

Hybrid Filter for the Treatment of Septic Tank Effluent

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Abstract— The term Ground water pollution is a major global problem. One of the main causes of ground water contamination is the effluent from septic tanks. Hence it is very important to protect surface and ground water from contamination. Various research efforts in the past have demonstrated that most of the known contaminants in the septic tank effluent –Suspended solids, BOD, bacteria, and viruses can be removed by movement through a few feet of soil under proper conditions. Septic systems that are improperly sited, designed, constructed, or maintained can contaminate ground water with bacteria, viruses, nitrates, detergents, oils, and chemicals. The purpose of this study is to investigate the effect of a horizontal flow biofilm reactor (HFBR) consisting of Corrugated PVC sheets with a stratified sand filter for treating septic tank effluent. HFBR and a sand filter are used to form a “hybrid filter” and are placed in an acrylic tank with suitable dimensions. The HFBR module consists of corrugated PVC sheets that will place with proper spacing in between each sheet. The wastewater is allowed to flow along each sheets from one side to another horizontally and down through the module and also considered that most of the substrates and solids would be removed in the biofilms on the sheets, substantially reducing the loads applied to the sand filter underneath. Hybrid filter consisting of Corrugated PVC sheets and river sand has 99.96 % of Total Coliforms removal after 3 weeks. The hybrid filtration system appeared to perform better in terms of TSS, BOD, COD and nitrification.

Index Terms— BOD, COD, Corrugated PVC, HFBR, Hybrid filter, Septic tank, TSS

1 INTRODUCTION

Ground water is the most essential source of fresh water contributing a major portion of the world's drinkable water. Throughout history, the quality of drinking and irrigation water has been a factor of determining human welfare. Access to water supply and improved sanitation is one of key factors in improving health and economic productivity. According to the World Resources Institute, within 20 years, more than half of the world population will be suffering severe freshwater shortages. The limited availability of water for agricultural production is increasingly affecting the ability of the farms in every continent of the globe to produce enough food for the ever-increasing population. The effluent from the septic tanks are found to be the main source of ground water contamination.

The Water Quality Control Commission (WQCC) in 1989 identified, in most places septic tank systems are the most frequently reported source of groundwater contamination. The World Health Organisation (WHO) has indicated that approximately 1.8 million deaths and 61.9 million disability-adjusted life years worldwide are attributable to unsafe water, sanitation and poor hygiene. Consumption of groundwater and surface water sources contaminated with pathogenic bacteria continues to be one the major causes of diarrheal diseases and gastrointestinal infections.

Septic tank process convert the organic nitrogen compounds into ammonium, no conversion of ammonium to nitrate is expected to occur in it. The removal of E-coli is also not possible in them. The effluent coming out from a septic tank contains large amount of organic matter and BOD. Due to these difficulties the effluent from septic tank should be properly disposed after proper treatment or else the ground water gets damaged which increase the bacterial contamination is a major concern. This is how the study gains its scope and importance. Some investigators estimate that as many as one half of all septic tank soil absorption systems are not operating satisfactorily. The acceptability of a site for a septic tank system is commonly based upon the percolation rate or the ability of the local soil to absorb water at a fast enough rate to handle the anticipated volume of effluent. It is assumed that if

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the percolation rate is acceptable and the tile field is large enough, there will be removal of pollutants from the effluent by natural adsorption and biological processes in the soil zone immediately below the tile field. Historically, system failure has meant that the capacity of the soil to absorb effluent from the tank has been exceeded and the waste added to the system moves to the soil surface above the lateral lines. This type of failure results from soil clogging and loss of infiltrative capacity. Biological factors are the principal influences on soil clogging. The deposition on suspended materials, bacterial build up, and bacterial decomposition of the organic material at the liquid soil interface produce an organic mat of only a few millimeter thicknesses that greatly reduce infiltrative capacity.

Various research efforts in the past have demonstrated that most of the known contaminants in the septic tank effluent, Suspended solids, BOD, bacteria, and viruses can be removed by movement through a few feet of soil under proper conditions. Septic systems that are improperly sited, designed, constructed, or maintained can contaminate ground water with bacteria, viruses, nitrates, detergents, oils, and chemicals.

The main aim of this study is to develop a new hybrid filter system, comprising a stack of horizontal PVC sheets vertically apart-over stratified Silver impregnated sand filter. Sand filtration is a common and effective method for treating septic tank effluent. However, if the loading rate is too high, clogging and ponding of the sand filter surface layer will occur due to excessive biomass and deposition of suspended solids. Hybrid filter is a novel method to treat septic tank effluent with little risk of clogging.

2. MATERIALS AND METHODS

Influent characteristics are kept constant in each experiment. the experiment was conducted at "Environmental Engineering Laboratory, Government Engineering College, Thrissur. The synthetic wastewater was prepared using distilled water and chemicals as given in the following table. Synthetic wastewater was seeded with cow dung to get bacterial concentration range of 10^6 CFU / 100 ml using trial and error method. Composition and concentration of synthetic septic tank effluent is given in the Table 1

TABLE 1
COMPOSITION AND CONCENTRATION OF SYNTHETIC SEPTIC TANK EFFLUENT

Sl. No	Composition	Concentration (g/l)
1.	Peptone	0.1225
2.	Beef extract	0.0805
3.	Urea	0.1475
4.	Sodium chloride	0.059
5.	Calcium chloride	0.059
6.	Potassium chloride (KCl)	0.012
7.	Mgso ₄ .7H ₂ O	0.035
8.	K ₂ HPO ₄	0.935
9.	KH ₂ PO ₄	0.117

were used to form a hybrid filter. This experiment was conducted in an acrylic module having size 30 cm X 30 cm X 39 cm. The size of HFBR was 26 cm X 26 cm X 26 cm. The HFBR consisted of 8 numbers of corrugated PVC at 30mm vertical spacing. Each sheets were fixed with the module with a small gradient. Synthetic water is then allowed to flow through the sheets from one side to the other and down through the module. The bottom sheet of the HFBR was drilled in a pattern to provide an even distribution of the treated waste water over a sand filter system. The diameter of the bottom sheets were 35 mm. There was an adequate gap at the side of the module for air entry in to the module.

The sand filter part of the hybrid filter was 13 cm. And the remaining portion of the acrylic module was HFBR with corrugated PVC sheets. Synthetic septic tank effluent was applied to this hybrid filter at a rate of 14 litre/day in 2 doses per day. The daily hydraulic loading rate remains the same throughout the experiment.

3. RESULTS AND DISCUSSIONS

Hybrid filter shows highest percentage removal of all parameters excluding phosphate and Nitrification was not complete but average 69 % removal, 99.96 % of Total Coliforms removal was achieved after 21 days. Effluent concentration of various parameters after 3 weeks are shown on the table 2. In hybrid filters phosphorus reduction is not satisfactory because aerobic and anaerobic conditions in biofilms could encourage phosphorus accumulating organisms. Biological oxygen demand is a measure of the amount of oxygen required to stabilize carbonaceous waste biologically (through the metabolic action of aerobic microorganisms). Carbonaceous compounds are oxidized to carbon dioxide during aerobic microbial metabolism, therefore a reduction of BOD was consistent.

Total Kjeldahl nitrogen is the amount of nitrogen contained within organic compounds (such as nucleic acids, amino acids, and urea) and in ammonia. Nitrate and nitrite are products of the process of nitrification, which involves the oxidation of ammonia. The reactions of nitrification are carried out by aerobic bacterial species of Nitrosomonas and Nitrobacteria, natural occupants of septic systems. As aerobic microbial metabolism proceeds amount of ammonia and TKN decrease. Conversion to nitrogen gas (N₂) occurs due to denitrification process which occurs in anoxic conditions (low oxygen). It generally occurs when the soil is nearly saturated with water. The reduction of nitrogen compounds considerably increased due to aerobic oxidising bacteria (AOB) and nitrite oxidizing bacteria (NOB) often grown in biofilms.

A horizontal flow bio-film reactor (HFBR) and sand filter

TABLE 2
EFFLUENT CONCENTRATION OF VARIOUS PARAMETERS

Parameters	Influent Conc.	Effluent Conc after 3 weeks	%removal after 21 days
Total Coliform (CFU/100ml)	32 x10 ⁵	1100	99.6
TSS (mg/l)	38	10.8	71.6
Ammonia Nitrogen (mg/l)	44.82	13.1	70.77
Nitrate Nitrogen (mg/l)	0.58	0.18	68.96
TKN (mg/l)	59.4	19	68.01
BOD(mg/l)	178.4	70.5	60.48
Phosphate (mg/l)	10.2	5.5	46

Biofilms has major role in removing phosphorus transport from septic tank effluent into subsurface soils. Biofilms (also called clog zones or clog mats) frequently form at the interface where septic tank effluent meets the sand layer of the drain field. Biofilms help treat effluent by slowing down the effluent flow, distributing effluent evenly in the drain field, increasing the microbial activity, and enhancing sorption, biotransformation, and die-off/inactivation processes leading to effective removal of phosphorus.

Adsorption (or sorption) occurs when phosphorus anions bind to soil surfaces. Phosphorus adsorption occurs on positively-charged particles such as aluminium, iron, and manganese oxides and hydroxides, and clay particles. However, adsorption is limited by the number of available sorption sites. Organic matter causes contradicting effects on phosphate sorption. Certain organic acids can entrap reactive aluminium and iron in stable organic complexes called chelates, thus making them unavailable for phosphate sorption.

Higher percentage reduction of Total coliforms was observed for hybrid filter consisting of corrugated PVC sheets with river sand. In the sand filter, effluent initially reaches at the top and percolates slowly and evenly throughout the bed. The removal of effluent contaminants occurs in the upper few centimetres of the bed where a bio-

logical active layer is formed.

4.CONCLUSION

As cities are growing in size with a rise in population, the amount of septic tank effluent generated is increasing and becoming unmanageable. Hence, coliform gets increase as a result reduction of coliform like E.coli is a major scenario. Also it is very important to protect surface and ground water from contamination. Hybrid filter is a novel method to treat septic tank effluent with little risk of clogging. The bacterial content of the influent and effluent varied greatly in hybrid filter. A longer period of experiment is deemed necessary to determine the highest capacity of the system in terms of pollutant removal. More extensive studies could be carried out in order to understand clearly the mechanism that occur in biofilms. In situ treatment will be made to evaluate the actual performance of the system.

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