Hybrid Down Flow Aerobic Trickling Filter Bed Reactor for Treatment of Dairy Industry Waste Water

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***Abstract*— in this study dairy waste water is collected from belagavi milk union limited (BMUL) located at belagavi district. The dairy waste water industry effluents have high pH, BOD, Total solids, organic and inorganic contents such wastewater, if discharged without proper treatment, severely pollutes receiving water bodies. To treat this dairy wastewater, the Hybrid Down flow Aerobic Trickling Filter Bed (DATFB) reactor is developed. In this study packing Medias are used such as recycle coarse aggregate, polypropylene pall rings, and steel scrubber. The pilot scale setup was operated for varying different HRT's of 72hours, 48hours, 24hours, 18hours, 12hours, 06hours with the different flow rate. The results obtained from this experimental study showed removal efficiency for BOD as 87.54%, alkalinity 47.11%, chlorides 49.68% , Total solids 78.64% , Total dissolved solids 79.08% , Total suspended solids 77.47%, for optimum HRT 24hours and the pH ranges from 7-10 in the final concentration. From the above results it is concluded that the Hybrid DATFB reactor gives more efficiency and good results. The filter media which is used in this reactor gives more than 80-90% efficiency in these results.**

***Keywords*— dairy industry wastes water, packing media, and trickling filter bed reactor.**

I. INTRODUCTION

Water is straightforward, vapid, unscented and bland. Water is clear colorless liquid, odorless and tasteless when pure, that occurs as rain, snow, and ice. Structures streams, lakes, and oceans, and is basic forever. The wastewater which is released from dairy industry is initially generated by cleaning and washing in effect of milk treatment plants. The portrayal of wastewaters are high Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) and contains more measure of fats, lactose, supplements , cleansers and sterilizing specialists. Normally happening water grabs shading and taste from substances in its condition. The earth surface is secured by water around 7%, among these 96.5% of the planet's outside layer water is found in the oceans and seas, and and 1.7% in groundwater, 1.7% in frosty masses and 0.001% is found in air as vapor, fogs and precipitation.

II. OBJECTIVES

- Initially to study the physical and chemical characteristics of dairy wastewater like pH, BOD, Alkalinity, Conductivity, Dissolved Solids, Suspended Solids, chlorides, total solids.
- Design the laboratory Pilot scale setup of Hybrid DATFB Reactor.
- To study the performance of multimedia filter with different packing media of varying sizes.
- To study the final characteristics of treated dairy wastewater.
- To study the optimum Hydraulic Retention Time (HRT) of Hybrid DATFB Reactor on the performance of filtration unit and the removal efficiency of parameters like pH, BOD, Alkalinity, Conductivity, Dissolved Solids, Suspended Solids, chlorides, total solids were studied.
- To study the overall efficiency of the reactor.

III.MATERIALS AND METHODOLOGY

a) **Materials:** Collecting materials such as:

1. *Sample Of Dairy Waste Water*
2. *Acrylic Tube*
3. *Acrylic Sheet*
4. *Argon Flow Regulator*
5. *Packing Materials Such As Concrete Stones, Polypropylene Pall Rings, and Steel Scrubber.*

1. Sample of Dairy Waste Water

The dairy wastewater sample collected from a Belgavi Milk Union Limited (BMUL) which is located in Belgavi , Karnataka. Dairy wastewater is generated in milk processing unit. A characteristic of Dairy wastewater sample was conducted immediately after the sample arrived to the laboratory. During dairy wastewater samples collected, observation are made that there will be minimize changes in the chemistry of the sample. As to maintain changes in the chemistry of the sample preservation methods such as refrigeration from light were performed.

Fig.1: dairy industry waste water collection

2. Acrylic Tube

An inalienably light weight yet inflexible material, ACRYLIC gives a financially savvy and flexible contrasting option to glass and other heavier plastics.

Description:

- Lightweight, rigid thermoplastic
- Wide variety of colours and textures available and Combustible.

Properties:

- Dimensionally stable
- Excellent flimsy transmission
- Virtually distortion-free
- Impact along with smash to smithereens challenging
- Weather unaffected by plus skilled UV stability
- Good severity also solidity
- Good insulation properties and Good thermal stability.

3. Acrylic Sheet

Poly methyl methacrylate (PMMA), also known as **acrylic** or **acrylic** glass as well as by the trade names Crylux, Plexiglas, Acrylite, Lucite, and Perspex among several others (see below), is a transparent thermoplastic often
Used in **sheet** form as a lightweight or shatter-resistant alternative to glass.

Properties:

- Acrylic is a prominent plastic accessible in misty and optically straightforward structures, utilized as a part of various applications.
- Acrylic shapes incorporate sheet, bar, 3D shapes, balls, tubes, and so on.
- Acrylic has numerous profitable properties.
- It is more adaptable and stun safe than glass.

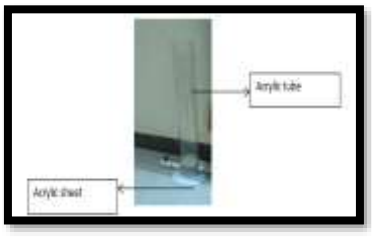


Fig.2: Acrylic tube & Acrylic sheet

4. Argon Flow Regulator

It is likewise known polypropylene (PP). It is made of thermoplastic polymer which is in assortment of utilizations including bundling and marking, materials, plastic parts and reusable compartments of different sorts, research center types of gear and polymer monetary orders. Its particulars are having low weight drop , high free volume , high flooding point , low mass exchange unit tallness, little particular gravity etc.

Fig.3: Argon flow regulator

5. Packing Materials Such As Recycle coarse aggregates, Polypropylene Pall Rings, Steel Scrubber.

- **Recycle coarse aggregate:** Concrete is a mixture of aggregates, cement and water. The purpose of the aggregates within this mixture is to provide a rigid skeletal structure and to reduce the space occupied by the cement paste. Concrete material used in construction including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. And widely used in also drainage applications & as base materials under foundations & roads.

- **Polypropylene pall rings:** It is also known polypropylene (PP). It is made of thermoplastic polymer which is in variety of applications including packaging and labeling, textiles, plastic parts and reusable containers of various types, laboratory equipment's and polymer bank notes. Polypropylene is used as packing material in many industries. Its specifications are having low pressure drop , high free volume , high flooding point , low mass transfer unit height, small specific gravity and so on. PP are used in scrubbing , stripping and absorption services and also able to adapt alternative to metal pall rings, constant decompress, all kind of separation, decarburization plant, separation of methylbenzene and separation of methylbenzene.
- **Steel scrubber:** Scrubbers are generally connected to homes, lodgings and eateries for cleaning the dishes, stoves and cooking utensils. They are likewise utilized as a part of businesses and developments for evacuating the grimy and slick parts of metal, porcelain, marble and glass things.

Fig.4 Packing Materials Such As Recycle coarse aggregates, Polypropylene Pall Rings, Steel Scrubber

b) Methodology

1. Design of reactor:

The details of Hybrid DATFBR:

Total height of the reactor	610mm
Effective height of the reactor	510mm
Inner diameter	84mm
Outer diameter	90mm
Effective volume	3.29L
No. of sampling used	3
Wall thickness of the reactor	3mm
Depth of the packing media used	150mm

Table.1: details of hybrid DATFBR

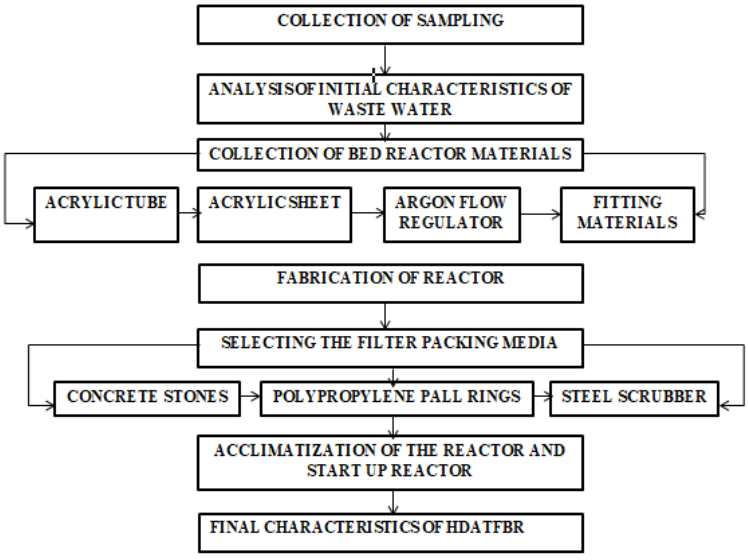


Fig.5: Trickling Filter Bed Reactor Flow Chart

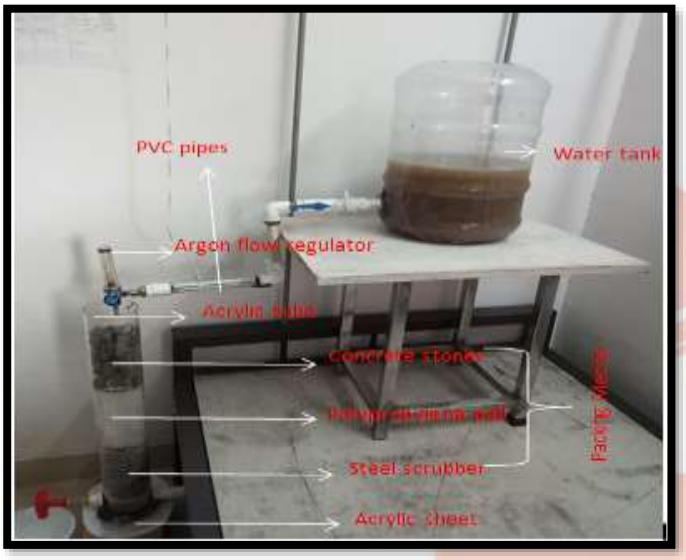


Fig.6: Down flow Aerobic Trickling Filter Bed Reactor With dairy waste water

Fig.7: Added cow dung slurry in the waste water

2. **Start-up of the reactor:**
   - The net volume of hybrid down-flow aerobic trickling filter bed reactor is 3.29litres.
   - Initially the leakage testing of reactor is done.
   - About 1litre of fresh cow dung slurry is added in to the reactor because it is necessary to introduce the bacteria and micro-organisms into the reactor.
   - Reactor is kept for acclimatization period under the aerobic condition for 20days.
   - Acclimatization is the process in which each individual organism gets adjusted to a change in its environment, which includes change in humidity, altitude, pH or temperature, which allowing it to maintain performance across a range of environmental conditions. It usually occurs in short period of time from days to week and where the bacteria's and organisms grown within lifetime.
   - For the acclimatization process, initially in the 20litres.tank fresh water was taken and added 1litre.of cow dung slurry in the reactor. Similarly, after it is continued with dairy waste water sample is added in to reactor.
   - For the present working reactor under aerobic condition, the acclimatization process was kept about 20days.
   - Hydraulic Detention Time is kept as up to 72hrs (3days).
3. **Treatment process after acclimatization**

After the acclimatization period, the observation was made that there was reduction in BOD. Then HRT was being reduced to 72, 48, 24, 18, 12, 6 hrs. and among them optimum HRT was to be found out. There is reduction in BOD during the some optimum HRT. The loading rate was being increased 6 to 72 hrs. And optimum loading rate was obtained after identifying optimum HRT. During this work process such parameters like pH, alkalinity, chloride, conductivity, TS, TDS and Suspended solids were the study.

IV. RESULTS AND DISCUSSION

Dairy industry waste water was collected from Belagavi milk union Limited (BMUL), and laboratory experiments done in Jain Engineering college of Technology. Dairy industry waste water treated using hybrid down flow aerobic trickling filter bed reactor. Three media of varying sizes used in it such as concrete stones, polypropylene pall rings, steel scrubber, The characteristics of dairy waste water used in this study. The initial characteristic of dairy waste water is given in below table.

CHARACTERISTICS	UNITS	AVERAGE VALUES
pH	----------	6
Electrical Conductivity	µS	369.8
BOD	Mg/L	1290
Chlorides	Mg/L	235.6
Total Alkalinity	Mg/L	262.6
Total Solids	Mg/L	5718
Total Dissolved Solids	Mg/L	4135
Total Suspended Solids	Mg/L	1583

Table.2: Initial characteristics of dairy waste water

Reactor Operation:
The reactor was filled with 1litr. Of cow dung slurry in the dairy waste water kept it for acclimatization for 20days. In the aerobic reactor concrete stones, polypropylene pall rings and steel scrubber are used as packing material. These packing materials are used in equal depth of the reactor i.e., 15cm of depth of the 80% of the reactor volume.

1. pH Removal

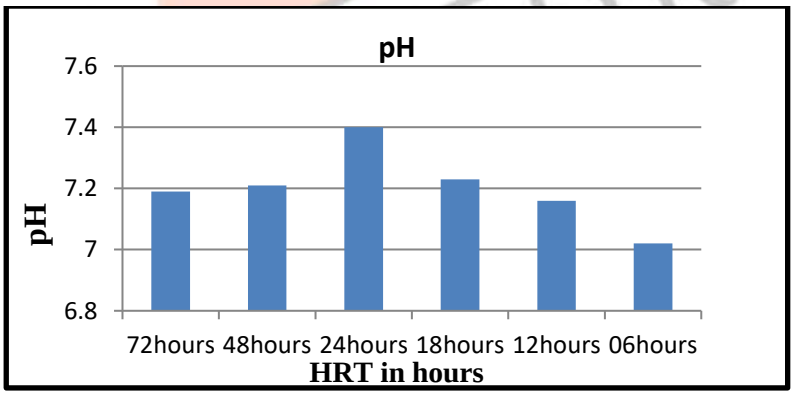
Reactor operation varying with HRT

Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.3: pH reduction in hybrid down flow aerobic trickling filter bed reactor

Initial Concentration	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR
10.23	72	7.19
10.28	48	7.21
10.54	**24**	**7.4**
10.37	18	7.23
10.09	12	7.16
10.36	06	7.02

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below



In this graph the result obtained the pH range before treatment was 7-11. After treatment the pH increases in the range of 7-8 in 24hours HRT.

2. Electrical Conductivity Removal

Reactor operation varying with HRT

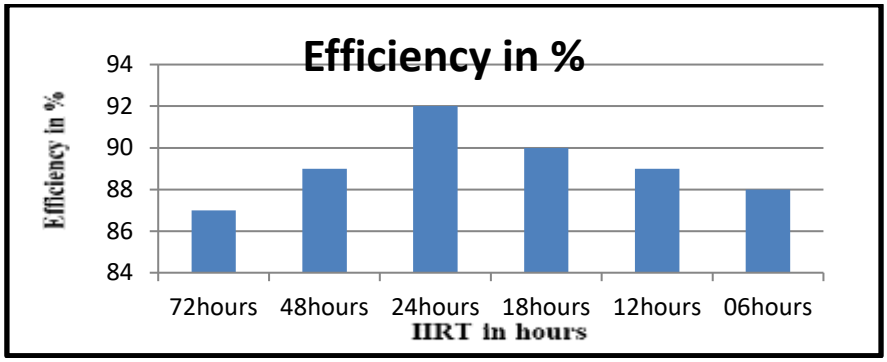
Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.4: Electrical Conductivity reduction in hybrid down flow aerobic trickling filter bed reactor

Initial Concentration (µS)	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR (µS)	Efficiency in %
367	72	47.71	87
366.4	48	40.30	89

369.1	**24**	**29.44**	**92**
368.2	18	36.82	90
367.8	12	40.458	89
367	06	44.04	88

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below



In this result, the optimum EC is found for different HRT period for 72hours, 48hours, 24hours, 18hours, 12hours, and 06hours. The optimum EC is 29.44µS for 24 hours with maximum EC removal efficiency is 92%. At 369.1 mg/L initial concentration.

3. BOD Removal

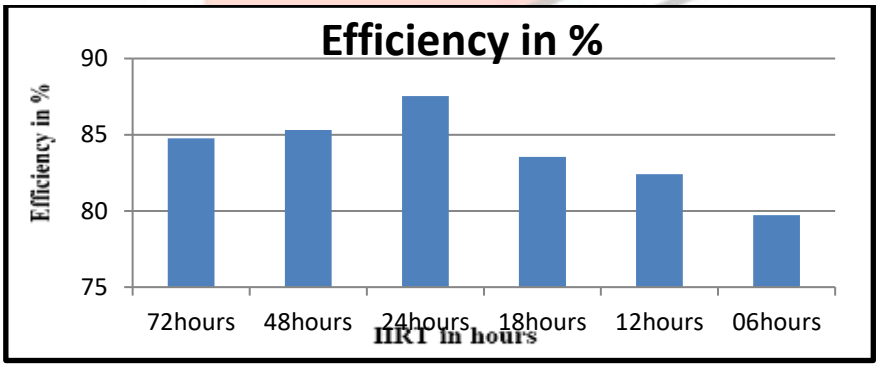
Reactor operation varying with HRT

Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.5: BOD reduction in hybrid down flow aerobic trickling filter bed reactor

Initial Concentration In mg/L	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR In mg/L	Efficiency in %
1254	72	191	84.77
1267	48	186	85.31
1260	**24**	**157**	**87.54**
1254	18	213	83.01
1262	12	222	82.41
1287	06	261	79.72

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below



In this result, the optimum BOD is found for different HRT period for 72hours, 48hours, 24hours, 18hours, 12hours, and 06hours. The optimum BOD is 157mg/L for 24 hours with maximum BOD removal efficiency is 87.54%. At 1260 mg/L initial concentration.

4. Chlorides Removal

Reactor operation varying with HRT

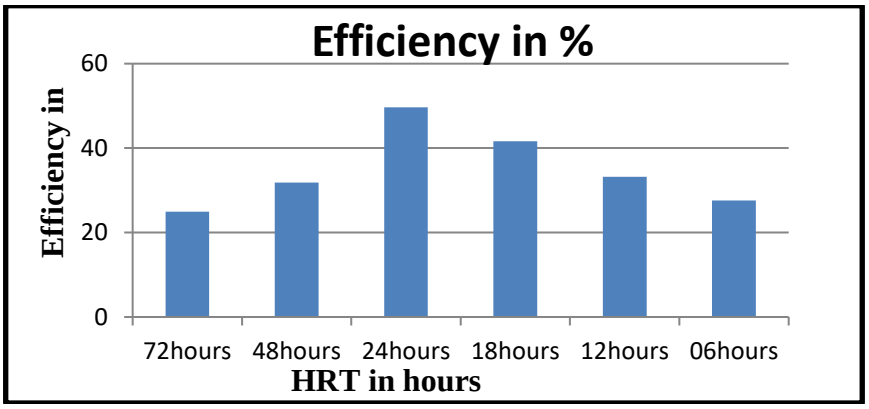
Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.6: Chloride reduction in hybrid down flow aerobic trickling filter bed reactor

Initial Concentration	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR	Efficiency in %
239.89	72	180	24.96
242	48	165	31.81
228.54	**24**	**115**	**49.68**
230.56	18	140	41.66
224	12	154	33.20

240	06	162	27.6

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below



In this result, the optimum Chloride content is found for different HRT period for 72hours, 48hours, 24hours, 18hours, 12hours, and 06hours. The optimum Chloride is 115mg/L for 24 hours with maximum Chloride removal efficiency is 49.68%. At 228.54mg/L initial concentration.

5. Total alkalinity Removal

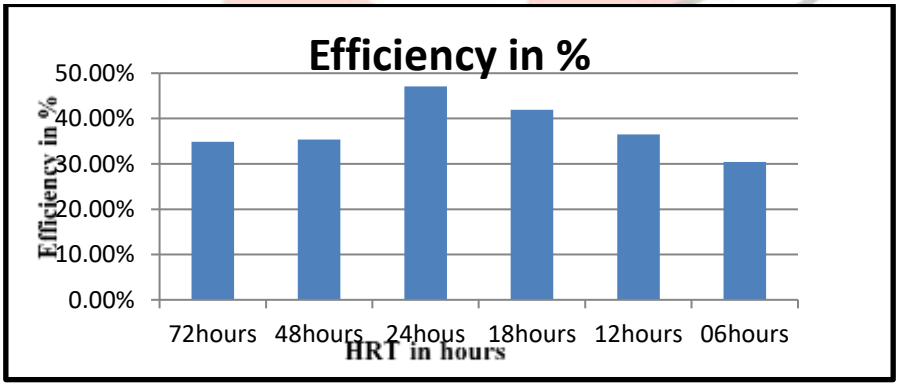
Reactor operation varying with HRT

Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.7: Alkalinity reduction in hybrid down flow aerobic trickling filter bed reactor

Initial Concentration	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR	Efficiency in %
252	72	164.18	34.84
250	48	161.54	35.384
262	**24**	**138.56**	**47.114**
275	18	159.67	41.944
280	12	177.77	36.514
265	06	184.4	30.4

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below



In this result, the optimum Alkalinity is found for different HRT period for 72hours, 48hours, 24hours, 18hours, 12hours, and 06hours. The optimum alkalinity is 138.56mg/L for 24 hours with maximum Chloride removal efficiency is 47.11%. At 262mg/L initial concentration.

6. Total solids Removal

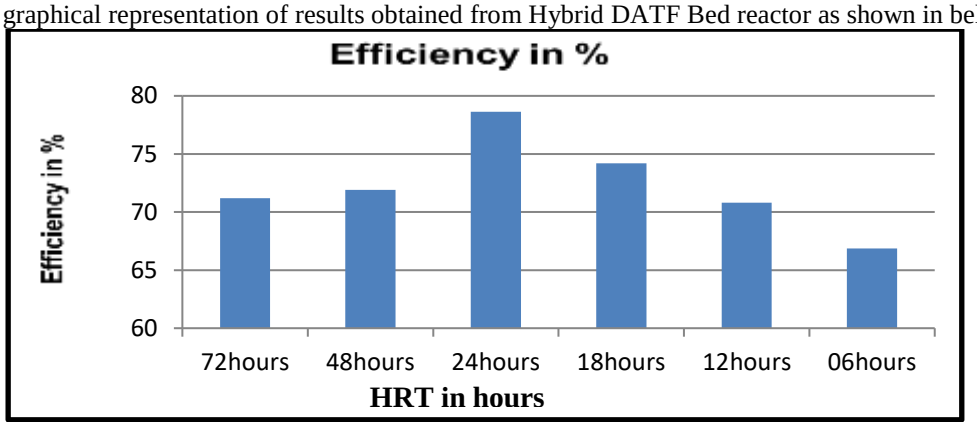
Reactor operation varying with HRT

Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.8: Total solids reduction in hybrid down flow aerobic trickling filter bed reactor

Initial Concentration	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR	Efficiency in %
5554	72	1600	71.19
5628	48	1580	71.92
5702	**24**	**1218**	**78.64**
5496	18	1418	74.19
5570	12	1625	70.8
5644	06	1870	66.86

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below



In this result, the optimum Total solids are found for different HRT period for 72hours, 48hours, 24hours, 18hours, 12hours, and 06hours. The optimum total solids are 1218 mg/L for 24 hours with maximum Total solids removal efficiency is 78.64%. At 5702mg/L initial concentration.

7. Total Dissolved Solids Removal

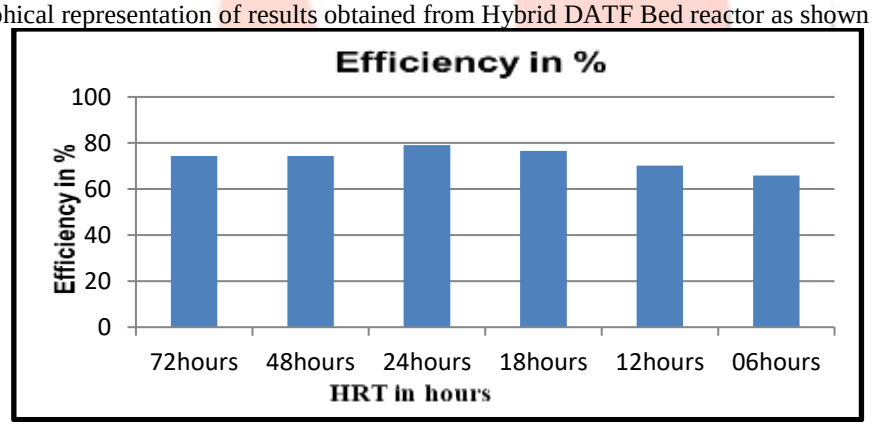
Reactor operation varying with HRT

Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.9: Total dissolved solids reduction in hybrid down flow aerobic trickling filter bed reactor

Initial Concentration	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR	Efficiency in %
4123	72	1060	74.29
4116	48	1055	74.36
4135	**24**	**865**	**79.08**
4128	18	968	76.55
4134	12	1234	70.14
4100	06	1400	65.85

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below



In this result, the optimum total dissolved solids are found for different HRT period for 72hours, 48hours, 24hours, 18hours, 12hours, and 06hours. The optimum total dissolved solids are 865mg/L for 24 hours with maximum total dissolved solids removal efficiency is 79.08%. At 4135mg/L initial concentration.

8. Total Suspended Solids Removal

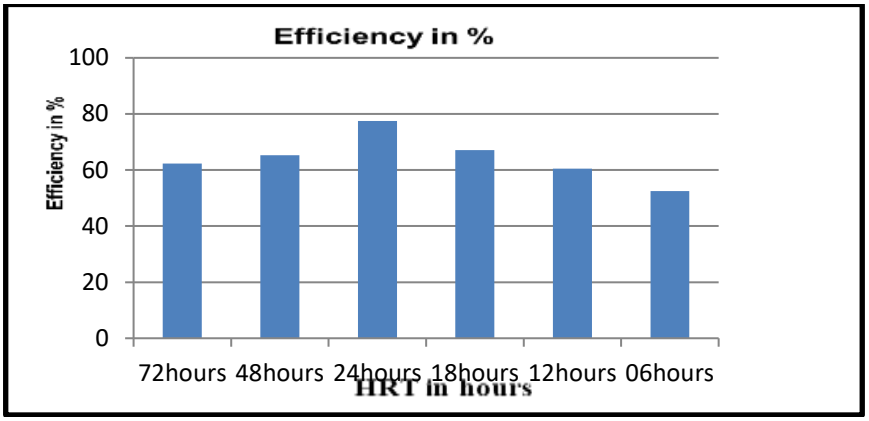
Reactor operation varying with HRT

Initially the reactor was filled with dairy waste water. The HRT for the reactor was set for 72hrs, 48hrs, 24hrs, 18hrs, 12hrs, 6hrs, with different flow rate. The results are given in a table as shown in below.

Table.10: Total dissolved solids reduction in hybrid down flow aerobic trickling filter bed reactor.

Initial Concentration	Hydraulic Retention Time In hrs.	Final concentration using HDATFBR	Efficiency in %
1413	72	540	62.26
1512	48	525	65.27
1567	**24**	**353**	**77.47**
1368	18	450	67.10
1436	12	391	60.47
1544	06	470	52.5

The graphical representation of results obtained from Hybrid DATF Bed reactor as shown in below.

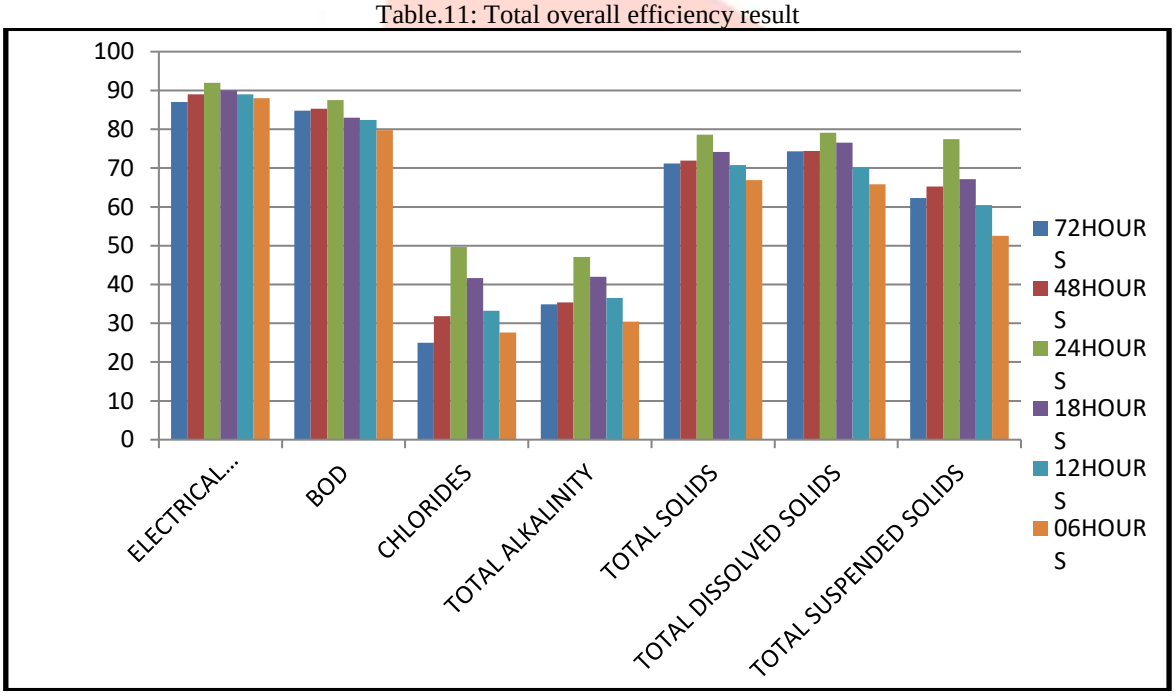


In this result, the optimum suspended solids are found for different HRT period for 72hours, 48hours, 24hours, 18hours, 12hours, and 06hours. The optimum suspended solids are 353mg/L for 24 hours with maximum suspended solids removal efficiency is 77.47%. At 1567mg/L initial concentration.

DISCUSSION:

Parameters	72hrs.	48hrs.	24hrs.	18hrs.	12hrs	6hrs
Electrical Conductivity	87	89	**92**	90	89	88
BOD	84.77	85.31	**87.54**	83.01	82.41	79.72
Chlorides	24.96	31.81	**49.68**	41.66	33.20	27.60
Total Alkalinity	34.84	35.384	**47.114**	41.944	36.514	30.40
Total solids	71.19	71.92	**78.64**	74.19	70.80	66.86
Total dissolved solids	74.29	74.36	**79.08**	76.55	70.14	65.85
Total suspended solids	62.26	65.27	**77.47**	67.10	60.47	52.5

Table.11: Total overall efficiency result



V. CONCLUSION

1) The following initial characteristics: pH- 7-12, colour-white, conductivity-369.8µS, BOD-1290 mg/L, Alkalinity-262.6 mg/L, Chloride-235.6 mg/L, Total solids-5718 mg/L, Total dissolved solids-4135 mg/L, Total suspended solids-1583 mg/L.

2) The laboratory pilot scale setup for hybrid down flow aerobic tricking filter bed reactor .with the experimental volume of 3.29L reactor was fabricated by using acrylic tube, acrylic sheet, PVC pipes and fitting other materials.

3) In the present designation work, hybrid down flow aerobic tricking filter bed reactor is having 80% of the reactor volume is filled by 15cm depth of each packing media such as Recycle coarse aggregate, polypropylene pall rings, and steel scrubber.

4) The hybrid down flow aerobic tricking filter bed reactor is added some amount of cow dung slurry in the volume of reactor for introducing the bacterial content and microorganisms.

5) The pH range before the treatment was 7-11and after the treatment increases in the range of 7-8 pH in 24hoursHRT.

6) Initially the BOD concentration was 1260mg/L and after treatment the BOD was reduced to 157mg/L. The efficiency of the reactor was found to be 87.54% at HRT of 24hours.

7) According to test of Chloride, the removal efficiency was 49.68% in dairy wastewater at HRT of 24hours.

8) The optimum alkalinity is 138.56mg/L for 24 hours with maximum Chloride removal efficiency is 47.11%. At 262mg/L initial concentration.

9) At optimum HRT of 24 hours, overall there was 78.64% reduction in total solids, 79.08% reduction in total dissolved solids, and 77.47% reduction in total suspended solids.

10) Conducting an after analysis of the entire test it can conclude that the hybrid down flow aerobic trickling filter bed reactor gives more efficiency and good result at HRT of 24hours.

VI.ACKNOWLEDGEMENT

It is a genuine pleasure to express my deep sense of thanks and gratitude to my guru, philosopher and guide **Mr. Rohan S. Gurav,** Assistant Professor, Dept. of Water and Land Management, Center for PG Studies, Visvesvaraya Technological University, Belagavi. His dedication and keen interest above all his overwhelming attitude to help his students had been solely and mainly responsible for completing my work.

I express my gratitude **to Dr. Anand V. Shivapur**, HOD & PG Coordinator, Dept. of Water and Land Management, Center for PG Studies, Visvesvaraya Technological University, and Belagavi for providing us with excellent infrastructure to complete my project work.

I thank my Parents and all my friends for their support, without them this project would not have been completed.

It's my pleasure to thank all those who have rendered their help during the period of my project work directly or indirectly.

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