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Application of MBBR & IFAS for the Treatment of Dairy Wastewater

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Abstract: ***Moving Bed Biofilm Reactor (MBBR) is a leading technology of biological solution for wastewater treatment based on the aerobic principle. In this study, lab scale experiments were done by using MBBR with Integrated Fixed-film Sludge(IFAS) process and polypropylene media to analyze BOD and COD removal from wastewater of dairy industries. The system efficiency in removal of BOD and COD was examined at a different rate of Hydraulic Retention Time (HRT) of 1, 1.5, 2, 2.5 and 3 hours. Similarly BOD and COD removal efficiency of 60% and 88% respectively was achieved with 3hrs HRT and also settling time was observed as 4 hours. Finally this study indicates that MBBR with IFAS process and polypropylene media as biofilm carrier posses very good removal of BOD and COD from Dairy Wastewater.***

Keywords: Dairy wastewater, MBBR, IFAS, Biofilm, COD, BOD and Hydraulic Retention Time (HRT).

I. INTRODUCTION

The dairy industry is generally considered to be the largest source of food processing wastewater in many countries. With increase in demand for milk and milk products, many dairies of different sizes have come up in different places. These dairies collect the milk from the producers, and then either simply bottle it for marketing, or produce different milk foods according to their capacities. Large quantity of wastewater originates due to their different operations. The organic substances in the wastes comes either in the form in which they were present in milk, or in degraded form due to their processing. As such, the dairy wastes though biodegradable, are very strong in nature. Several methods are available to reduce the high load content of pollutants in Dairy waste water. Among them Moving Bed Biofilm Reactor (MBBR) is considered as one of the promising process for treatment of wastewater. The basic principle of moving bed process is the growth of biomass on plastic supports that move in the biological reactor via agitation generated by aeration systems (aerobic reactors) or by mechanical systems or by anaerobic reactors.

Integrated Fixed Film Activated Sludge (IFAS) is emerging technology that is highly efficient low footprint activated sludge solution. IFAS consists of submerged fixed bed polypropylene, textile media which promotes attached growth biomass in Integrated Fixed Film Activated Sludge.

II. MOVING BED BIOFILM REACTOR (MBBR)

Two technologies are commonly used for biological treatment of sewage which is activated sludge and trickling filters, a MBBR is a compilation of these two technologies. The biomass in the MBBR exists in two forms suspended flocs and a biofilm attached to media. MBBR has become popular in the field of wastewater treatment because it maximizes the capacity and efficiency of the treatment plant by minimizing the footprints. It has the capacity to retrofit the old treatment plants, higher nutrient removal ability, produce less sludge as a result of high biomass, retention time, and easy maintenance, economical and so on. The key element of the MBBR is the use of small plastic biofilm support media to allow a high concentration of protected biofilm growth in a well-mixed reactor. The reactors can be operated under aerobic conditions for carbonaceous and nitrogenous organic matter removal and under anoxic conditions for denitrification. In an aerobic reactor, circulation of media is facilitated through the action of air bubbles injected into the tank by a diffused aeration system. In an anoxic reactor, a submerged mechanical mixer is typically supplied.

Before treating wastewater in MBBR (FIG 1), it passes through grit chamber where the grit (dense material such as sand, dirt) is removed. After preliminary treatment this water is fed to aerobic reactor for removing organic matter for the designed retention time.

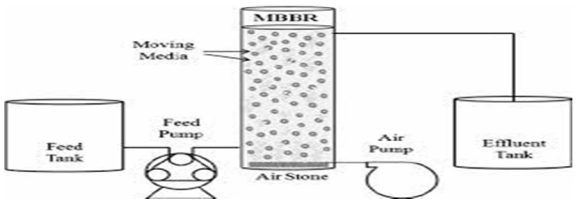

Fig 1: Treatment By MBBR Proess

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III. INTEGRATED FIXED FILM ACTIVATED SLUDGE (IFAS)

After biological treatment, effluent passes through the secondary clarifier where biomass is separated as sludge from the treated wastewater. The sludge is removed from the bottom of the clarifier and supernatant is separated from the upper side of clarifier. The sludge is reintroduced into the reactor tank for further treatment of dairy wastewater to increase the efficiency of treatment process (FIG 2).

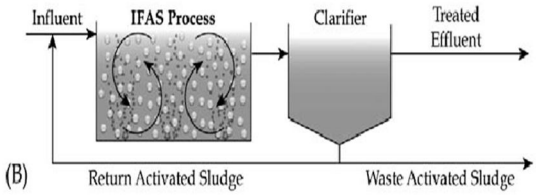

Fig 2: Treatment By Ifas Proess

IV. NEED FOR THESTUDY

A. Dairy wastewater is characterized by high BOD and COD concentration.
B. It generally contains fats, nutrients, lactose as well as detergents and sanitizing agents.
C. Hence without pre-treatment when discharged into the land surrounding area gets polluted.
D. The industries wastewater is characterized by high COD, BOD, turbidity etc. Such wastewater main reason for this study is to reduce the pollution of dairy wastewater and to make the water for usability.

V. OBJECTIVE OF THESTUDY

A. Implement the MBBR and IFAS technology as an alternative successful method in treating dairy wastewater.
B. To evaluate the removal efficiency of BOD and COD at varying HRT.
C. The project is to carry out a laboratory and pilot scale.

VI. SCOPE OF THESTUDY

A. Scale up the reactor for effective use in the industry.
B. It is also suitable for nitrification, dentrification and removal of phosphorous in industrial wastewater.

VII. MATERIALS

A. Media

Media is the important parameter of MBBR system. Media provides surface area to the microorganisms for growth as biofilm. These media move freely into the wastewater and increase contact between substrate available in wastewater and microorganisms present on the media. Generally this media is made by polypropylene.

B. Polypropylene Media

1) Material Used: K1 BIOFILTER MEDIA(Polypropylene) (FIG 3)
2) Key Features
a) Increase the efficiency of filter system.
b) Self cleaning media.
c) Provide large surface area for bacteria to colonize.
d) Provide mechanical and biological filtration.
e) Can be used in static and moving bed filtration system.

Fig 3: Polypropylene Biofilter Media

Table 1: Properties of K1 Bio Filter Media

Material	Polypropylene
Density of Media (g/m^3)	0.19
Length (mm)	8
Diameter (mm)	22
Specific surface area (m^2/m^3)	900

C. Working Principle

As a static media, K1 media does work biologically, but its primary use in this respect is to trap solids. The media's structure collects suspended particles, and it can then be backwashed (most effectively with air) to clean this away. This is the basis of the nexus k1 filter's mechanical filtration.

D. Collection And Analysis Of Wastewater

The waste water is collected from the Amman dairy products pvt. Ltd, Piththalapatti in Dindigul. Fresh waste water from the industry is collected. It consists of many large particles they are removed by screening the water at initially. After screening process the basic initial characteristics of water sample is taken such as pH, Biological Oxygen Demand, Chemical Oxygen Demand, Total Dissolved solids and Turbidity.

Table 2: Apparatus Used In Characterization Of Wastewater

PARAMETERS	METHODS
pH	pH meter
TURBIDITY	Nephelometric Turbidity Meter
BOD	BOD Incubator
COD	COD Digester
TOTAL SOLIDS	Muffle Furnace

VIII. REACTOR SETUP

A. Prefabrication Of Reactor

MBBR Reactor was fabricated. Laboratory scale setup was used having volumetric capacity 10 L (FIG 4). Reactor is made by glass. Two Diffused aerators were kept at the bottom of the reactor for providing required aeration. Partition is provided in the reactor for allowing flow of water form one compartment which is a MBBR reactor to the other compartment which is a sedimentation tank for IFAS process.

Table 3: Size Of The Reactor

MATERIAL	GLASS
TOTAL DEPTH(cm)	23.3
WIDTH(cm)	22.3
LENGTH(cm)	46

Fig 4: Reactor

B. Diffused Aeration

Aeration is important parameter of MBBR for providing oxygen to microorganisms and keeping media in suspension by distributing it homogeneously. So, two submerged motor is used at the bottom of the reactor. Air moves upwards.

IX. EXPERIMENTAL METHODOLOGY

A. Acclimatization

Biofilm development is first step in the MBBR. At the time of bio-film development sludge gets penetrate into the media. This accumulated sludge adheres to the surface of media. The adhered biomass starts to grow on the media. It is called as bio film. The duration of this process is 10 days (FIG 5).

Fig 5: Acclimatization

B. Development Of Biofilm

Initially, 25% volume of reactor was filled by the wastewater.5% of reactor was filled with cow dung slurry. 2% jaggery slurry was added in the reactor. Sufficient aeration was provided. Phosphate buffer, Magnesium sulphate, Calcium chloride and Ferric chloride were added as nutrients.

Fig 6: Biofilm Development

C. Quantifying The Adhered Biomass

Quantifying the adhered biomass is very essential. To quantify the adhered biomass around 4-5 media were collected from reactor and immersed in 100ml of distilled water in a beaker which was shaken vigorously till the biomass get detached from media. Media were removed and suspended solids remaining in the beaker were measured. Then adhered biomass was expressed in the form of mg biomass/media.

Table 4: Characteristics Of Wastewater After Treatment With Varying HRT

VARYING HRT(hours)	pH	TURBIDITY (NTU)	BOD (mg/l)	COD (mg/l)	TOTAL SOLIDS (mg/l)
Initial	9.17	94.1	285	700	4000
1.5	8.87	29	110	500	3500
2	7.96	25.6	64	300	3000
2.5	7.94	24	45	360	2500
3	6.92	23	35	280	2500

X. RESULT AND DISCUSSIONS

A. pH

After the treatment of wastewater, the pH obtained with varying HRT,

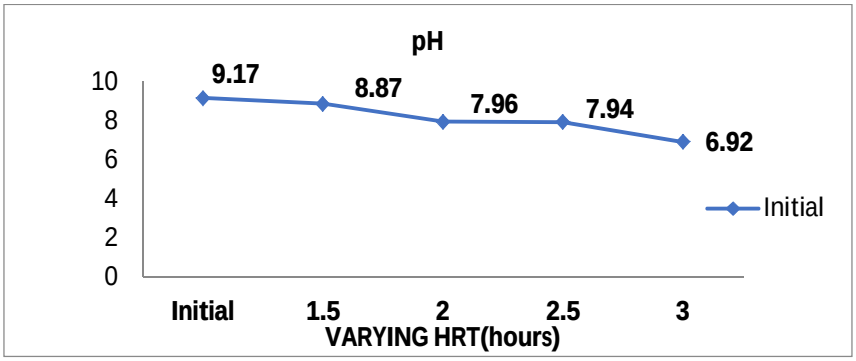

Fig 7: pH Obtained by Varying HRT

In the FIG 7, it is found that the pH value changes 8.87 at 1.5 hrs HRT and decreases upto 6.92 at 3hrs HRT. Then the optimum pH obtained at the HRT of 3hrs.

B. Turbidity

After the treatment of wastewater, the turbidity obtained with varying HRT,

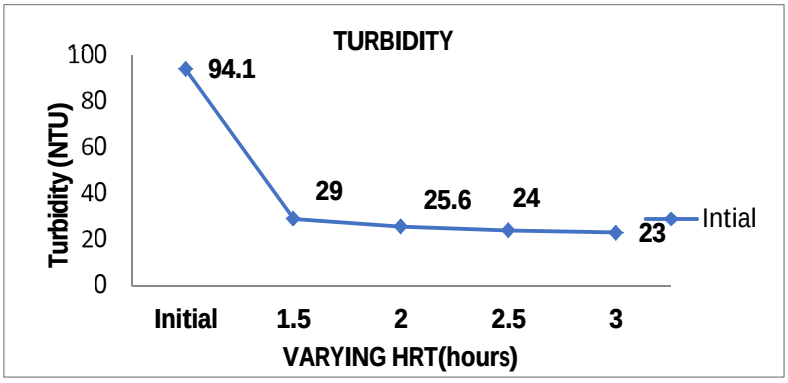

Fig 8: Turbidity Obtained By Varying Hrt

In the FIG 8, it is found that the turbidity changes 29NTU at 1.5hrs HRT and decreases up to 23NTU at 3hrs HRT. The desirable limit of turbidity is found to be 30NTU. Then the Maximum reduction of turbidity obtained at the varying HRT of 3hrs, which is the optimum turbidity.

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C. BOD

After the treatment of wastewater, the BOD obtained with varying HRT,

In the FIG 9, it is found that the BOD changes 110 mg/l at 1.5hrs HRT and decreases upto 35 mg/l at 3hrs HRT. The desirable BOD value is 40 mg/l and hence optimum BOD obtained at 3hrs HRT.

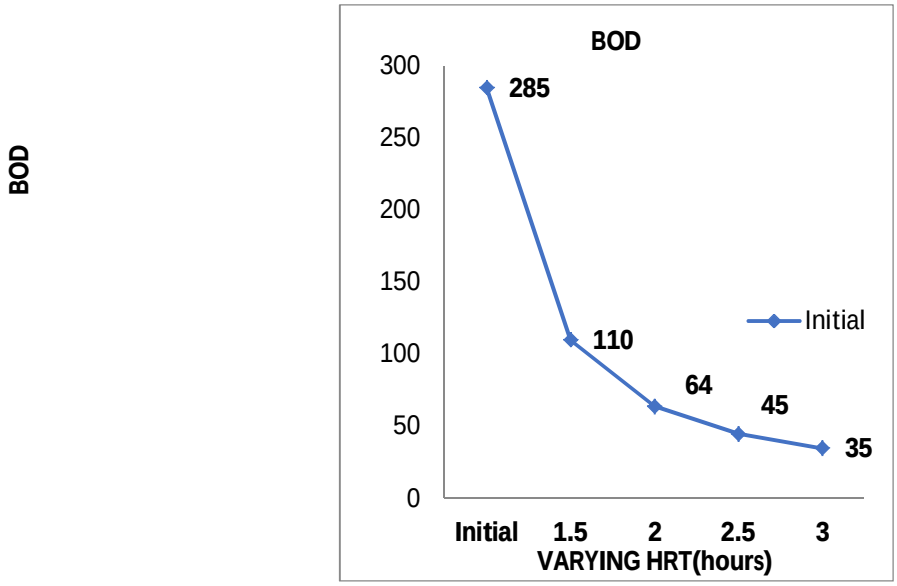

Fig 9: BOD Obtained By Hrt

D. COD

After the treatment of wastewater, the COD obtained various with varying HRT,

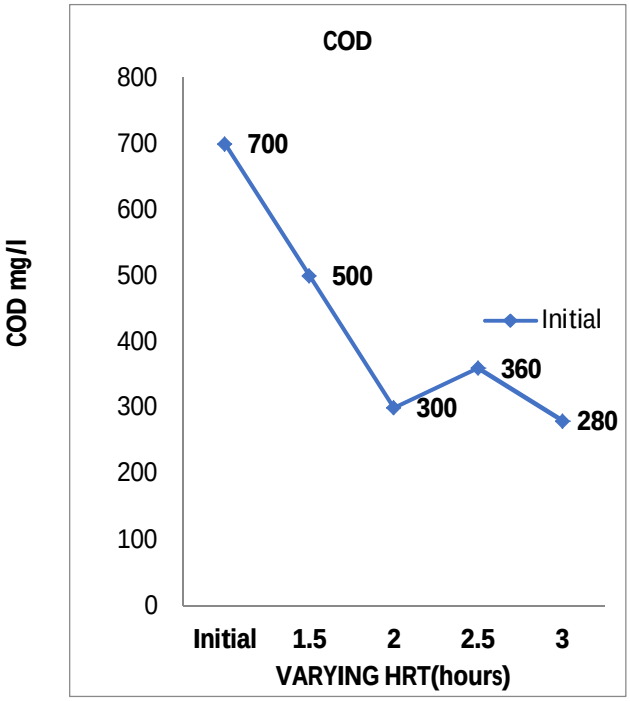

Fig 10: COD Obtained by Varying HRT

In the FIG 10, it is found that the COD changes 500mg/l at 1.5hrs HRT and decreases upto280 mg/l at 3hrs HRT. Then the Maximum reduction of COD occurs at 3hrs HRT, which is the optimum COD since desirable limit of COD is 120 mg/l.

E. Total Solids

After the treatment of wastewater, the total solids obtained various with varying HRT,

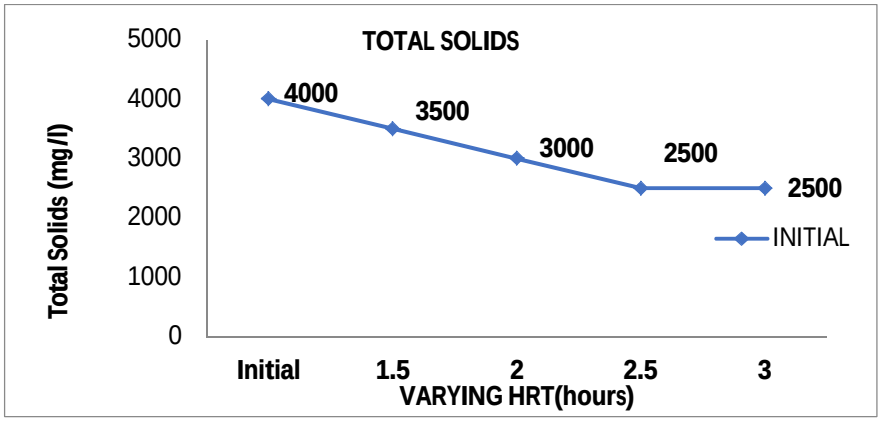

Fig 11: Total Solids Obtained By Varying Hrt

In the FIG 11, it is found that the Total Solids changes 3500 mg/l at 1.5hrs HRT and decreases upto 2500mg/l at both 2.5hrs and 3 hrs HRT. The desirable value of TDS ranges between 2000-2200mg/l and hence the optimum TDS obtained at both 2 and 2.5 hours HRT.

F. 1.5 Hours HRT

The characteristics of water after treatment of Dairy wastewater at 1.5 hours,

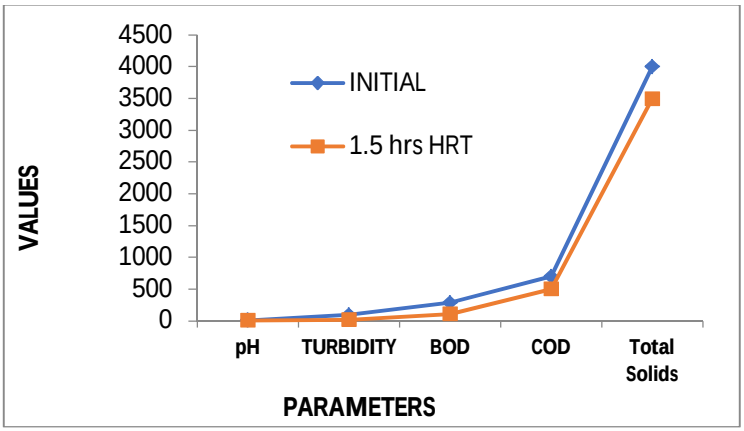

Fig 12: Comparison of Initial And 1.5 Hours HRT Values

G. 2 Hours HRT

The characteristics of water after treatment of Dairy wastewater at 2 hours HRT,

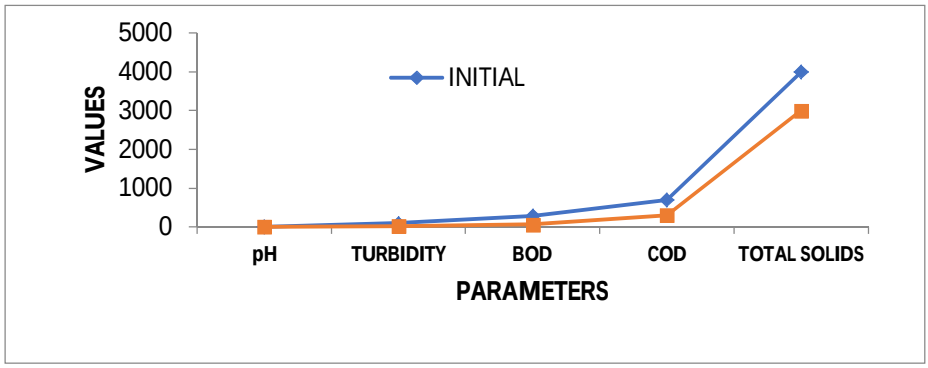

Fig 13: Comparison Of Initial And 2 Hours Hrt Values

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H. 2.5 Hours HRT

The characteristics of water after treatment of Dairy wastewater at 2.5 hours HRT,

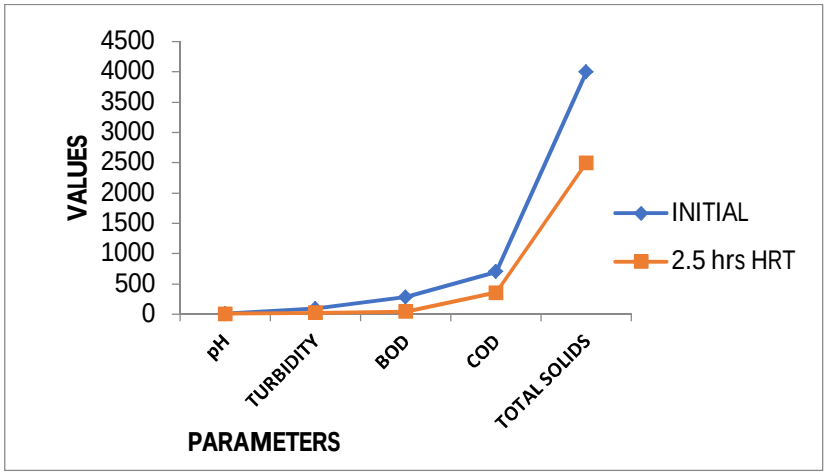

Fig 14: Comparison Of Initial And 2.5 Hours Hrt Values

I. 3 Hours HRT

The characteristics of water after treatment of Dairy wastewater at 3 hours HRT,

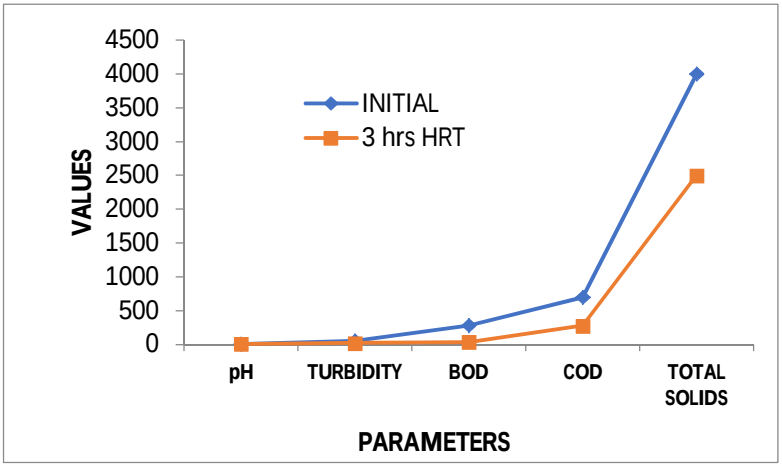

Fig 15: Comparison Of Initial And 3 Hours Hrt Values

J. Comparison between 2.5 hours HRT and 3 hours HRT

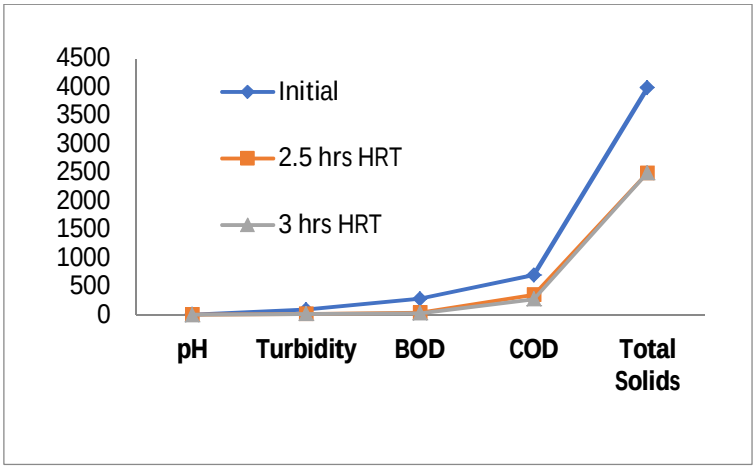

Fig 16: Comparison of Initial, 2.5 and 3 hours HRT values

In the FIG 16, the pH value reaches 7.94 at 2.5 hours HRT and 6.92 at 3 hours HRT from 9.17 initial pH values. The maximum reduction of pH value is at 3 hours HRT. The turbidity changes 24 NTU and 23 NTU at 2.5 hours and 3 hours respectively from initial turbidity as 94.1 NTU. The lowest turbidity value obtained is at 3 hours HRT. The BOD value falls to 45mg/l at 2.5 hours HRT and 35 mg/l at 3 hours HRT from 285mg/l which is the initial BOD value. The ultimate reduction of BOD is at 3 hours HRT. The COD value decreases as 360 mg/l and 280 mg/l at 2.5 hours HRT and 3 hours HRT respectively from initial COD value 700 mg/l .The maximum fall of COD is at 3 hours HRT. Total Dissolved Solids is reduced to 2500 mg/l at both 2.5 hours and at 3 hours HRT from initial TDS value 4000mg/l.

K. Removal Efficiency

The decrease in the parameter values of treated values from untreated values is given by,

$$\textbf{Removal efficiency} = \frac{\text{INITIAL VALUE} - \text{FINAL VALUE}}{\text{INITIAL VALUE}} \textbf{X100\%}$$

Removal Efficiency is expressed in percent.

Table 5: Removal Efficiency Of Varying Hrt

PARAMETERS	REMOVAL EFFICIENCY			
VARYING HRT	1.5hrs	2 hrs	2.5 hrs	3hrs
TURBIDITY	69%	73%	74%	76%
BOD	61.4%	78%	84%	88%
COD	29%	57.1%	49%	60%
TOTAL SOLIDS	13%	25%	37.5%	37.5%

XI. CONCLUSION

From the experimental results, we have concluded that among the chosen varying HRT, showed a better coagulation and turbidity removal for colSlected dairy wastewater. The characteristics of untreated dairy wastewater are pH-9.17,Turbidity -94.1 NTU, BOD-285 mg/l ,COD- 700 mg/l and Total solids – 4000 mg/l. The pH is reduced to 6.92; turbidity decreases to 23NTU;BOD is decreased to 35 mg/l; COD is reduced to 280mg/l and TDS decreases to 2500mg/l. Among the four varying Hydraulic Retention Time (HRT), the maximum reduction of turbidity, BOD,COD and total solids is found to be 76%, 88%, 60% and 37.5% with 3hours HRT;hence 3 hours HRT is suggested for more effective treatment of dairy wastewater. MBBR does not have common problems such as sludge bulking and rising,poor settling and foaming. Storng resistance to impact makes it easier to operate .IFAS process is proven to be comfortable and efficient upgrade for the improval efficiencies of poorly performing WWTP. It can handle shock loads, extreme stresses, and temperature variations. As long as the system is properly maintained, it can function efficiently for decades without major problems. IFAS process will play a vital role for the better scope in the treatment of wastewater in the future era. Both process proved to be economically cost effective. This reactor should be scaled up for effective implementation in the industries. According to the results of lab-scale experiments and literature review, MBBR and IFAS processs could be used as an efficient and effective treatment for BOD and COD removal from dairy wastewater. Considering the effluents quality with HRT of 3 hrs, the system meets the desirable limits in eliminating the organic materials.

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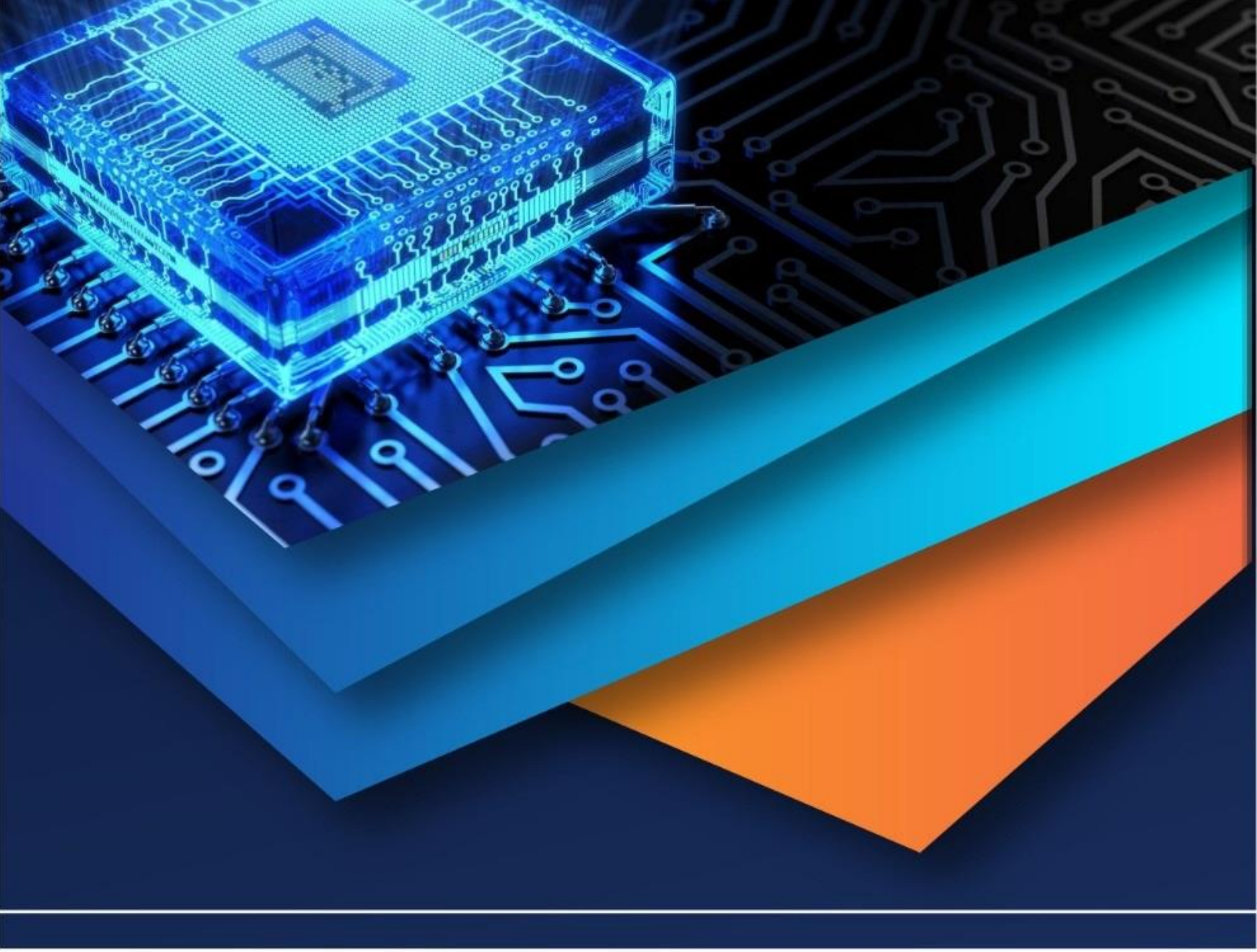

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