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COCONUT COIR: A MEDIA TO TREAT THE WASTEWATER

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Abstract: Development of appropriate low cost treatment techniques that suits to developing countries is of great importance. For this purpose, efforts are going on, to reduce the cost of the wastewater treatment and to minimize the economical burden of the industrialist, to control the environment pollution. In the continuing efforts the fixed bed reactor is the one which will give the best solution to treat the wastewater. Till now, the packing materials used in these is of synthetic material such as ceramic rings, PVC tubes which is relatively of high cost. If we can use the agricultural by-products such as coconut coir, areca husk fibre, coffee husk blend with wooden chips then it can necessarily reduce the cost of treatment plant. Some of the researchers have made the comparative study of these natural fibrous medias in the fixed film (attached-growth) process. Of all these natural fibrous materials, only coconut coir fibre is found effective, strong and durable to treat various wastewater. In this paper, a review on different researchers experience using coconut coir as a media and its performance to treat various wastewaters is discussed in detail.

Keywords: Coconut coir, Wastewater, Coir fibre, Cellulose, lignin, Fixed bed reactor

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INTRODUCTION

By the stringent laws and regulations imposed by Government of India to dispose the polluted wastewater in river or on land, it's the need of the time to reduce the cost of the treatment plant itself, so that the industrialist will not consider it as the overburden to them. So the investigations are on and now-a-days the fixed bed reactor having a naturally available agro industrial byproducts packing material is emerging as an old technology into a new concept.

The utilization of fixed films for wastewater treatment process has been increasingly considered due to inherent advantages over suspended growth system. One of the advantages is high biomass per reactor volume which permits higher organic loading rate, short liquid detention times and good performance stability (G. R. Shivakumaraswamy et.al.). Biomass accumulation and retention in biomass systems are enhanced by attachment to a fixed medium. Many different natural materials such as granite chips, pebbles, clay, corals, mussel shells and many technically designed sophisticated materials such as corrugated modular blocks, Pall rings, honey comb, corrugated plastic rings etc. have also been used as support media for biomass retention in wastewater treatment reactors but their biggest disadvantage is the relatively high cost. In this context, coconut coir is a relatively inexpensive and easily available natural medium and can be used for such systems in place of synthetic media (Valsa Remony Manoj 2012).

COCONUT COIR FIBER

Coir is the natural fiber found within the shell of the coconut. Coconut Coir is a lingo-cellulosic natural fiber. It is a seed-hair fiber obtained from the outer shell, or husk, of the coconut, the fruit of Cocos-nucifera. The coarse, stiff, reddish brown fiber made up of smaller threads, each about 0.03 to 0.1 cm long and 12 to 24 micrometer in diameter, is composed of lignin, a woody plant substance, and cellulose. The individual fiber cells are narrow and hollow, with thick walls made of cellulose (Girisha. C et. al. 2012). Mature brown coir fibers contain more lignin and less cellulose than fibers such as flax, jute, sisal and cotton etc. and are thus stronger but less flexible.

Coir fiber is an inexpensive fiber, abundant in tropical regions and is strong, flexible, and durable. Coir fiber is shown in fig.1. Coconut fiber is the most ductile fiber amongst all natural fibers. Coconut fibers are capable of taking strain 4-6 times more than that of other fibers. Coir fibers are classified as "Brown" or "White" coir. The darker brown coir

Fig.1 Coir fiber

fibers are long and stiff. (Majid Ali, 2010). Lignin is a natural polymer and gives coir its elasticity and strength. (A. R. Vinod, 2014). The high lignin content also makes the fiber resistant to biodegradation.

LITERATURE REVIEW

According to, "G. R. Shivakumaraswamy et.al. (2013)" the most important aspects in the design of an anaerobic fixed bed reactor is selecting an adequate support material. An ideal packing material for the attached-growth process should not only be inexpensive, light weight, durable, and easy to ship and install, it should also have a large specific surface area for bacterial growth and high porosity to prevent clogging by the increased biomass. It has also been reported that the organic matter removal efficiency in fixed-bed reactors is directly related to the characteristics of the support materials used for the immobilization of anaerobes. The use of fibrous material is effective in increasing the surface area of the support media in fixed film reactors. Several fibrous biomass support mediums such as coir (coconut husk fiber or areca husk fiber) sisal fiber are available for use in attached growth system.

In this paper, he explained the comparative study of the application of areca husk fiber and conventional gravel bed as a fixed bed for treating domestic wastewater to know the removal efficiency of COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand) and NH3-N (Ammonium Nitrate) in a small volume reactor. He concluded that compared to gravel bed a removal efficiency of areca fibers bioreactor seems to be satisfactory and effective for batch mode of operation.

K V V S Kudaligama et. al. in his paper, "Coir: a versatile raw material to produce stationary media for biological wastewater treatment systems" explained that several researchers are trying to develop coir as a practical medium in wastewater treatment systems and had tried to

pack coconut coir as loose filled fibre, fine fibre cuts, curled coir, coir twines, rubberized coir, coir bound with synthetic & natural polymers and coir fibre arranged in bottle brush like configuration. He insisted on using coir as a media by giving examples of various scientists such as Warnakula in 1993 used coir fibre arranged in bottle-brush like configuration, and found that it is the most feasible configuration of using coir as a biomass retainer in wastewater treatment to achieve optimum treatment efficiency. In 1989, Anon, Senevirathna in 1991, Rathnayaka in 1995; Jayamanne, 2003 all these researchers have tested an anaerobic reactor with rubberised coir as the biomass retainer and reported that rubberised coir was superior to poly vinyl chloride (PVC) rings, which they previously used. He gave the reason behind this as better attachment of bacteria on porous & rough surfaces of coir.

Finally he concluded that Cost of Bio-brush media using coir is about 1/10th of the cost of available high-tech media in the market. So coir fibre base media could play a vital role in developing low cost treatment facilities for different biodegradable liquid waste like natural rubber, dairy, fruit processing, desiccated coconut industry and rice processing etc.

K V V S Kudaligama et. al.(2005), had discussed the application of five different specific surface areas (SSA) of Bio-brush in a Covered Activated Ditch (CAD) type test reactors under four different organic loading rates (OLR). He observed that the efficiency of treatment increased with increasing SSA of media. The best combination of specific surface area and organic loading rate for anaerobic filter type CAD reactor is 200 m2/m3 and 1.0 COD kg/m3/d respectively and the average COD removal achieved was about 89%. Operating under higher OLRs prevents clogging of reactor due to continuous removal of suspended solids from the reactors. Reactors with higher SSA of media were able to tolerate organic shock loads comparatively.

K V V S Kudaligama, (2007) et. al. in his paper, “Possibility of treating rubber factory wastewater in biological reactors using media with low specific surface area” had discussed the use of bio-brush in Covered Activated Ditch (CAD) system and found that this bio-brush media with low SSA may be effectively used to remove COD (about 60-75%) with a final aerobic treatment part for removing the remaining pollutants. He tested 25, 50, 75, 100 m2/m3 different specific surface area of Bio-brush media to treat the wastewater in CAD and found that100 m2/m3 SSA is economical to treat the wastewater in CAD.

According to, “Gopan Mukkulath et.al. 2012”, who had also discussed the application of coir as a media by naming it as woven and unwoven coir geotextile. He compared the use of sand and woven and unwoven coir as a media in a biofilter (fixed bed reactor) treating low volume organic rich industrial wastewater and found that un-woven coir geotextile media filter was

most efficient as far as Nitrate and Phosphate removal. This can be achieved by low packing density and better conditions (anoxic) for nitrification and de-nitrification in unwoven coir geotextiles. Unwoven coir geotextile provides a better attachment media than sand for the growth of microorganisms and filter clogging was also minimum in coir geotextile filters.

Mohamed Suhail et.al. also studied the same coir as a media in down flow mode packed bed reactor. He used non-woven needle punched coir geotextile and used the synthetic wastewater samples for the experiment. He concluded that with various density packings the percentage reduction in BOD increases as the HRT increase using non-woven geotextile filter beds. The test reveals that as the density packing increases the percentage reduction of BOD decreases. The maximum percentage reduction of BOD (78%) was obtained for 100 kg/m3 density packing.

Valsa Remony Manoj et.al. (2012) also studied the application of coconut coir fibre in a fixed film denitrification processes/bioreactors and made a comparative study of Coconut coir fibre and a commercially available synthetic reticulated plastic media (Fujino Spirals) as a packing medium in two independent upflow anaerobic packed bed column reactors using aquaculture wastewater. He studied removal of nitrate nitrogen in correlation with other nutrients (COD, TKN (Total Kajaldel Nitrogen), dissolved orthophosphate). He observed that COD removal of upto 81% was achieved at reactor where coconut coir was used as support medium compared to 72% of COD removal by Fujino Spirals.

He found that the performance of the column packed with coconut coir has been consistent and marginally better than Fujino spirals. He concluded that, this has been attributed to the organic nature of coconut coir, which could have added some COD; lowering the net carbon requirement. The presence of micronutrients such as Ca, K, Mg, Na, etc., in coconut coir fibre could also serve as an influencing factor for denitrification, which is independent of the nutrients obtained from the wastewater going into the reactor system. Such advantages cannot be observed in synthetic medium though they may offer non-degradability and increased surface area. Physical and biochemical changes to the support medium indicated that coconut coir fibre could withstand significant exposure to the experimental conditions. These observations indicate that coconut coir fibre could be utilized as effectively as commonly available synthetic bacterial support medium, for the removal of nutrients from aquaculture wastewater.

A. R. Vinod et.al. 2014 had also studied two different fibrous packing materials in a packed bed reactor for sewage treatment. He took coffee husk blended with wooden chips and coconut coir as a media for microbial growth. Fibrous reactor RC-1 packed with coffee husk blended

with wooden chips used in this study took shorter detention time of 24 h to achieve removal efficiency of COD, NH3-N, TSS and PO43- greater than 70%, while at the same contact time RC-2 and RC-3 reactor packed with coconut coir packing density 40kg/m3 in comparison to reactor of packing density 70kg/m3 exhibited more than 75% of all selected parameters. He observed that the best performance (highest percentage removal) was given by the reactor packed with coconut coir packing density 40 kg/m3 compared to other two reactors.

From these discussions, I have also decided to use the coconut coir in a bottle brush like configuration as a media for the growth of microbes to treat the dairy industry wastewater in a fixed film fixed bed reactor.

CONCLUSION

Fixed film processes in a fixed bed reactor using a naturally available low cost media proves essentially a best option to industrialist to prevent the environmental pollution. Coconut coir fibre 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. It can be used as effectively as commonly available synthetic bacterial support medium, for the removal of nutrients from wastewater. Coconut coir fiber filter beds can be used as an alternative option for any wastewater treatment instead of conventional beds. It is necessarily the cost effective technology of the wastewater treatment for better performance of the system.

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