Geosynthetics for Rapid Redevelopment of Water and Wastewater Facilities

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Abstract: In the aftermath of a natural disaster such as a Tsunami or Earthquake one of the biggest difficulties is contamination of drinking water especially by accidental release of untreated or partially treated wastewater. Geosynthetics, especially geomembrane liners, provide a capacity for rapid redevelopment of water and wastewater treatment and storage facilities. This paper provides an overview of how these materials can be utilized.

Introduction.

Geosynthetics, especially geomembrane liners and geosynthetic clay (GCL) liners, provide a capacity for rapid redevelopment of water and wastewater treatment and storage facilities.

This paper will discuss geosynthetic systems for water supply storages for treated drinking water. It will also discuss wastewater treatment facilities and process systems using these geosynthetic materials.

It will not focus on the restoration of reticulation systems for water supply or the restoration of sewer and wastewater collection systems.

1. Water Supply and Storage

The world today has very few sources of water that do not require some form of treatment. Usually this treatment will take the form of some sort of filtration and settling processes. In the aftermath of natural disasters treatment may also take the form of microfiltration using a portable facility such as was used in Banda Aceh after the recent Tsunamis.

Whatever the form of treatment we will find a need for secure storage of clean water and geosynthetic systems can help provide this because they have the following attributes.

(a) They can be placed in simple temporary storages with minimal preparation with water extraction by simple pumping using flexible pipes over the embankment.

(b) They are readily available for rapid deployment – by air if necessary.

(c) They are robust and cost effective for short and long term term unprotected use. Expected service life of exposed HDPE exceeds 20 years.

(d) They can also be engineered to provide secure long term service in more permanent facilities with inlet and outlet arrangements that are hydraulically more efficient.

(e) Unlike bituminous materials the polyolefin based geomembranes are accepted as biologically inert and suitable for potable water use in reservoirs.

Fig 1. A water storage facility based on a GCL liner with concrete covering.

For more permanent facilities there is a concern over the potential contamination of the stored water by wind blown contaminants or by animal life and there is also a desire to limit the degradation of chlorine disinfectant in the water when it is exposed to sunlight. For this reason covers are often placed over water storage basins. These covers may be fixed structural roofs or they may be floating membrane covers systems. Fixed roofs present concerns over the integrity of liner systems at supports whilst floating membrane covers do not need support and are significantly more cost effective.

Fig 2. A large water storage basin with a fixed roof structure with hundreds of columns.

Fig 3. A floating membrane cover to a water storage facility

A further possibility is the use of geomembrane materials to fabricate water storages that might be described as bladders which provide full enclosure of the stored water. These can be prefabricated and packaged for transportation to the intended location where it is merely a matter of limited site preparation and connection of inlet and outlet pipes.

Fig. 4 Geomembrane bladder for water and gas storage

In summary geosynthetic liner systems are a valuable aid in temporary and permanent re-establishment of water storage facilities because they are readily available, cost effective and durable.

2. Wastewater Storage and Treatment

Geosynthetics are used in various applications for waste water facilities. The most common use is in lagoons operating with anaerobic and aerobic lagoon processes. Other applications include enhanced evaporation of wastewater and sludge dewatering by permeable geotextile geotubes.

2.1 Anaerobic Lagoons With Covers

When wastewater with a reasonably high organic load is kept in a lagoon for several days an active anaerobic sludge accumulates at the bottom of the lagoon. In an uncovered lagoon the anaerobic digestion activity takes place at the base of the lagoon and the activity near the surface tends to be more aerobic. Lagoons left uncovered in this way are said to be facultative.

We can cover these lagoons with a geomembrane floating cover to:

(a) enhance the anaerobic digestion activity by the exclusion of air (oxygen)

(b) enable the harvesting of gas (especially methane) which can be used as a fuel

(c) reduce the effect of odour from the anaerobic activity

This anaerobic process is a very effective way of treating wastewater, especially wastewater with a strong organic content such as animal waster from piggeries or abattoirs or mixed municipal wastes.

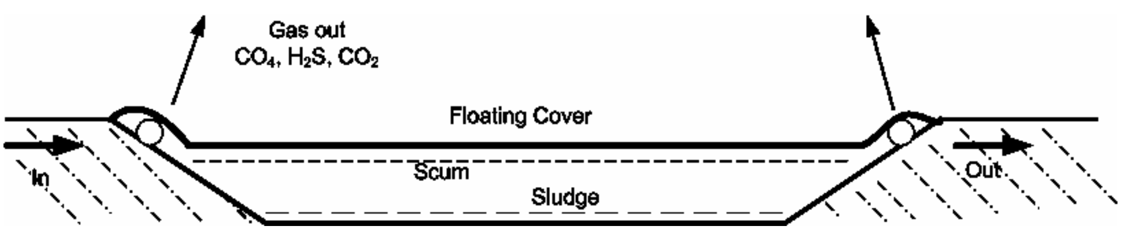

Fig 5 Typical anaerobic lagoon with floating cover

Generally these lagoons will take wastewater with BOD of 400 to 5000 g/cum and the output effluent will have the BOD reduced by 90 to 95%. Detention time is normally 4 –7 days.

The progress also produces significant quantities of methane and other gasses which require careful and safe handling but can be very successfully harvested for fuel.

The anaerobic process is largely self propelled and the only mechanical input is that required to feed wastewater to the lagoon and force its ultimate exit at an overflow outlet.

There may be a need for systems to deal with excessive accumulations of sludge (base) and scum (surface under cover) but this will depend on the nature of the wastewater and the dynamics of the system.

Fig 6. An Anaerobic wastewater processing facility with floating cover and gas collection

2.2 Aerobic (Aerated) Lagoons

Aerated systems use either surface aerators or diffuser systems to introduce air into the wastewater and this results in consumption of the organic content of the wastewater which is mostly released as carbon dioxide.

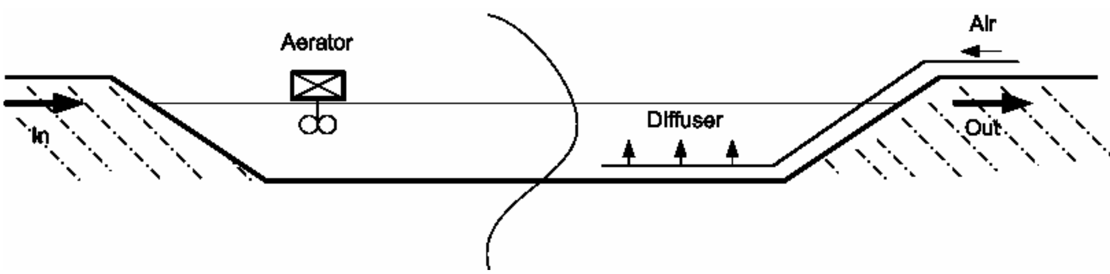

Fig 7 Typical aerobic lagoon

Fig 8. HDPE Lagoon with Floating surface aerators

Typically these systems take wastewater with BOD in the order of 500 to 1500 g/cum and the output effluent will have the BOD reduced by around 90%. Detention time is normally 4 –7 days.

These aerobic systems require considerable mechanical input to operate the aeration system and further work may be need to remove excess sludge from the base from time to time

2.3 Combined Anaerobic and Aerobic Lagoons

Many wastewater plants make use of anaerobic and aerobic systems as a combined or two part process. This can be readily achieved in one lagoon using a specially designed geomembrane floating cover.

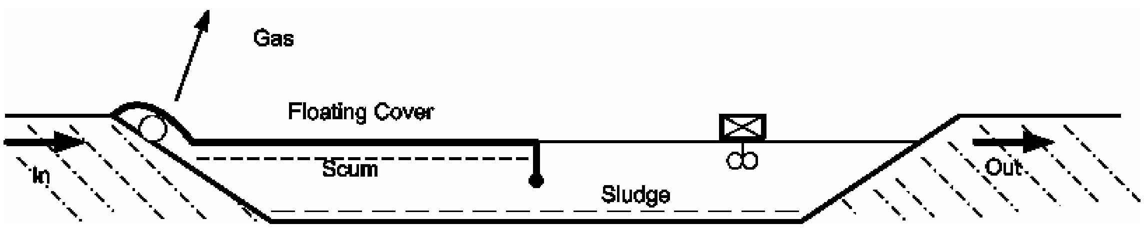

Fig 9. Combined anaerobic and aerobic system

These combined systems have a capacity to take wastewater with BOD of 5000 g/cum and to achieve an output effluent less than 100 g/cum. Total detention times would be in the order of 10 days although some systems use final 'polishing' lagoons or grass filtration and irrigation.

The combined systems also have the capability for the gas to be used on-site to provide power which can be used for the aeration energy input.

Fig 10. A combined anaerobic and aerobic system as part of a much larger system

3 Applications for Geosynthetics

The applications for geosynthetics in these lagoon systems are essentially associated with the liner system and with the floating cover system but there are many variations that may be chosen according to circumstances.

(a) Liner Systems

The liner systems may be a Geosynthetic Clay Liner with soil or concrete cover. However the soil or concrete surface is rather rough and in some cases it will be desirable to use a very smooth low friction HDPE upper liner as this can help to move the sludge to locations from which the excess can be removed.

(b) Cover Systems

The more durable and stable cover systems are based on polyethylene materials (PE) but most cover applications and designs will not allow the use of HDPE for the whole cover because it is too stiff.

One option is to construct the whole cover in a flexible reinforced geomembrane such as polypropylene or elvalloy. Another option is to use a hybrid of more flexible PE materials such as mPE-R or LLDPE which are placed in the flex zones of the cover. This hybrid cover gives the stiffness and security of the HDPE cover with the flexible zones where they are required.

Cover designs may also vary with factors such as the intended operation of the cover with respect to effluent levels, gas collection and associated factors, as well as the construction and launching restrictions which may limit the cover design options.

4 Enhanced Evaporation

A typical black geomembrane with shallow wastewater over it will see the wastewater temperature rise with solar radiation creating an enhanced capacity for evaporation. This is used in wastewater disposal and for salt and mineral extraction processes.

A variation of this process can be used in regions with seasonal rainfall and a pronounced dry season. A floating cover over the wastewater will prevent growth of waste volume in the wet season as well as enabling fresh water to be gathered from the cover. In the dry season wastewater can be pumped onto the cover for enhanced evaporation. This will require some management of cover residues at change of seasonal operations.

5 Sludge Dewatering

Geotubes were initially developed as a construction tool enabling the used of dredged sands to build groynes and other erosion protection features. These filtration properties can also be used to take wastewater sludges with high water content and rapidly dry them to a solid state which allows truck transport without dripping.

Fig 11. Dried sludge from a geotextile sludge dewatering bag

Conclusions

This document provides an outline of the capabilities and issues associated with the use of geosynthetic materials in water storages and wastewater treatment using lagoons and other facilities.

References

SADLIER M., RUSSEL J., HARRIS M. 'Innovative Geosynthetic based Waste Water Treatment Systems' Fifth International Conference on Geotextiles Geomembranes and Related Products, Singapore September 1994.

SADLIER, M., TAYLOR, R "Recent Developments in Polyethylene Geomembranes for use in Floating Covers" Seventh International Conference on Geosynthetics, Nice September 2002.

SADLIER M.A., FROBEL, R., COWLAND J.W. "Liner Systems - Appropriate Technology and Performance", GeoAsia 2004, Seoul, Korea.

FINLAY P.J. AND SADLIER, M.A. "Geosynthetic and Technical Aspects of a Double LLDPE Liner in a 200,000 m^3 Roofed, Concrete Lined Reservoir", GeoAsia 2004, Seoul, Korea.

SADLIER, M.A. "Geosynthetics Aspects of a Methane Gas Storage Bladder" GeoFrontiers 2005, Austin, TX, USA

SADLIER, M.A. "Geosynthetics in Wastewater Treatment" International Geosynthetics Society Education Committee leaflet series (in production).