IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

EXPERIMENTAL STUDIES ON FIBROUS MATERIALS AS AERATED BEDS FOR DOMESTIC WASTEWATER TREATMENT

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ABSTRACT: *The use of various fixed beds having higher surface area is effective in removing organic matters and nutrients from municipal wastewater. Due to the higher specific surface area, fibrous materials are often considered a better choice for increased microbial support and treatment efficiency. In the present study, efforts have been made to check the efficiency of two different fibrous materials, Agave sisalana fibres and Areca husk fibres having higher specific surface areas. They were used as packing media in two different bio-reactors for sewage treatment, under batch mode and similar experimental conditions. The reactors were continuously aerated for different contact times. The study reveals that these fibrous media could be acceptable for the efficient removal of organics and nutrients present in the sewage.*

1. INTRODUCTION

The production of organic waste is an integral part of a developed society. 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 the installation of these units [Praveen and Srilakshmy, 2008].
A biofiltration media consist of a reactor packed with solid material on which a biolayer is formed by proper microbial populations [Mohammed Suhail and Vijayan.]. Systems based on naturally occurring media include sand filters and peat-based biofilters. Artificial media include open-cell foam, textiles, plastics, and recycled, ground glass. All such filters operate as fixed-film systems [Kevin M. Sherman, 2006].
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 BOD5 (biochemical oxygen demand) levels and nutrients have also been observed in fibre-based reactors. Also, various studies have established the utility of polymer fibre geotextiles to support biofilm development and also augment the biodegradation rate. Besides a higher biodegradation rate, the ability of the treatment unit to withstand sudden shock is also a vital requirement for any wastewater treatment operations. Hence it is a reliable choice for a biofilter medium that could be based on any naturally available fibrous material containing rich organic matter [Praveen and Srilakshmy, 2008]. Numerable investigations were carried out using synthetic fibrous materials as a fixed media in the wastewater treatment, but only limited efforts have been made to use natural fibrous materials such as Sisal and oil palm fruit bunch as submerged aerated bed. Natural fibres have low density, low relative cost and good biodegradability while polymers have high resistance to moisture and impact. India has a vast resource for different natural fibres viz., jute, sisal, banana, coir etc., which are abundantly available in many parts. Presently, the production of natural fibres in India is more than 400 million tonnes. In the present study, emphasis has been given to viable and cost-effective technology by adopting naturally available fibrous materials such as sisal and oil palm empty fruit bunch (OPEFB) fibres as fixed beds for the sewage treatment.

OBJECTIVES

The main objective of the study aims at treating the domestic wastewater in a fixed film reactor filled with Agave sisalana fibres and Areca husk fibres.

The specific objectives are:

1. To study the performance of the Agave sisalana fibres and Areca husk fibres used as filter media at different contact periods.
2. To study the comparative removal efficiency of COD, BOD, sulphate, and nitrate using Agave sisalana and Areca husk fibres.

2. MATERIALS AND METHODOLOGY

MATERIALS:

Agava sisalana as a filter media

Agava sisalana

Agave sisalana is a species of Agave native to southern Mexico but widely cultivated and naturalized in many other countries. It yields a stiff fibre used in making various products.

Areca husk fibre as a filter media

Areca husk

Among all the natural fibre-reinforcing materials, areca appears to be a promising material because it is inexpensive, abundant and a very high potential perennial crop. It belongs to the species Areca catechu L., under the family palmecea and originated in the Malaya peninsular, East India.

SAMPLE COLLECTION (Chikkamagaluru)

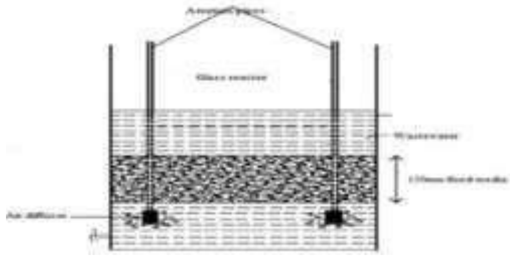
Chikkamagaluru is a district of Karnataka. According to the 2011 census, it has a population of about 1,20,496, and its population growth rate over the decade 2001- 2011 was -0.28%. The quantity of wastewater being generated is 13.01MLD. The sewage is discharged from individual residential colonies directly into the open drain since there is no under-drainage system for the collection and disposal of sewage.

SAMPLING

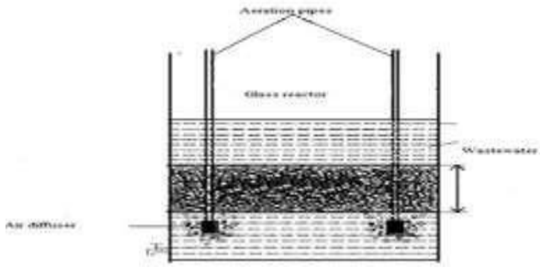
Sampling was conducted every 72 hours for 15 days between 5:30 pm to 6:30 pm. Grab samples were collected in plastic cans rinsed with distilled water. The sample was collected from the open drain channels and the treatment process was carried out.

Open drainage channel

METHODOLOGY



Cross-section of RC-1 Reactor (Agava sisalana)



Cross-section of RC-2 Reactor (Areca husk)

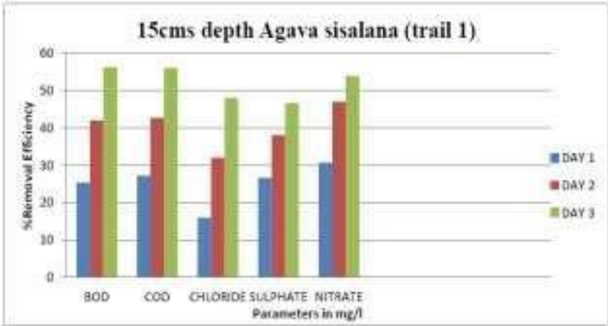
3. RESULTS AND DISCUSSIONS

Two different fibrous packing materials used for the present study, Agave sisalana and Areca husk fibre were analysed for the following parameters:

BOD, COD, Chloride, Sulphate, Nitrate, PH.

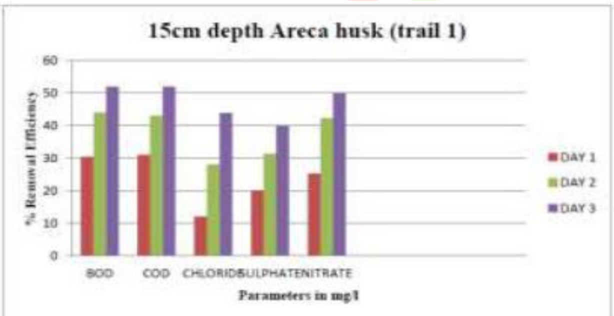
3.1 Removal efficiency using 15cm Agava sisalana filter bed

PARAMETERS	INITIAL	15 cm depth AGAVA SISALANA (trial 1)					
		1st Day	Removal Efficiency (%)	2nd Day	Removal Efficiency(%)	3rd Day	Removal Efficiency(%)
BOD(mg/L)	240	179	25.4	139	42	105	56.2
COD(mg/L)	305	222	27.2	175	42.6	133	56
Chloride(mg/L)	25	21	16	17	32	13	48
Sulphate(mg/L)	1.5	1.1	26.6	0.93	38	0.8	46.6
Nitrate(mg/L)	1.3	0.9	30.7	0.69	46.92	0.6	53.8
pH	7.5	7.6		7.5		7.5	



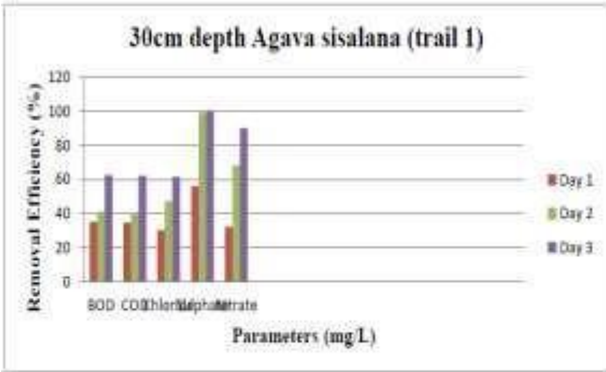
3.2 Removal efficiency using 15cm Areca Husk filter bed

PARAMETERS	INITIAL	15 cm depth ARECA HUSK (trial 1)					
		1st Day	Removal Efficiency(%)	2nd Day	Removal Efficiency(%)	3rd Day	Removal Efficiency(%)
BOD(mg/L)	240	167	30.4	134	44.1	115	52.08
COD(mg/L)	305	209	31	169	43	146	52
Chloride(mg/L)	25	22	12	18	28	14	44
Sulphate(mg/L)	1.5	1.2	20	1.03	31.3	0.9	40
Nitrate(mg/L)	1.3	0.97	25.3	0.75	42.3	0.65	50
pH	7.5	7.56		7.6		7.5	



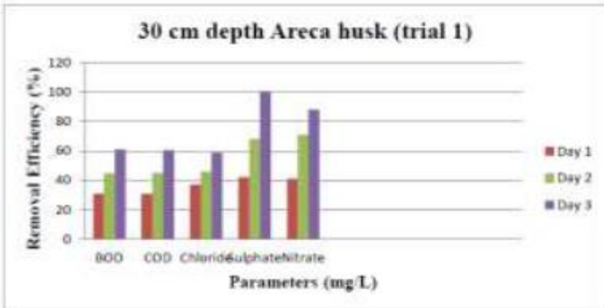
3.3 Removal efficiency using 30cm Agava sisalana filter bed

PARAMETERS	INITIAL	30 cm depth AGAVA SISAANA (trial 1)					
		1st Day	Removal Efficiency(%)	2nd Day	Removal Efficiency(%)	3rd Day	Removal Efficiency(%)
BOD(mg/L)	320	208	35	189	40.9	120	62.5
COD(mg/L)	398	260	34.6	237	40.4	151	62
Chloride(mg/L)	70	49	30	37	47.1	27	61.4
Sulphate(mg/L)	1	0.44	56	0.01	99	NIL	100
Nitrate(mg/L)	1	0.68	32	0.32	68	0.1	90
pH	7.7	7.6		7.7		7.5	



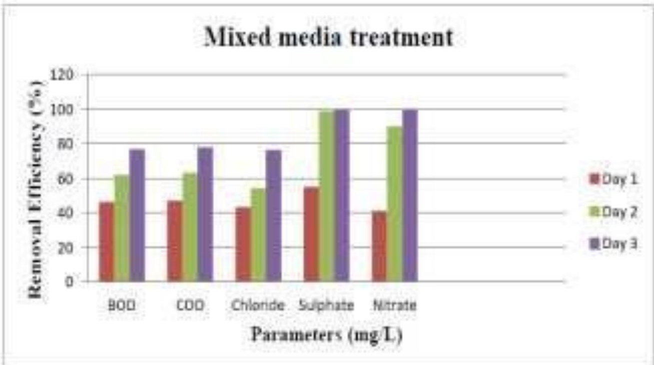
3.4 Removal efficiency using 30cm Areca Husk filter bed

PARAMETERS	INITIAL	30cm depth ARECA HUSK (trial 1)					
		1st Day	Removal Efficiency(%)	2nd Day	Removal Efficiency(%)	3rd Day	Removal Efficiency(%)
BOD(mg/L)	320	221	30.9	177	44.68	125	61
COD(mg/L)	398	276	30.6	220	4407	157	60.5
Chloride(mg/L)	70	44	37.1	38	45.7	29	58.5
Sulphate(mg/L)	1	0.58	42	0.02	98	NIL	100
Nitrate(mg/L)	1	0.59	41	0.29	71	0.12	88
Ph	7.7	7.7		7.6		7.6	



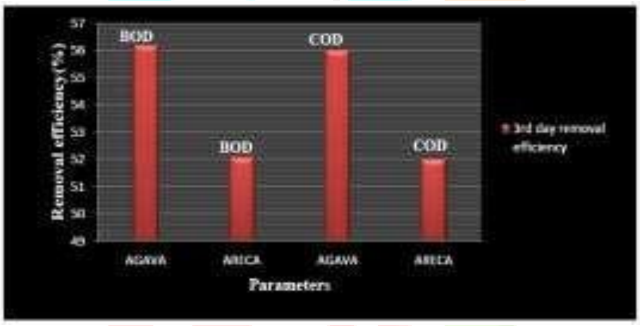
3.5 Removal efficiency using combined filter beds

PARAMETERS	INITIAL	COMBINED TREATMENT					
		1st Day	Removal Efficiency(%)	2nd Day	Removal Efficiency(%)	3rd Day	Removal Efficiency(%)
BOD(mg/L)	420	225	46.4	160	61.9	97	77
COD(mg/L)	529	280.2	47	195	63.1	120	78
Chloride(mg/L)	81	46	43.2	37	54.3	19	76.5
Sulphate(mg/L)	1	0.45	55	0.01	99	NIL	100
Nitrate(mg/L)	1.02	0.6	41.2	0.1	90.1	NIL	100
Ph	7.6	7.5		7.6		7.6	

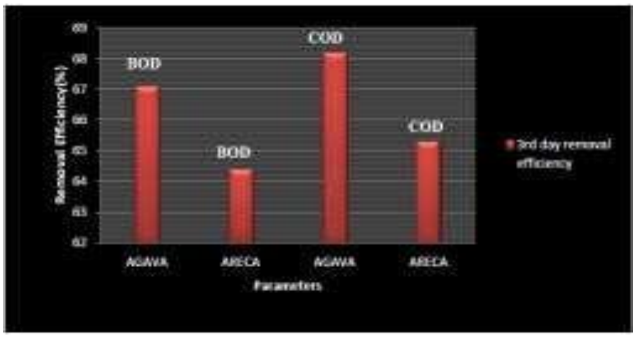


3.6 COMPARISON OF AGAVA SISALANA AND ARECA HUSK FIBRES

Comparison of BOD and COD Removal Efficiency (15cm depth)



Comparison of BOD and COD Removal Efficiency (30 cm depth)



3.7 COST ANALYSIS

Characteristics	processing fees	labour fees	transportation charges	total cost
Agava sisalana(4kg)	20/-	50/-	50/-	120/-
Areca husk(4kg)	-	20/-	50/-	70/-

4. CONCLUSIONS

From this study the following conclusions are drawn:

1. Considerable reduction in BOD, COD, and nutrients such as nitrates, sulphates, and chlorides was achieved.
2. The removal efficiency of BOD and COD by using Agava as filter media was found to be 56.2% and 56% respectively, for 15 cm depth which was higher than that of Areca which was found to be 52.08% and 52% respectively.
3. The removal efficiency of BOD and COD by using Agava as filter media was found to be 67.1% and 68.3% respectively, for 30 cm depth which was higher than that of Areca which was found to be 61% and 61.5% respectively.
4. The removal efficiency for BOD and COD were 77% and 78% respectively when both the filter media were combined.
5. The operation trouble faced during the study was foul odour emission due to the early decomposition of the fibres.
6. The cost of Areca fibres used for the treatment of 25 litres of wastewater was about Rs.70, which is more economical than compared to Agava fibres which cost about Rs.120. However, the treatment efficiency of Agava was found to be higher than that of Areca fibres.
7. The treated wastewater can be used for gardening and other domestic purposes like washing and cleaning purposes.
8. The spent fibres were rich in nutrient values and can be used as organic manure.

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