USING GEOTEXTILES AS BIOMASS ATTACHMENT MEDIA IN SEPTIC SYSTEMS

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Abstract: The United States Environmental Protection Agency estimates that one in four households utilize a subsurface sewage disposal (septic) system for wastewater treatment. This practice will continue into the future. Current emphasis should be centered on optimizing the performance of, and treatment provided, in these systems in order to ensure adequate water quality. It has been shown that geotextiles are well suited as an attachment media to host a biomass for wastewater treatment. Therefore, the task at hand is to find a way to select the appropriate geotextile for the application, and encourage the development (and subsequent health) of the biological layer (schmutzdecke) that is involved in the wastewater treatment. A pilot study is proposed at an institutional facility located on the eastern seaboard of the United States, whereby monitoring of the biomass development, growth, and sustenance will be performed. Underground arched chambers will be used for effluent distribution, and a geotextile underlining will provide the vehicle for attachment media, as well as anti-scouring protection. In addition, an innovative method will be introduced to improve the aerobic conditions within the chambers, which will further encourage biomass health, and the treatment efficiency of the system.

Keywords: water quality, nonwoven geotextiles, groundwater-protection, environment protection, sewage

INTRODUCTION

The project consists of the construction and monitoring of a subsurface sewage disposal (septic) system (also known as “decentralized wastewater treatment systems”) for an operating institutional facility located on the Eastern Shore of the United States of America. Considerations for the optimization of the design include the utilization of geotextiles as both a microbiological attachment media, and anti-scouring component. Additionally, aerobic augmentation is proposed, through an air-exchange method, to provide oxygen-rich conditions within the disposal bed and encourage effluent digestion. The disposal field will be divided into four (4) zones, with each zone receiving a cyclical dose of effluent. All four of the zones will be underlain with geotextiles, and two of the zones will receive aerobic augmentation. Daily sewage flow rates have been monitored at the site, and confirmed by two methods: the number of operating hours of the effluent delivery pumps to the septic disposal fields; and the volume of groundwater withdrawn by on-site wells - used to provide potable water to the facility. Pump and well records indicate an average daily flow of 74,500 liters per day.

BACKGROUND

The use of geotextiles as attachment media for biological treatment has been established (Koerner, 1993), (Korkut, 2003), (Yaman, 2003). In the Koerner study, microbial populations incubated geotextiles in the filter of a landfill. It was noted that the permittivity of the filter was re-established between dosing events – presumably through endogenous respiration – as lysis of the cell walls occurred, the active microbes consumed the dead ones. Korkut’s work was centered on the treatment of stormwater and combined sewer effluent through the use of a vertical baffle geotextile sequence. The emphasis was on the initial incubation of the geotextile, and sustenance of the biomass (and digestion by same) of the substrate contained within the effluent stream during subsequent rainfall events. Yaman’s work considered the incubation of microbial populations in a series of geotextiles placed between layers of filter sand in a vertical column. The application of this work was in conventional and mounded septic systems. In addition to the foregoing, proprietary septic treatment modules are available in the Northeast United States, which utilize an encapsulated geotextile component for biomat development and effluent treatment. A Scanning Electron Microscope photo of biomass floc incubation in a non-woven geotextile is shown in Figure 1 below.

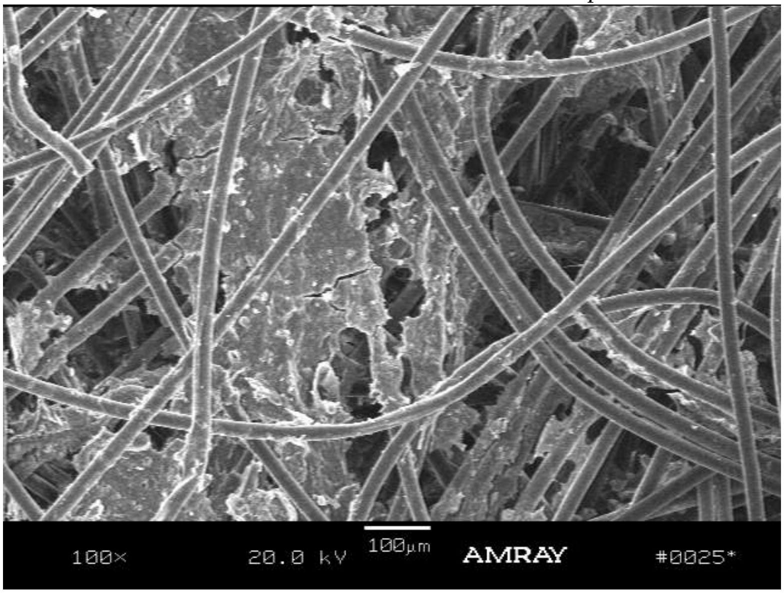

Figure 1. Biomass capture in non-woven geotextile

SYSTEM COMPONENTS

The effluent delivery system consists of a 10 cm diameter PVC lateral, which is pitched from the building through a series of septic tanks. Baffle walls within the septic tanks encourage the settling of suspended solids having a specific gravity greater than 1.0. The effluent then travels into the pump station (a concrete chamber housing the pumps, float switches, and discharge piping) via gravity. As the pumps are activated by the float switches at pre-determined elevations corresponding to discharge volume that can be accepted by the disposal field, the effluent passes through a valve pit which sequences which zone of the disposal field receives the dose. The effluent then is directed by the force main to a “surge tank” (effectively another septic tank with interior baffle wall), where additional settling of solids is encouraged prior to discharge by gravity into the disposal field. Figure 2 shows the system layout with components and numbered quadrants of the disposal field.

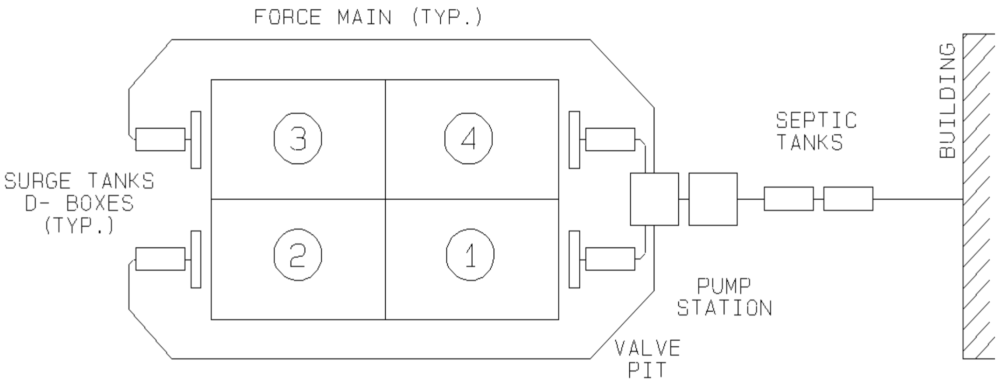

Figure 2. Plan View Layout of septic system

The disposal field consists of rows of open-bottom arched polyolefin chambers, set at a zero percent longitudinal slope, with a non-woven geotextile underlayment. Below the geotextile is a 1.2 metre thick layer of loamy sand – considered as the ‘Zone of Treatment”; and another 1.2 metre layer of soil considered as the “Zone of Disposal”. Governing jurisdictional agency standards require field permeability for underlying soils of 15-50 centimetres per hour. Verification with this standard is accomplished through a laboratory Permeability Class Rating analysis – consisting of both sieve and hydrometer analyses; and a falling head permeameter test. If the in-situ soil does not meet the required permeability, the soil must be removed and replaced with suitable material. Figure 3 below shows a profile of the chambers and subgrade in the septic disposal field.

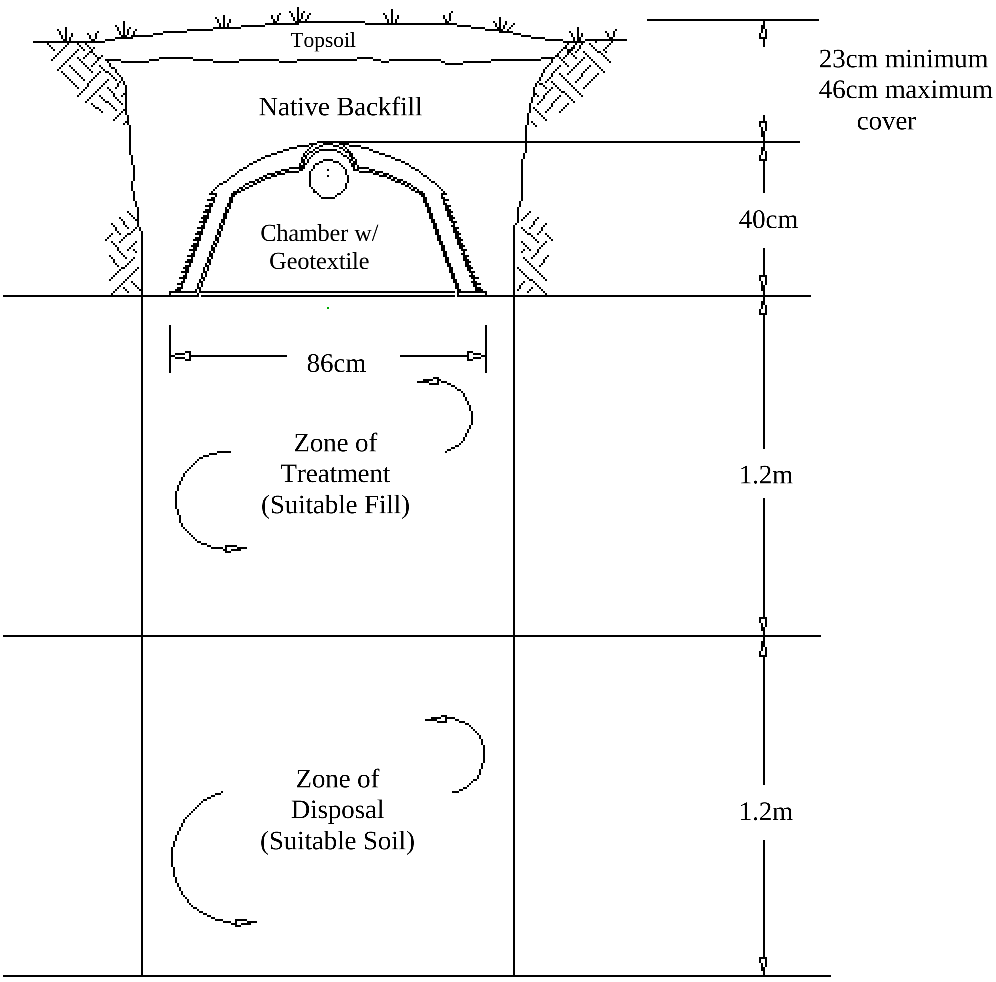

Figure 3. Profile of disposal field

SELECTION OF GEOTEXTILE

Traditionally, the geotextile design selection is determined based on its required application – the implementation of one or more of the following functions: filtration, separation, drainage, or reinforcement. In this application to septic systems, drainage, filtration, and porosity were considered. The geotextile applied to this design performs the function of anti-scouring of the soils that are exposed in the base (invert) of the arched chambers; as well as providing an attachment media for the biomat. The applicable jurisdictional standard for this site requires the size of the disposal field land area to be based on the permeability of the soil (and presumably the Long Term Acceptance Rate – based on the saturated hydraulic conductivity of the biomat that subsequently forms). The intent, therefore, is to select a geotextile that has filtration potential (filter, cake, and depth), but also has a permittivity that provides enough effluent flow to allow for the development of the biomat beneath the geotextile at the interface with the underlying soils. The subsequent biomat developed at the geotextile/ soil interface will grow into the pore space in the underside of the geotextile, and will eventually connect with the biomat that is formed within the geotextile as a function of filtering. The geotextile selected for this application has a permittivity of $1.2s^{-1}$.

SYSTEM OPERATION

The proposed disposal field is divided into four (4) zones, or quadrants. Each quadrant will receive a sequenced effluent dose from the pump station (and valve pit). The advantage of the sequencing is that – while one quadrant is being dosed, the remaining three quadrants can hydraulically recover from their last dose. Since the effluent discharge from the facility is on-going, the biomat will remain saturated, and a continuous substrate supply will be provided, thereby sustaining the microbial population.

Dispersion Within Chambers

Each disposal field quadrant is 46 metres in length. If a lateral from the distribution box discharges by gravity into each chamber bay, the biomat would form progressively from the point of discharge to the end of the bay. This progressive approach requires an extensive time period to manifest itself, and causes excessive hydraulic loading at the inlet end. Even after complete biomat formation has occurred, the entire chamber bay would continue to experience uneven loading. Therefore, in order to ensure evenly loaded effluent contact throughout the manifold bay, a perforated PVC pipe with a gentle slope will be suspended longitudinally from the ceiling of the chamber toward the end of each bay.

PROPOSED OXYGENATION OF SYSTEM

A distinct advantage exists when using arched chambers over the conventional disposal field configuration of perforated pipe encased within a stone bed. The geometric configuration of the chambers allows for significant “head space”, or air volume, within each row. The result is that more oxygen is available for aerobic treatment within the chambers. If one can promote an exchange of air, additional oxygen will be available for aerobic treatment of the effluent. Therefore, an air exchange method is proposed. Turbine vents, also known as “onion vents” are used on rooftops of buildings to create negative pressure within attic space to evacuate heated air. They are “non-mechanical” in that there is no motor required to cause them to function. Onion vents move air when wind is present – in fact, a 0.3 metre diameter onion vent can move 41 cubic metres of air per minute with a wind speed of only 8 kilometres per hour. The subject facility is located on the Eastern Seaboard of the United States, where winds are prevalent on a daily basis. Additionally, the disposal field is located in an area away from public use, and the resultant vented odors from the septic system will not be a cause of concern. The turbine vents will be located at one end of the chamber rows, and vented caps will be installed at the opposite end of the rows in order to allow the air exchange to occur.

MONITORING OF SYSTEM

Of the four quadrants, two will be equipped with the venting system, and two will not be equipped with the venting system. Monitoring of the biomat formation will be performed in all quadrants through the use of 10 cm PVC “inspection ports”, extending from grade to the invert of the chambers. Additionally, a 1.2 metre wide manifold will be constructed across the center of the disposal field for access to each chamber row. Monitoring, as well as repairs, or geotextile replacement if warranted, can also be performed from the manifold. Data will be collected throughout the biomat formation phase, and the performance and treatment efficiency of the system will be evaluated for both the air-exchange quadrants, and the conventional operation quadrants using only the non-woven geotextile underlayment.

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