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Domestic wastewater treatment in reactors filled with areca husk fiber and pebble bed

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ABSTRACT

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 are available for use in attached growth system .one of these support materials are areca fibers. In this study the experiment was conducted for a batch mode of operation. The bio-reactors were continuously aerated and fed with residential wastewater having an initial average COD of 860 mg/L, BOD of 450 mg/L and NH_3-N of 70 mg/L. This present study reveals the study of COD, BOD and NH_3-N removal in two reactors, one filled with gravel bed and other areca fibers. Two sets of experiments were conducted to study the effects of detention time, elevated NH_3-N concentration. The reactors with gravel bed and areca fibers showed reasonable amount of COD removal (72-74%), BOD removal (92%-94%) and NH_3-N removal (58%-60%) within 4-16 hrs of detention period. In both the reactors denitrification was almost absent. Here comparative study of both reactors has been done and it is hypothecated that at fixed MLSS concentration of 2210 mg/L, efficiency of areca fibers bio-reactor seems to be satisfactory and effective for batch mode of operation.

Introduction

Biological wastewater treatment processes can be classified as either attached growth or suspended growth. In the attached-growth process, micro-organisms are immobilized on a support surface, forming biofilms. Substrates in the wastewater are adsorbed into the film and gradually degraded by the micro-organisms. In the suspended growth process, the micro-organisms in suspension have more intimate contact with the substrates. The attached growth process seems to be more stable than suspended growth process when the wastewater has considerable fluctuations in flow rate and concentrations (Toda and Ohtake ,1985). Limitation of mass transfer can effectively shield the micro-organisms from the shock loadings of substrates and toxins. Furthermore, even if the growth rate of biomass is reduced by adverse condition, the population of micro-organisms can still be maintained since they are physically retained in the system .

The utilization of fixed films for wastewater treatment process has been increasingly considered due to inherent advantages over suspended growth system (Jennifer B.Browar, 1996). One of the advantages is high biomass per reactor volume which permits higher organic loading rate, short liquid detention times and good performance stability (Khursheed Karim ,1999.).

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 bacteria growth and high porosity to prevent clogging by the increased biomass. Materials used in the past include stone, coke, honey comb, and corrugated sheets. Novel packing materials such as ring lace (Iwai et al.1990: Lessel 1991), net plates (Nambu et.al, 1991), and fibrous materials (Fang et.al 1991), have also been used in the past.

The present work is intended to study the application of areca fiber as a fixed bed for treating domestic wastewater and to know the comparative removal efficiency of COD, BOD and NH_3-N, with conventional gravel bed in a small volume reactor.

2. Materials and Methodology: In the present study two different bed materials were taken, one of which is Areca husk fiber. It is a versatile natural fiber extracted from mesocarp tissue, or husk of the areca fruit. It belongs to the species areca catechu L., under the family palmacea and originated in Malaya Peninsular, east India. The Physical and chemical properties of areca fibers are listed in Table2.1, and Plate1 shows the natural areca husk from which the fiber is extracted.

Another material used for the study is Gravel which is widely used as packing material in treating wastewater. Gravels of 25 kgs dry weight were used in the reactor wherein it was sieved for 10mm size. After sieving it was washed thoroughly with distilled water and dried .The physical properties of Gravel materials is depicted in Table2. 2.

Plate. 1 Areca husk fiber

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Table 2.1 Physical and Chemical properties of areca husk fibers:

Diameter in mm	0.3188 to 0.465
Ultimate Stress (Mpa)	85 to 101.85
Breaking elongation (%)	11 to 12.5
Lignin (%)	13 to 24.6
Hemi cellulose (%)	35 to 64.8
Ash content (%)	4.4
Water content (%)	8 to 25

Tabele2.2 .Phycial properties of the Gravel material

Crushing strength	Not less than 10N/mm^2
Hardness	Not less than 12
Percent wear	Not more than 4
Specific gravity	Not less than 2.6
Permeability	0.02169 cm/sec

2.3Experimental set up of Reactors:

Reactors filled with Gravel bed (R-1) and Areca fiber (R-2):

The reactors used in this study were made of acrylic fibre, which is rectangular in shape and fabricated for down flow mode and for batch operation process. The volume of R-1 is 0.1518 m^3. wherein the effective volume of gravel bed is 0.05365m^3, placed 0.12 m above the bottom of reactor. The volume of R-2 is 0.1215m^3 and the effective volume acquired by areca fiber bed is 0.03241 m^3 (900 gm).

Fine bubble diffused aerators were used to maintain the dissolved oxygen level of 3-3.5 mg/L inside both the reactors. Accessories such as mesh, Inlet and outlet pipes and taps were used.

Methodology: Mode of operation:

An aerobic sludge of 20 liters collected from a nearby diary was applied to both the reactors R-1 and R-2. Seeding was done with small quantity of wastewater. After the complete growth of biomass on the surface of fixed beds in both reactors, 20 liters of wastewater was fed through inlet pipe and MLSS is kept constant at an average of 2010 mg/L in R-1 and 2210 mg/L in R-2, neglecting F/M ratios since the process is performed for a batch reactor. The typical characteristics of the medium strength wastewater used for the study is shown in table 2.3.

The aeration should be provided continuously in each reactor, and observations were made in order to maintain aerobic conditions. The detention period of 16 hrs was fixed and sampling done was of grab type. After the steady state conditions were reached first set of sampling was done at an interval of 4 hours for a period of 16 hours. Second set of sampling was done after the seven days from the previous one nearing regime phase. The tests conducted were pH, COD, BOD, and NH_3-N as per Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, 20th Edition.

Table 2.3: Typical characteristics of the medium strength wastewater

Characteristics	Values
pH	7.8
Temperature	28^0 C
Alkalinity	290 mg/L
COD	860 mg/L
BOD	450 mg/L
NH_3-N	70 mg/L

3. Results and Discussions:

For the present study, experimental factors governing the process were flow, where it is same for both reactors, DO was maintained around 3-3.5 mg/L and detention time of 0-16 hrs, and MLSS concentration was almost between 2000-2210 mg/L. The Arithmetic mean values of COD, BOD and NH_3-N removal from both the reactors were presented in the tables 3.1 and 3.2.

From the Figs 3.1 and 3.2 it is observed that COD, BOD, and NH_3-N has been dropped quickly for the first 4 hrs in both reactors indicating that the system has attained steady state and the micro-organisms are adapted better to the environment at the end of the start-up period. But after 4 hrs, upto 16 hrs even though reduction was gradual, both the reactors show almost simultaneous decrease in organic matter and nutrient NH_3-N.

For the average initial COD of 860 mg/L, in R-1 after 16 hrs it has reduced to overall 229 mg/L, the net removal is 631 mg/L and efficiency ranges up to a 73.5% . In R-2, the COD reduced to overall 230.5 mg/L, the net removal is 629.5 mg/L and efficiency ranges up to 89%. For the average initial BOD of 450 mg/L, in R-1 it has reduced to overall 31.5 mg/L, the net removal is 418.5 mg/L and efficiency ranges up to 93%. In the R-2, the BOD reduced to overall 51.8 mg/L the net removal is 398.1 mg/L and efficiency ranges up to 89%.

There were slight decreases on removals of NH_3-N in R-1.For the average initial NH_3-N of 70 mg/L in the R-1, it has reduced to overall 27.89 mg/L, the net removal is 42.11 mg/L and efficiency ranges up to 60%. In the R-2, the NH_3-N reduced to overall 17.1 mg/L, the net removal is 52.9 mg/L and efficiency ranges up to 76%. Even though both reactors were maintained with equal concentration of dissolved oxygen, better performance was noticed in R-2, indicating that denitrification was very small comparatively, since anoxic zones in the biomass are low achieving towards higher nitrification leading to better removal of NH_3-N than R-1.

Table 3.1: Arithmetic mean values of Reactor No.1. (R-1)

Time (hrs)	COD (mg/L)	BOD (mg/L)	NH_3-N (mg/L)	Nitrate (mg/L)
0	513	287.5	46.4	1.36
4	393	82.8	39.5	1.805
8	338	49.5	33.7	2.65
12	267	67.5	29.45	5.4
16	229	31.5	27.89	9.45

Table 3.2: Arithmetic mean values of Reactor No.2.(R-2):

Time (hrs)	COD (mg/L)	BOD (mg/L)	NH_3-N (mg/L)	Nitrate (mg/L)
0	551	308.6	38.9	1.91
4	372.5	85	31.5	2.69
8	290	50.54	25.46	5.35
12	273.5	68.95	22.2	11.2
16	230.5	31.9	17.1	12.05

4. Conclusions:

The present study aimed at performing a biological oxidation analysis of domestic wastewater in a fixed film reactor filled with gravel bed (R-1) and fibrous areca husk (R-2). On the basis of the study following significant conclusions can be drawn.

- This study founded that Areca husk fiber could be applied as an alternative medium to gravel bed for packed bed filters for the treatment of domestic wastewater since areca fiber filter could achieve highly stable BOD_5, COD and NH_3-N removal.
- Good performance of the reactors was achieved, where the average COD, BOD and NH_3-N in the treated effluent of R-2 were 230.5, 31.9 and 17.1 mg/L at the end of the 16 hrs detention period, and in R-1 average removal were 229, 31.5 and 27.89 mg/L.
- Removal of COD, BOD_5 and NH_3-N were $\geq$ 73% , 85% and 60% respectively, in both the filters.

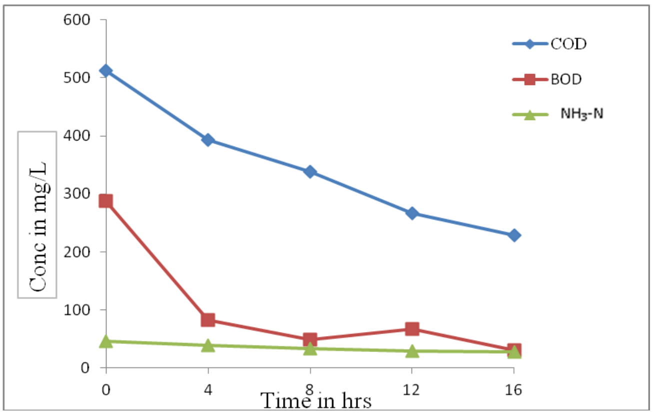

Fig 3.1: Arithmetic Mean Values of BOD, COD and NH_3-N in R-1

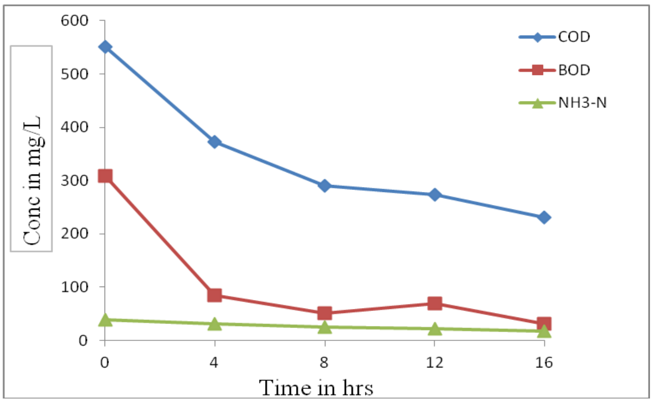

Fig 3.2. Arithmetic mean values of BOD, COD and NH_3-N in R-2

References

1. H.H.P. Fang and C.L.Y .Yeong. (1993). "Biological wastewater treatment in reactors with fibrous packing". Journal of Env. Engg. Vol.119., pp946-957.

2. Iwai., S., Oshino, Y., and Tsckada , T. (1990). "Design and operation of small wastewater treatment plants by the microbial film process". Water Sci. Tech. , Vol22, 139-144.

3. Jennifier B.Brower, Carol C. Barford, Oliver J.Hao. (1996)."Biological fixed film systems". Water Environment Research., Vol.68, No.4, pp.469-479.

4. Khursheed Karim and R.C.Vaishya (1999). "Biological wastewater treatmen in a reactor filled with coconut coir". Indian J. Environ Health. Vol41, No.4, pp 356-363.

5. Lessel T.H. (1991). "First practical experiences with submerged rope-type bio-film reactors for upgrading and nitrification". Water Sci. Tech. Vol.23, pp 825-834.

6. Nambu. T., Kawarura K., and M.Kaneko. (1991). "Wastewater treatment by a submerged contact media process using Net plates". Water science and Technology. Vol 23., pp1853-1862.

7. Standard Methods of practice for testing water and wastewater ., APHA, AWWA. HPCR, 20th Edition.

8. Toda , K. and Ohtake, H. (1985). "Comparative study on performance of biofilm reactors for waste treatment". J. Gen Appl. Microbiol. Vol. 31(2), pp 177-186.