Anaerobic Treatment of Dye Wastewater for the Removal of Organic Pollutant

Kavimani. T, Balaji. K, Poongothai. S, Senthil Kumar.PL, Mohamed Ashik Ali. J

Abstract: ***The removal of cotton textile dye wastewater to the environment is a greater problem by its toxicological and aesthetical reasons. Many physicochemical methods were employed for treating the cotton textile dye wastewater. High cost and dangerous products produced by the physicochemical treatment reduce using these treatment methods. Hence the biological processes are employed for treating the cotton textile dye wastewater due to its cost effectiveness and less toxic effects. . Bio filter can be an effective solution for producing high quality water and saving water for recirculation. Bioball gives 80% reduction efficiency in BOD whereas Fixed filter media gives approx. 70% reduction efficiency in BOD The overall performance of the HUASBR achieved maximum COD removal of 87% at 24hrs HRT respectively. It is clearly understood that the % COD reduction is directly proportional to the HRT. Hence the HUASBR is suitable for treating real textile dye wastewater even upto 1300mg/l efficiency.***

Keywords: Color, Cotton, Decolourisation, Dyes, HUASBR.

I. INTRODUCTION

The real cotton textile dyeing wastewater includes various acute color dyes. The wastewater dyeing processes is not just an aesthetically unpleasant. Color interfere aquatic ecosystem of receiving water bodies. Color carrying away of outflow from the several physico-chemical treatments such as advanced oxidation, biological process and the combination of processes is pertain to treat the regulatory discharge extremity [1]. Anaerobic digestion of real cotton textile wastewater is an auspicious process since it is economical and safe.

Dyes usually degrade under anaerobic condition due to the cleavage of the bond resulting in color removal. Later the remaining products can be processed by aerobic treatment methods [2, 3].Color removal process can be achieved by biodegradation of dyestuff by azo reductase activity [4] and nonenzymatic azo reduction of dyestuff under anaerobic condition by [5,6]

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Kavimani. T, Assistant Professor, Department of Civil Engineering, Government Engineering College, Thanjavur, Tamilnadu, India.
Email: tkavimani@gmail.com

Dr.K.Balaji, Assistant Professor, Department of Civil Engineering, University College of Engineering, Anna university, Panruti Campus, Tamilnadu.

Dr.S.Poongothai, Professor, Department of Civil Engineering, Annamalai University, Chidambaram, Tamilnadu.

PL.Senthilkumar, Assistant professor, Department of Civil Engineering, Government College of Engineering, Thanjavur,

Dr.J.Mohamed Ashik Ali , Lecturer , Department of Civil Engineering, Srinivasa Subbaraya Government Polytechnic College. Puthur. Nagai dist.

The most visible pollutant in cotton textile dying waste is color which can be easily identified in wastewater. Before release into water bodies or on land, wastewater should be treated properly. The existence of color in industrial wastewater or in domestic which is considered to be unacceptable. Apart from the circumstance of several coloring agents such as dyes, inorganic pigments, tannins and lignin which are the chief contributor for environmental substance with predominant dyes waste. Dyes are extensively utilized in several Industries like textile dyeing, food, cosmetics, paper printing, leather and plastics. But textiles industry is the major user compared to all industries [7]

HUASB reactor is the time required to achieve an equilibrium condition. This depends on concentration of wastewater i.e. organic load. The main objective to be achieved in the first start-up of high rate anaerobic reactors is to perform an adequate and homogenous immobilization of anaerobic organisms. In current year, immobilization of microbial cells has expanded in the field of wastewater treatment. The immobilized microbial system significantly upgrades the efficiency of the bioreactor. Immobilized cells system has likely to reduce the poisonous chemicals compound faster than conventional wastewater treatment systems [8, 9].

Bio filter is a biological filter with attached biomass on the filter-media. The microorganism attaches on the surface of media and grows up to biofilm will degrade the organic compounds present in the water. Bio filter can be an effective solution for producing high quality water and saving water for recirculation. Bioballs gives 80% reduction efficiency in BOD whereas Fixed filter media gives approx. 70% reduction efficiency in BOD [10].

Anaerobic treatment technologies are regularly used for dyes wastewater treatment [11]. Among the various anaerobic reactors, HUASB reactor is found to be more resistant to toxic compounds present in wastewater and appears to be highly suitable for the treatment of wastewater.

II. MATERIAL AND METHODS

The real cotton textile dye wastewater was collected from cotton textile dyeing common Effluent Treatment plants (CETPS) located in Tirupur, Tamilnadu, India. The bio ball media was placed and operated at a hydraulic retention time (HRT) of 24 hrs. In this stage, the system continued to run for 48 days until the reduction in the percentage of chemical oxygen demand (COD) reached a constant level.

This was considered as study period.

A.Experimental Set Up

Owing to prior knowledge and the ample advantages of the HUASB reactor, it was decided to utilize a laboratory scale HUASB reactor for this study was designed and fabricated using Perspex tube is shown in table.1 and schematic reactor figure is shown in Fig-1.

Table-1: Physical Features of HUASBR

1.	Volume of reactor	0.03m^3
2.	Effective volume of reactor	0.02m^3
3.	Diameter of reactor	0.15 m
4.	Height of reactor	1.42m
5.	Effective height of reactor	1.17m
6.	Pump used for the influent feed	Peristaltic pump PP-20model (Miclin's product)
7.	Packing Media	Bio ball with bio sponge(inside), 28mm
8.	Specific area of Packing media	550 m^2/m^3
9.	Void ratio of the Packing media	97%
10	density of Packing	27g/l
11.	Material of the reactor	Plexi glass

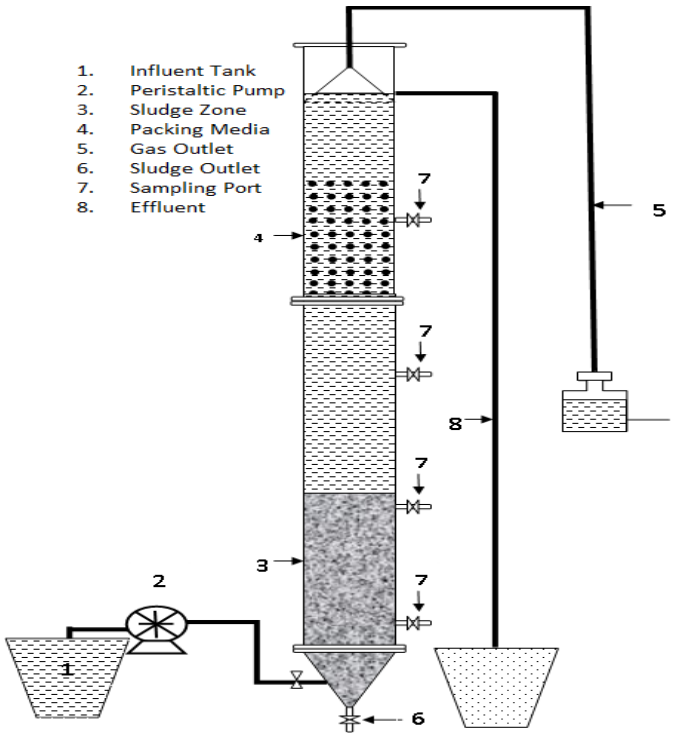

Fig.1.Schematic Diagram of HUASBR

B. pH

The instrument pH meter was used to measure pH which is Elico make, model no. LI. 120. The instrument was calibrated before measuring pH, with standard buffer solutions of 4.01 and 9.14 at 30˚.

pH of the reactor outlet was more or less equal to pH of feed for first 23 days after the start-up and 24th day onwards pH of the inlet varies vary much but the outlet pH are maintained as constant. The outlet pH was alkaline condition (7.6 – 8.0), during the initial start-up pH of methanogenic reactor was in the level of 7.6 and as the time increases the pH also get slightly increased and maximum pH was attained from 22nd day onwards this indicates the steady state operation of the reactors.

C. Chemical Oxygen Demand

The chemical oxygen demand (COD) can be used to determine the oxygen equivalent of the organic content of a specimen that is adaptable to oxidation with strong chemical agent. The COD level of feed ranging 5200 – 5600 mg/l, for acidogenic outlet was about 2320 – 5120 mg/l and for methanogenic outlet was about 800 – 4800 mg/l.

D. Characterization of real cotton textile dye wastewater

Samples of untreated cotton textile dyeing wastewater were collected from the cotton textile dyeing common Effluent Treatment plants (CETPS) located in Tirupur, Tamilnadu, India and their characteristics were analyzed and observed values were tabulated in the **Table 2.**

Table-2: Characteristics of untreated real cotton textile wastewater

Analytical Parameters	Samples
pH	10.5
BOD_5 mg/l	685
COD mg/l	1360
TDS mg/l	5925
Chlorides mg/l	900
Sulphates mg/l	612
TKN mg/l	65.32
TP mg/l	47.21
Color (OD @600nm)	1.8

E. Bioball Medium

The filter media selected for designing is Bio Ball. Bio Ball is selected because it is light and easily available. Biofilter has been proved to be an effective system in treating water in an economical manner [12, 13]. 152 pieces of black bio-ball were used as attached growth media of the same size which has a diameter of about 2.8 cm, a specific area of 550 m2/m3, and porosity hollow of 0.97. This bio-ball prevents the escape of bio granules from the reactor. Totally 5 sampling ports were installed for ease collect of sample for analysis at different heights. The reactor was operated at 31º C to 35º C.

III. RESULT AND DISCUSSION

A. General

Reactor with effective volume of 20 L and the total height of the reactor was about 1.42 m. The effective height and the diameter of the reactor are 1.17m and 0.15m, shown in fig 1. HUASB reactor for this study was designed and fabricated using Perspex tube. The solid-gas-liquid separator (GLSS) were placed in the top portion in the arrangement by inverted conical funnel for bio gas collection which is produced by anaerobic digestion and also to prevent the loss of granules. The amount of gas produced is measured by water displacement method. About 20ppm of peristaltic pump was used to achieve the constant discharge flow in the reactor.

The top third segment of reactor was filled with bio-ball as support media. 152 pieces of black bio-ball were used as attached growth media of same size which has a diameter of about 2.8 cm, a specific area of 550 m2/m3, and porosity hollow of 0.97. This bio-ball prevents the escape of bio granules from the reactor. Totally 5 sampling ports were installed for ease collect of sample for analysis at different heights. The reactor was operated at 31º C to 35º C.

B. Characterization of real cotton textile dye wastewater

The characterization of real cotton textile dye wastewater collected from tirupur was highly colored, highly alkaline, low BOD/COD ratio and high TDS in nature. The COD ranges from 900 mg/l -1800 mg/ l which exceeds the Indian effluent standards of permissible limit of 250 mg/l for COD parameter as IS 10500.The higher TDS of the real textile dye wastewater exceeds the permissible Indian effluent standards of 2100mg/l for the disposal of the inland surface source. The high pH which exceeds the permissible limit of Indian effluent disposal standards of 5.5-9.0 by IS-10500. The highly colored characteristics of the real cotton textile dye wastewater affect the transparency and affect the aquatic eco-system.

Table-3: Characterizations and
Comparison of real and synthetic dye wastewater

Analytical Parameters	Real textile dye	Synthetic textile dye	Permissible limit as per is 10500
pH	10.5±0.6	9.5±0.6	6.5-8.5
BOD_5 mg/l	670±15	600±85	30mg/l
COD	1360±50	950±50	250mg/l
TDS mg/l	5925±100	4652±100	500-2000mg/l
Chlorides mg/l	900±50	824±50	250-1000 mg/l
Sulphates mg/l	612±50	540±50	200-400 mg/l
TKN mg/l	65.32±20	57.55±20	150mg/l
TP mg/l	47.21±10	35.25±10	20mg/l
Color	1.8±0.2	3.3±0.2	-

C. Start up process

After attaining the steady state condition within 48days, for the acclimatization process the procedure was begin with the domestic wastewater feeding in the reactor. Initially 100% of domestic sewage effluent was fed into the reactor, there by gradually decreasing domestic sewage such as 20%, 40%, 60%, 80% and100% with simultaneously fed of Real cotton textile dye by gradually increasing the cotton waste as 20%, 40%, 60%, 80% respectively. In the present study substrate like Nitrogen (NH4)2SO4and Phosphorous KH2PO4 were Added with the COD: N: P ratio of 550:5:1. The stock solution of trace nutrients containing ferric chloride, zinc sulphate, copper sulphate etc. were added at a concentration of 1.0 ml /l of the feed solution to the reactor (Ahn 2003)[14].

D. pH during start up period

The textile dye effluent exhibit alkaline characteristics. The influent which has high pH ranging from 8 to 11.5 got reduced after treatment to the range of nearly neutral condition of 6.4 to 7.2

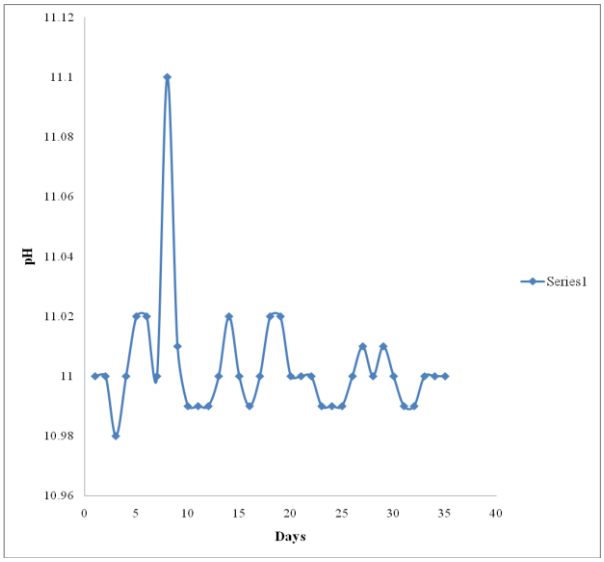

Fig. 2.pH during start-up period

E. % COD removal during start up period

The COD removal efficiency rate during the first five days was low in the range of 5-20%.

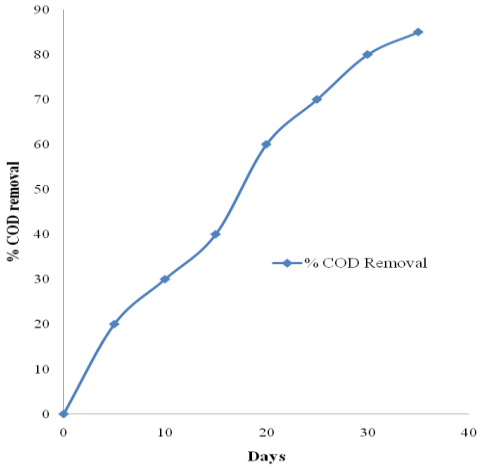

Fig.3. % of COD removal efficiency during start-up period

After 25th days the COD removal efficiency is above 60% and shock loading was observed in the reactor because the real cotton textile wastewater was gradually fed to the reactor. Due to the shock loading of real cotton textile wastewater, the COD removal efficiency suddenly decreased to 38% and VFA concentration increased 900mg/L. However the operation parameter HRT was maintained at 24hr for stabilizing the reactor. At 35th days the COD removal efficiency is above 80%.

F. VFA during startup period

The VFA concentration in the effluent during the first 25 days was in the range of 250-900 mg/l. It was dropped to 85 mg/l on the 40thday; higher levels of VFA in the wastewater during the initial stage of operation indicate the prevalence of acid fermentation subsequently the VFA in the effluent decreases gradually 85 to 40mg/l. towards the end of startup period.

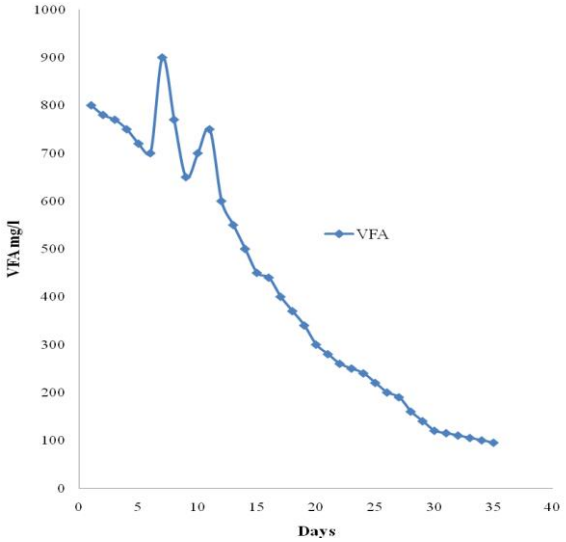

Fig.4. VFA during start-up period

G. Overall performance of upflow anaerobic sludge blanket reactor

The overall performance of the upflow anaerobic sludge blanket reactor maximum COD removal of 87%, 84 % and 79% for the COD concentration of 1300 mg/l at 24 hrs HRT respectively. From the study result it is interpret that the %COD reduction is directly proportional to the HRT. 80% of COD removal is achieved in 20 hrs HRT with the COD concentration of 1300mg/l. The operational parameters HRT were varied 24hrs, 12hrs, and 6hrs. Based on HRT, concentrated samples were collected for analysis from the inlet and outlet of the reactor.

IV. CONCLUSION

The hybrid upflow anaerobic sludge blanket reactor models were studied for the percentage of COD and color removal efficiency under optimum parameter of hydraulic retention time. The experimental model is a modified UASBR with an effective liquid volume of 20L. The experiment was run continuously for 48days. The experiment was run COD concentration of 1300mg/l. The operational parameters HRT were varied as 24hrs, 12hrs, and 6hrs, for each COD concentration subsequently. Based on HRT, concentrated samples were collected for analysis from the inlet and outlet of the reactor. The biogas generation is found to vary from 0.22 to 0.29m^3/kg COD removal with respect to varied days and HRT 6hrs, 12hrs and 24hrs. The experiment work on HUASBR model is found to be successful for treating textile dye wastewater with higher % of COD removal and % color removal. The overall performance of the HUASBR achieved as higher COD removal of 87%, 84 % and 79% for the COD of 1300mg/l at 24hrs HRT respectively. From the results obtained it shows that the % COD reduction is directly proportional to the HRT. 80% of COD removal is achieved at 20hrs HRT in the COD concentration of 1300mg/l. Hence the HUASBR is suitable for treating real textile dye wastewater even upto 1300mg/l efficiency. From the above results it was confirmed that an HUASB reactor was create to be more successful in decolourisation of real textile dyeing effluent.

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AUTHORS PROFILE

T. Kavimani is currently working as Assistant professor in Department of Civil Engineering, Government College of Engineering, Thanjavur, Tamilnadu. He has been teaching UG & PG classes well over 15 years. His research interests include Industrial Wastewater Treatment and Environmental Engineering.

Dr.K.Balaji is currently working as Assistant professor in Department of Civil Engineering, University College of Engineering, Anna University, Panruti Campus, Tamilnadu. He has done Ph.D at Annamalai University in 2016. He has been teaching UG & PG classes well over 15 years. He has to his credit 19 research papers of which 5 papers are Scopus Indexed.

Dr.S. Poongothai is currently Professor, Department of Civil Engineering at Annamalai University, Chidambaram, Tamilnadu. He has been teaching UG & PG classes well over two decades. He has to his credit more than 50 research articles of which most of the papers are Scopus Indexed. Her research interests include Wastewater engineering, Irrigation engineering and watershed management. She has completed guiding more than 10 research scholars.

PL.Senthil Kumar is currently working as Assistant professor in Department of Civil Engineering, Government College of Engineering, Thanjavur, Tamilnadu. He has been teaching UG & PG classes well over 15 years. His research interests include Solid Waste Management and Environmental Engineering.

Dr.J.Mohamed Ashik Ali is currently working as Lecturer in Department of Civil Engineering, Srinivasa Subbaraya Govt Polytechnic College. Puthur.Nagai dist. He has done Ph.D at Annamalai University in 2018. He has been teaching UG & PG classes well over 14 years. He has to his credit 3 research papers of which 2 papers are Scopus Indexed.