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Coir geotextile-packed conduits for the removal of biodegradable matter from wastewater

A. Praveen[1,*], P. B. Sreelakshmy[2] and M. Gopan[3]

[1]Department of Civil Engineering, Government Rajiv Gandhi Institute of Technology, Pampady, Kottayam 686 501, India
[2]Department of Civil Engineering, Government Engineering College, Thrissur 680 009, India
[3]Kerala State Council for Science, Technology and Environment, Sasthra Bhavan, Thiruvananthapuram 695 001, India

Majority of residential units and small-scale commercial operators in India dispose wastewater either onsite or into the public drainage systems, without paying any attention to the public health and environmental impacts. Need for high investments and the requirement for large operational space are the reasons often quoted against the installation of a proper wastewater treatment unit. This communication presents a viable and cost-effective technology using coir geotextile, for the removal of organic matter from wastewater. Coir geotextile conduits, prepared using non-woven-type material and having a specific weight of 0.9–1.7 kg/m^2 could be an acceptable solution for most of the small-scale units.

Keywords: Biofilters, coir geotextiles, conduits, onsite disposal.

DESIGN and implementation of efficient wastewater treatment methods to meet the regional demands of pollution control have always been a major challenge facing the technologists. Several attempts in the past to limit uncontrolled discharges of polluted water have led to the development of wastewater-treatment solutions using innovative process concepts[1]. In spite of wide options being available for the choice of technology, the current approach in most developing countries is still to follow the conventional practices, without paying attention to better techniques and solutions. Among these, the most common method usually adopted by most of the residential or small-scale commercial units in India is either to discharge the wastewater onsite or drain it into any public wastewater carriage systems. It is also obvious that the setting up of conventional treatment systems for the above-mentioned situations may not be feasible due to the high cost of equipment and inadequate space for installation of these units. Also, setting up of a new, centralized wastewater treatment facility together with the laying of fresh sewer lines in emerging urban locations in India is certainly a cumbersome exercise. Under such circumstances, search for solutions that accommodate factors like cost-effectiveness in operation and low space requirement demands a more pragmatic approach in the

*For correspondence. (e-mail: arakkalpraveen@gmail.com)

planning and design of sewage treatment systems. Hence, the best possible solution for such scenarios would be to install compact units capable of reducing the waste load entering the sewers. This would finally result in the design of more efficient and smaller treatment plants capable of achieving better level of purity at low operational cost and environmental damage.

Biological filtration is a waste treatment process where organic pollutants present in any fluid stream could be brought in contact with the microorganisms attached to the surface of the filter media. These microorganisms utilize the absorbed organic molecules for their growth and thus initiate the process of biodegradation. This process could be either aerobic or anaerobic depending on the type of operational environment maintained in the treatment unit[2]. Due to the higher specific surface area, fibrous materials are often considered a better choice for increased microbial support and treatment efficiency. In addition, high removal rates in BOD_5 (biological oxygen demand) levels and nutrients have also been observed in fibre-based reactors[3]. Also, various studies have established the utility of polymer fibre geotextiles to support biofilm development and also augment the biodegradation rate[4,5]. Besides higher biodegradation rate, the ability of the treatment unit to withstand sudden shock is also a vital requirement for any wastewater treatment operations. Organic-rich soils like peat and compost, when used as biofilters for onsite disposal have exhibited better ability to take shocks like sudden increase in the organic loads during their routine treatment cycles[6]. Hence it is understood from the published research results that a reliable choice for a biofilter medium could be based on any naturally available fibrous material containing rich organic matter.

Coir is a hard and tough organic fibre extracted from the husk of coconut. It is rich in cellulose and lignin, besides having high specific area and wetting ability – factors which are essential for bacterial adhesion in fixed film processes[1]. One of the major uses of coir is in the manufacture of geotextiles that have large-scale applications in the fields related to soil engineering and water resources management[7]. Detailed field-based investigations have confirmed the superior ability of coir geotextiles, over other natural fibres, to provide effective protection against soil erosion and in improving vegetation[8]. Hence it was decided to explore the possibility of using small conduits packed with coir geotextiles to drain the wastewater. Thus, coir fibre-packed conduits were designed to promote biodegradation of waste matter present in the water during its flow through them.

Non-woven coir geotextiles having specific weight of 0.9–1.7 kg/m^2 were chosen for detailed experimental investigations to assess their capability with respect to the biological wastewater treatment process. The structural composition of the coir geotextile material used in these experiments is given in Table 1. The basic unit of the laboratory reactor used in this study consists of a 10 cm diameter PVC pipe with the geotextile mat rolled and placed in the form of concentric circles (Figure 1). Such a choice was made because it was not feasible to place the geotextiles properly in a smaller diameter pipe, while a larger diameter pipe packed with geotextiles could not ensure smooth flow of wastewater. The reactor length of 60 cm was fixed as the optimum length obtained from an initial study undertaken using four different dimensions (90, 75, 60 and 40 cm). The entire experiment was conducted on synthetic wastewater samples prepared using analytical grade starch powder and urea in appropriate proportions. Wastewater samples having BOD_5 levels of 500, 1000, 1500 and 2500 mg/l were prepared in this manner. Bacterial pure cultures for faecal coliforms, streptococcus and staphylococcus were prepared in the laboratory and later transferred to the geotextile mat in equal quantities (20 g) to ensure uniformity in performance across all the reactor units. This was necessary as the wastewater streams did not contain any microorganisms to initiate the process of biodegradation.

The primary objective of the experiments was to arrive at an optimum packing density of geotextiles that could successfully treat a broad range of organic loads. Hence the conduits, each having a uniform packing density of 110, 80, 50 and 30 kg/m^3 were prepared. Experiments using these units were conducted under two different conditions. The first was the sequential batch process, where the entire reactor volume of the wastewater at a particular BOD_5 level was retained in the reactor for 24 h before discharging. This process was continued until a constant removal rate or maximum substrate utilization, measured as change in BOD_5 level between the influent and effluent,

Table 1. Structural composition of coir geotextile

Parameter	Values
Particle density	0.49 g/cm^3
Organic carbon	40.6% (of dry weight)
Nitrogen	0.68% (of dry weight)
C : N ratio	60 : 1
Total P	0.026% (of dry weight)
Total K	0.360% (of dry weight)

Source: CCRI, Alappuzha.

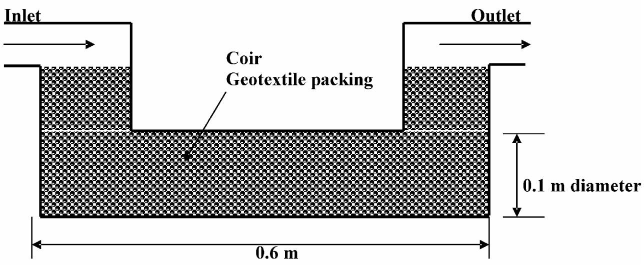

Figure 1. Line diagram of coir geotextile bio-reactor.

could be attained. The sequential batch experiments were repeated in the reactors with different coir packing for organic loading rates from 0.5 to 2.5 kg/m^3/day by appropriately using wastewater at different concentrations. In the case of continuous flow reactors, the wastewater samples prepared at the BOD_5 levels discussed earlier, were passed continuously through another set of reactors as used for the sequential batch process. The maximum possible wastewater flow rate in each type of fibre packing was held constant throughout the experiment by controlling the pressure head. Also, the reactors were subjected to a different set of organic loading rates by varying the influent concentration. The ability of the reactor to remove the organic component in the wastewater for each loading rate was estimated by measuring the BOD_5 levels present in the respective influent and effluent samples. Experiments in both types of reactors were continuously monitored for a period of 200 days.

The results from the sequential batch studies provided all the necessary information regarding the maximum possible substrate utilization for different organic loading rates in each type of fibre packing. Figure 2 gives the variation of percentage reduction in BOD_5 levels for different organic loading rates in the sequential batch reactors. Figure 2 also includes a comparison on the above behaviour across different fibre-packing densities used in the reactors. It is obvious from the results that the degree of removal increases with the organic loading rates for less dense filters. This clearly displays biofilm growth in the filter with a higher substrate supply. However, at higher packing density the above variation was not significant across different organic loading rates. This was expected as increased packing may not provide equivalent increase in the available surface area for biofilm development due to overlapping of the fibres.

Experiments on continuous flow regime were carried out to gather adequate data on the performance of coir geotextile filters under a regular flow situation. The final analysis presented here is based on data recorded beyond the maximum substrate utilization for each loading rate in the filter. From the results shown in Figure 3, increased biological activity was observed on low-density filters (packing density 30 kg/m^3) under lower organic loads. Unlike the sequential batch process, where the entire volume is stationary during the contact time, the continuous flow process would result in more continuous supply of organic matter across the entire reactor length, which could be the reason for such a behaviour. At higher organic loading rates in all the reactors, the potential absorption of organic matter onto the fibres is consistent with those obtained with sequential batch units. Thus it is confirmed that the coir geotextile-packed conduits, with well-graded fibre density along their length, would be reliable and consistent in the removal of biodegradable matter from wastewater. This could also result in the better quality of effluents for safe onsite disposal and prevent considerable damage to the soil and water quality prevailing in that area[9].

The long-term performance of coir textile reactors depends on their degradation rate and clogging frequency in the filters under routine operational conditions. Studies done earlier on the degradation of coir fibres report that

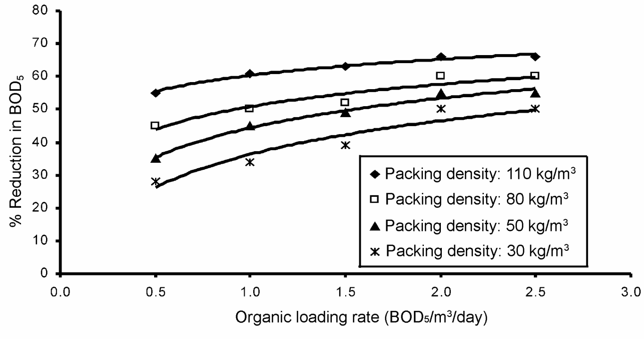

Figure 2. Performance of coir geotextiles in sequential batch process.

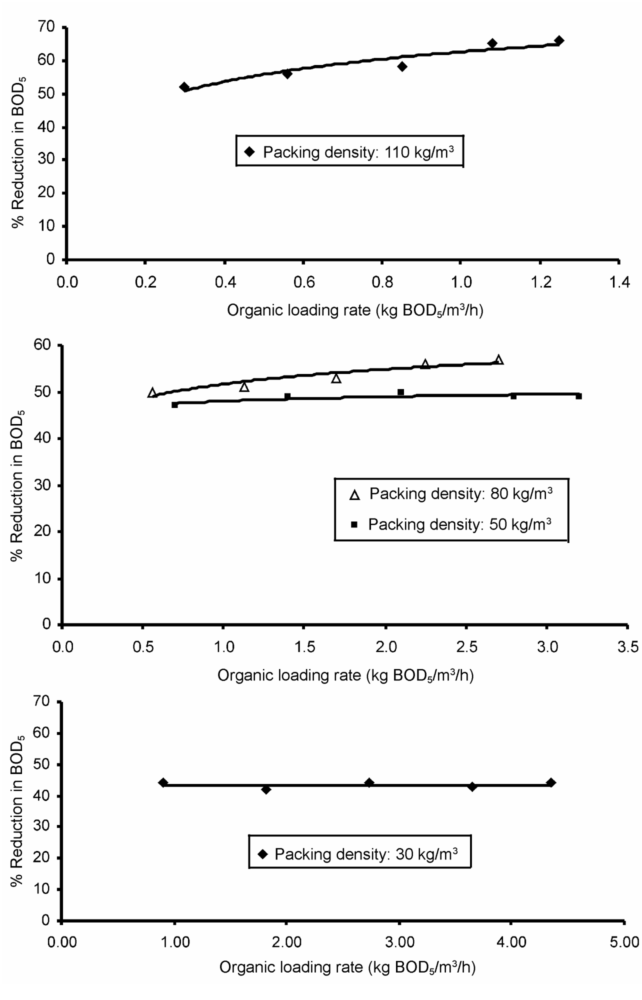

Figure 3. Performance of coir geotextile filter during continuous flow.

the combined effects from a variety of factors like the type of curing, diameter of the fibre and environmental/exposure conditions initiate their deterioration[10]. In the present study, though the coir fibres facilitate microbial activity, these microorganisms are expected to depend on the substrates from the wastewater for their growth rather than the coir material. However, an adaptive shift in substrate dependence should be expected when these reactors are subjected to a repeated cycle of closure and re-use. A preliminary assessment done on reactors that were operated continuously for a period of one year showed only a marginal reduction in the dry weight (less than 2%). On clogging, the stiffness of the fibres and porous matrix of non-woven coir geotextiles provided enough space for the wastewater to flow and prevented any such problems in low-density filters. However, for higher fibre packing (above 80 kg/m^3), continuous operation of the filters required frequent cleaning due to the formation of biological flocs in the inlet region of the reactors.

The utility of coir geotextiles in the design of biofilters for the treatment of wastewater, loaded with biodegradable matter, has been successfully established in this communication. This would certainly result in expanding the engineering application for coir geotextiles, which are presently used more extensively in geotechnical engineering and water management projects. The laboratory results obtained from this study have given the necessary information to design and evaluate the long-term performance of a field-scale, reactive sewer unit. Future work must look into coir geotextile filters that could be directly attached along the sewer lines to make the wastewater treatment operations more energy-efficient.

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Prioritizing land-management options for carbon sequestration potential

Divy Ninad Koul and Pankaj Panwar*

Department of Forestry, Uttar Banga Krishi Viswavidyalaya,
P.O. Pundibari, District Cooch Behar 736 165, India

Global warming is inevitable. Therefore, the need is to develop strategies to reduce the greenhouse gases from the atmosphere. Carbon sequestration through biomass seems to be a cheap and viable option. There are several land-use options which can sequester carbon. Their potential of locking carbon differs not only with the type of species, but also with the agroclimatic zones. Hence, location-specific land-use systems need to be prioritized taking both carbon sequestration potential and socio-economic needs into account. It was found that in the terai zone of West Bengal, fallow land and agricultural field sequester 5.86% and 4.73% carbon respectively, compared to the natural forest of *Shorea robusta*. However, agroforestry systems, viz. tea garden and agrihorticulture contributed 24.24% and 9.09% carbon respectively. The agrihorticulture system while sequestering carbon also provides agricultural crops and other economic gains, including carbon credits, and hence seems to be the best option. The potential of carbon storage of tree + crop-based system can be further increased using improved planting materials of perennial components.

Keywords: Agrihorticulture, carbon sequestration, global warming, greenhouse gases.

THE implications of increased concentration of CO_2 for climate and health of the global environment are topics of intense scientific, social and political concern. In contrast to economic globalization, no country can be left out of environmental globalization, as its consequences will sooner

*For correspondence. (e-mail: dr_pankajp@yahoo.co.in)