting plants (marsh # 2). The selected plant species have been selected for their removal capacity of phosphates and nitrates.
Finally the system, incorporated an organic filter consisting of plants selected for their removal capacity of residual phosphates and nitrates. This area looks like a grass green area.
The system characteristics are presented in Table-1 and an aerial view of cells are presented in Figure-8. For information, the average BOD and nitrogen reduction after a year of monitoring are presented in Table-1. Analysis of the system performance have shown to be are a viable low-cost alternative to conventional methods when site conditions were not conductive for proper treatment and that the quality of the treated leachate permits the disposal of wastewater through the environment.

Figure-8 : aerial view of the marsh

Table-1: system characteristics

Marsh	Total area m^2	Total capacity m^3	BOD_5 reduction %	N_2 reduction %
Sedimentation section	2528	7710	40 - 50	15 - 20
Swamp section	1640	2460	65 - 75	25 - 30
Marsh section # 1	2050	2460	55 - 65	50 - 60
Marsh section # 2	2050	2460	55 - 65	50- 60
Organic filter	4050	40	20 - 30	80 - 90

3 CONCLUSION

Experience has shown that it is possible to multicelled wetlands and intermittent sand filters on permeable sites. By using an appropriate bottom lined system that incorporates a geomembrane permeation can be controled. For this type of application, a prefabricated bituminous geomembrane can offer a low permeability and is very adaptable to new configuration during the construction phases. The PBGM was especially appreciated for its ease of installation around accessories and protruding elements as well as for its durability