B. Tech Thesis on

WASTEWATER TREATMENT USING INVERSE FLUIDIZATION UNIT BY ALGAE

For partial fulfilment of the requirement for the degree of

Bachelor of Technology

in

Chemical Engineering

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Under the guidance of

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CERTIFICATE

This is to certify that the project report entitled **"Wastewater treatment in Inverse Fluidization Unit using Algae "** submitted by **Nikita Dewangan , Roll No: 111CH0067** in partial fulfilment of the requirements for the award of B. Tech Degree in Chemical Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the report has not been submitted to any other University/Institute for the award of any Degree.

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ACKNOWLEDGEMENT

Words are only representation of my regards and gratitude that I have towards my mentor.
As a matter of fact, without co-operation no thought could be coined into action. Consistent motivation and invaluable support throughout the project is an issue that cannot be quantitatively measured.

It gives me immense pleasure to express my sincere and deepest sense of gratitude that I had an opportunity of working under the guidance thus I sincerely thank my Supervisor,
Prof. Abanti Sahoo for guiding me throughout the project by making me to understand the work and providing me with all the facilities necessary to complete the project successfully.

I am also grateful to **Prof. Pradip Rath**, Head of the Department, Chemical Engineering for providing me the necessary opportunities for the completion of my project.
I am also grateful to all the faculty members and staff for helping me to successfully complete my project.

Lastly, I would like to thank my friends for helping me to collect necessary requirement for the project and support me morally.

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NOMENCLATURE

COD: Chemical Oxygen Demand

BOD: Biological Oxygen Demand

IFBR : Inverse Fluidization Bed Reactor

EDTA: Ethylene –diamine- tetra- acetic acid

FAS : Ferrous Ammonium Sulphate

LPM : Litres per minute

hr : Hour

V_b : Bed volume

V_R : Reactor volume

ABSTRACT

Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) play important role in determining the quality of wastewater. Hence it is necessary to calculate COD and BOD of water before setting up of wastewater treatment plant. Algae has been used for decades for various purposes. It is one of the important characteristics is to nitrogen, phosphorus etc., which are harmful for drinking and other purposes but they act as food for algae. Thus in this study COD and BOD analysis is done for sterilized and non-sterilized wastewater after and before treating it with algae in inverse fluidization under aerobic condition, for different time interval and found that percentage reduction in COD and BOD for sterilized wastewater gives greater value than non-sterilized water the reason for this difference being the decrease in the competition between algae and other micro-organism which are present in raw wastewater. And COD % reduction is 65-70 % and BOD % reduction is 68.75- 70.5%.

Keywords: Chlorella Scenedesmus, COD, BOD, wastewater, inverse fluidization unit

CHAPTER -1

INTRODUCTION

1.1 Inverse fluidization process

Among many conventional processes available for wastewater treatment inverse fluidisation process which is a three phase fluidisation process has been widely used for many applications such as hydro-treating and conversion of heavy petroleum and synthetic, crystaliization,food processing,biomedical engineering, methanol production, treatment of municipal sewage wastewater and similarly many processes. Some of the benefits which one's process can gain if this unit is used are easy to handle, less consumption of power, low space requirement, less chemical waste and eco-friendly as it does not produce any chemical as its waste after the process. Indeed the most significant feature of it is high efficiency as compared to the other conventional fluidization processes.

The name inverse fluidisation comes from the direction of flow of liquid and gas which depends upon the density of the particle. Here the liquid is fed continuously from the top using pump if it is a continuous process and gas is released from using sparger form the bottom after it has been compressed in a compressor, thus it makes the process counter current flow process. In this counter current flow process the density of the particle is lesser than that of the liquid which is in a continuous phase.

With the rapid growth in population and industrialization is leading to the depletion of natural resources and causing major environmental problems such water pollution, soil pollution etc. The environmental problem which is of our concern is water pollution which is mainly caused due to the discharge of heavy metals from steel ,dairy and fertilizer industries and nitrogen ,phosphorus, sulphides and chlorides . Due to rapid use of nitrogen in fertilizer industries an excessive amount of it may cause several health related problems and causes eutrophication and acidification of water bodies. To overcome this process there are various methods which have been used for decades but the question arises is which process is more economical and numerous benefits over others.

1.2 Why inverse fluidisation technique and not the conventional one?

- The bio film thickness which grows very fast on the surface of the solid particle ,if provided proper conditions .Sometimes it also happens that bio film thickness increases so much that it causes bloom and proper mixing and growth of film is degraded. Thus some new particle have to be added to provide new surface to the biomass from time to time. The advantage of IFBR lies here that it controls bio film thickness in a very narrow range.
- Due to power failure sometimes it needs to start the fluidization process from the beginning itself but with the IFBR this problem is almost sorted out as we can re-fluidize the process.
- The growth of microorganism is very faster as seen from the literature survey due to high mass transfer rate.
- Carryover of particle is minimized due to low particle or solid attrition.

1.3 Type of Algae and why it is used in waste water treatment process.

Algae involves process which is very similar to the green plants and the most common process in plant is photosynthesis. Algae absorbs sunlight which is a source of carbon di oxide for it and convert it into oxygen and photosynthesis takes place through chlorophyll present in it. Algae size varies from single cell to branched size of visible length. Some of the algae which grow in waste water are chlorella sp., Spirulina sp., Microactinium sp., and some more. The treatment of wastewater can be achieved by biodegradation of it using bacteria or algae. Biodegradation converts organic matter into smaller molecules which requires oxygen for the process. And supply of oxygen is tedious and costly. Thus it is better to use natural abundance source of oxygen which can give lot of benefits apart from biodegradation. Algae absorbs various compounds and nutrients such as nitrogen, phosphorus and metals required for its growth.

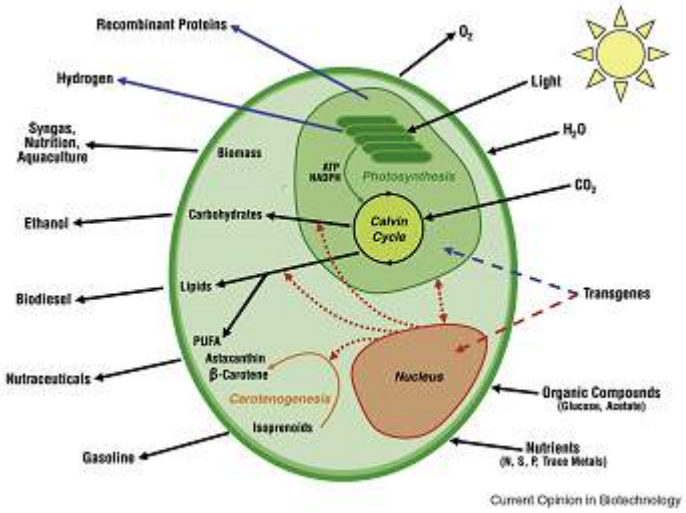

Figure -1: Structure of algae and basics compounds produced by algae (Source: Oilgae.com)

In all other conventional method for wastewater treatment which does not uses algae the treatment process produces lots of sludge which eventually goes to off-site for its disposal and maintaining sludge which is diurnal and seasonal is a costly process. Some of the benefits which is prominent in today's century are reduction in green -house -gases and production of useful products from end product which is a highly rich nutrient containing algae itself and can further be used for production of biofuel and diet supplementary. Aeration is an energy intensive process and accounts for 45-70 % of total energy cost of treatment plant. Algae consumes CO_2 in a larger amount than it is released during the process. Chlorella Scenedesmus is one among the fastest growing genus of single celled green algae, includes 14%-22% of lipid, 51%-58% of protein, 12%-17% of carbohydrates, and 4%-5% of nucleic acid.

Algae can act as a bio-filter for nutrient laden, CO_2 laden, and can convert low oxygen water into highly rich oxygen water. Thus any wild algae can be grown in the area where the wastewater is reserved. End use of algae can be in production of biodiesel or biofuel as compared to soy seed (60-100 gallons), coconut (230 gallons), and palm oil (500 gallons) can produce 5000 or more gallons per acre of area.

1.4 Biological Oxygen Demand (BOD) and Chemical Oxygen Demand(COD)

COD test is used to measure the amount of organic compounds in water in other words we can say that it is the amount of oxygen required to chemical oxidize the pollutants. The applicable range of COD is 3 – 900 mg/ml.

BOD test is used to determine the amount of oxygen required by the microorganism to break the organic material present in the sample at a particular temperature over a specific period of time. Generally the time taken for test is 5days at a temperature of 20 degree Centigrade. It is also a principle test which predicts the biodegradability of any water or wastewater sample.

The efficiency of wastewater is measured by measuring the effluent BOD and influent BOD of the sample taken. Any effluent to be discharged into the water should have BOD less than 30mg/ml.

COD value is always greater than BOD value .It is found from the research that the COD values for domestic and industrial wastewater is about 2.5 times the BOD value. The ratio of BOD to COD if greater than 0.8 then it is considered that the water is highly polluted and amenable to biological treatment.

CHAPTER -2

LITERATURE SURVEY

1. **Chan et al in 2013** worked on heavy metal uptake by three types of algae Chlorella sp., Spirulina sp., and other algae found in wastewaters of industries. They used untreated and autoclaved effluents as a substrate and observed that microalgae removed up to 81.7% of copper and 94.1 % of zinc and also found that higher heavy metal removal is obtained in autoclaved effluents because the presence of microbes in untreated effluents put negative impact on the removal efficiency.
2. **Deviram et al in 2011** used the microbial mats for the study using different species of algae such as Ulva sp., Cladophora sp. and Chlorella sp. and observed COD and BOD in three different types of process free cell process, batch process and continuous process and found that better results were developed in continuous process with 52.1(COD) and 50.8(BOD) along with changes in dissolved oxygen (DO) and pH.
3. **Kim et al. in 2010** studied the capability of Chlorella vulgaris to remove nitrogen in the form of ammonia and ammonium ion from local wastewater. The wastewater effluent leaving the plant was found to include high concentrations of nitrogen (7.7± 0.19 mg/L) (ammonia (NH_3) and ammonium ion (NH_4^+)) and total inorganic carbon (58.6±0.28 mg/L) at pH 7, and to be suitable for growing Chlorella vulgaris. When Chlorella vulgaris was cultivatedin a batch mode under a closed system, half of the nitrogen concentration was dramatically removed in 48 h after a 24h lag-phase period.
4. **Kothari et al in 2012** studied the physical and chemical parameters of dairy wastewater quality such as nitrates, sulphides, phosphates, chlorides and hardness. They founded that nitrogen and phosphate removal is achieved to be 49 % and 83 % respectively.

5. **Sheekh et al in 2012** investigated the treatment efficiency of wastewater by using single or mixed cultures of cyanobacteria and they found that single culture was better than mixed culture. The lower efficiency of mixed culture is due to competition between cultures for nutrients and also found that organic matter removal (COD) is between 20 – 57.1 %.
6. **Sokol et al in 2009** performed the wastewater treatment process in inverse fluidization unit using biomass and observed the changes in COD value with time in hour for various ratios of settled bed volume to the reactor volume (V_b/V_R) and air velocity U_g.
7. **Sriram et al in 2012** highlighted a review on the current scenario in the cultivation of microalgae in wastewater for nutrient removal.
8. **Yadavalli et al. in 2013** studied the removal of organic content and nutrients from dairy effluents by chlorella sp., and euglena sp. In both open and closed systems and found that NH4, +N was reduced to 96% by Chlorella sp. than Euglena sp.
9. **Zhigang et al in 2013** studied the effect of light emitting diode's wavelength and intensities on the microalgae biological wastewater treatment system .They founded that the optimum light intensity is 2000 μmol /m2*s and experimental illumination time is 120 h. And the species was successfully able to purify under this optimum condition.

CHAPTER -3

MATERIALS AND METHODS

3.1 Materials Required:

1. Algae

-Chlorella Scenedesmus and local algae from pond

-Quantity used: 250 ml

Table -1: Nutrients required for growing Chlorella Scenedesmus

S.No.	Compounds Name	Quantity per litre
1.	Fog's Medium	
	- Magnesium sulphate hepta-hydrate($MgSO4.7H_2O$)	0.2 g
	- Dipotassium hydrogen phosphate(K_2HPO_4)	0.2 g
	- Micronutrients solution	1 ml
	- Calcium chloride hydrated ($CaCl_2$. H_2O)	0.1g
	- Fe-EDTA solution	5.0 ml
	- Distilled water	1.0 L
	- Agar(Difco)	12.0 g
2.	Micronutrient solution	
	- Hydrated Manganese Chloride ($MnCl_2.4H_2O$)	181.0 mg
	- Boric Acid (H_3BO_3)	286.0 mg
	- Zinc sulphate hepta hydrate ($ZnSO_4$.$7H_2O$)	22.0mg
	- Sodium Molybdate ($Na_2MoO_4.2H_2O$)	39.0 mg
	- Copper Sulphate penta-hydrate($CuSO_4$.5H2O)	8.0 mg
	- Distilled water	100.0ml
3.	Fe-EDTA In hot water 745.0 mg of Na_2EDTA was dissolved and then 557.0 mg of $FeSO4.7H_2O$ was added. The solution was boiled for few minutes and the volume was made to 100.0 ml.	

2. Wastewater from Rourkela Steel plant

- Quantity used: 1 litre

Table -2: Composition of wastewater obtained from Rourkela Steel plant, Rourkela, Orissa

Component	**Amount in ppm**
Phenol	70 - 72
Sulphate	76.8
Chloride	192-223
Nitrite	0.2 -0.34
Ammonia	116.8
Total Kjeldahl Nitrogen(organic nitrogen)	246.6

3. Polypropylene balls

-Density: 910 kg/m^3

4. Glass-wares

3.2 Procedure for growing algae:

1. Petri dishes containing growth medium with 1 – 1.5 % agar medium was prepared. And the agar medium should be ½ to 2/3 the depth of dish.
2. 1-2 drops of algae sample from the slant was placed near the periphery of the agar. The wire loop was sterilized using burner.
3. The petri plate was covered and sealed with parafilm. Then it was incubated in a low light at constant temperature.
4. The colonies were selected which are free of other organism for further isolation process.
5. The sample was removed using sterile wire loop and placed in a drop of sterile culture media on a glass slide.
6. Then the species was checked microscopically for whether the species is uni-algal or not.
7. The streaking procedure was repeated with a single colony and again allowed to colonies to develop.
8. The second streaking is done to reduce the possibility of bacterial contamination and species containing more than one algal species.

9. Then the selected colonies were transferred to the liquid nutrient medium and allowed to grow in an incubator shaker for temperature maintenance of around 20 – 25℃ . The alternative for maintenance of temperature is by keeping it in an AC room and for stirring keep it in a magnetic stirrer at low rpm.
10. After 5 -10 days growth is observed in a beaker of liquid medium and the growth substantially increases but pH and nutrient level in a medium must be checked and maintained.

Figure 2 :
Algae culture after transferring its colonies from petri plate

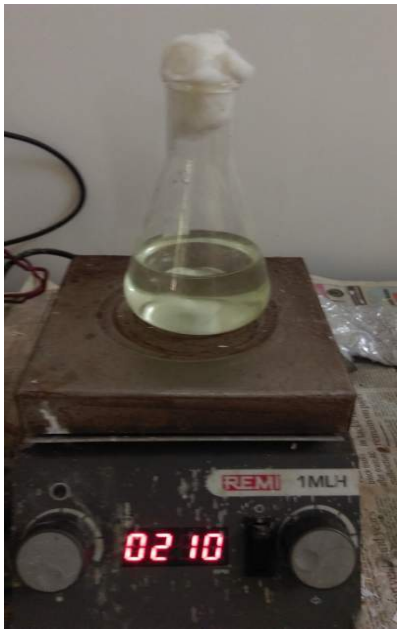

Figure 3 :
Algae after 10 days growth

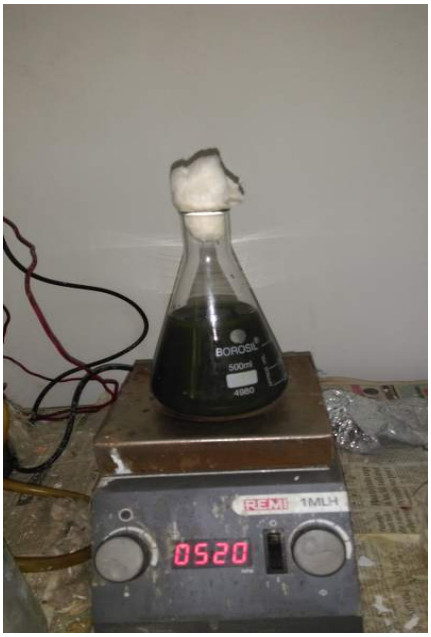

Figure 4 :
Algae after 1 months growth

3.3 Experimentation

Inverse Fluidisation Unit

3.3.1 Design of IFBR:

1. The unit consist of long perplexed glass tube –

- Height = 1.240 m
- Diameter = 10 cm
- Wall thickness = 3 mm

1. Centrifugal pump

- Power 0.5 HP
- Head = 14ft

2. Calibrated Rotameter

- For water = 0-100 LPM
- For Gas = 0 -200 m^3/hr

3. Manometer

- Number = 4
- Length = 1m

4. Circular pith distributed plate
5. Conical heads (at the top and bottom)

- Apex angle = 60˚
- Inner diameter = 10 cm
- Height = 30 cm

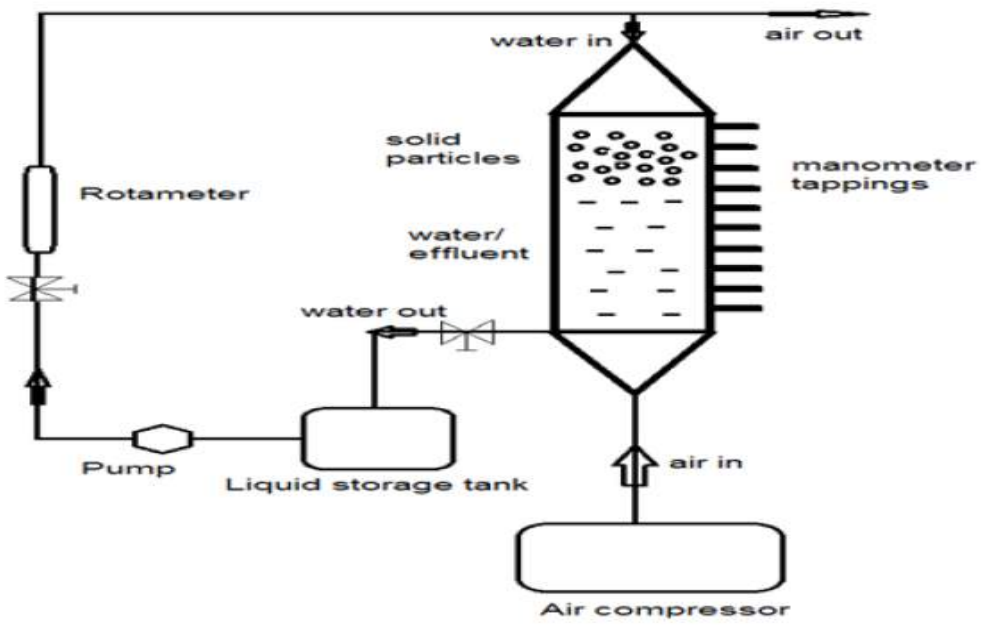

Figure – 5: Outline sketch of the IFBR unit

3.3.2 Experimental Procedure for operation in IFBR:

1. The column was loaded with some amount of polypropylene balls.
2. Fill the liquid storage tank with 10 litre of water and mix wastewater around 200 ml to it. Then add 250 ml of algae sample to the tank and mix it very well.
3. Pump the water from liquid storage tank to the vertical unit with the liquid flow rate of 10 LPM and till certain height is reached in the bed measured from the scale stick to it on the outer surface.

4. The pressure drop across the test section is measured with the help of manometer connected across the bed.
5. The flow rate of the gas is slowly increased to bring the bed into the state of mixing , as mixing provides better growth of microbes due to continuous interaction with each other .
6. The bed continuously kept under light of intensity which is required for the growth of algae.
7. The mixture of wastewater, algae and nutrients was kept in fluidization for hours and sample was taken for COD and BOD analysis after 6hr, 24hr, 32 hr, 48hr, 96 hr,120 hr.
8. Two wastewater samples were taken untreated and sterilized wastewater for the treatment.

(a) Fixed bed (b) Onset of fluidization (c) Turbulent fluidization

Figure -6: Experimental set up for hydrodynamic studies

3.4 COD Analysis

3.4.1 Materials required**:**

1. Potassium dichromate
2. Concentrated sulphuric acid
3. Ferroin indicator
4. Ferrous Ammonium Sulphate(FAS)
5. Mercuric sulphate
6. Distilled water
7. Glassware's (conical flask, beaker, heater, stirrer, measuring cylinder)

3.4.2 Procedure:

1. Potassium Dichromate ($K_2Cr_2O_7$) solution

- 12.259 g of $K_2Cr_2O_7$ was dissolved in 1000ml distilled water.

2. FAS solution

- 98 g of FAS is dissolved in distilled water and then 20ml of Conc. Sulphuric acid was added and the solution is diluted to 1000ml

Molarity of FAS can be calculated as

$$\text{Molarity FAS} = \frac{\text{Volume of K2Cr2O7 in ml} * 0.25}{\text{Volume of FAS used in ml}} \quad \text{----------(1)}$$

3. Now 20 ml of the sample was taken in a 500 ml flask
4. Then 10 ml of $K_2Cr_2O_7$ was added to it.
5. 30 ml of conc.H_2SO_4 was added slowly and cautiously.
6. 0.4 gm of Mercuric sulphate was then added then the sample was heated at 120° C for around 10 min.
7. Then the sample was cooled to room temperature
8. The solution was diluted to two times its volume with distilled water
9. Fill the burette with FAS solution and add 2-3 drops of Ferroin indicator to the diluted solution and titrate it against FAS solution.
10. The end point of the titration is determined by sharp colour change from blue green to reddish brown which persisted for 1 min.
11. Similarly the wastewater sterilized and untreated were also titrated to check the COD before process.

3.4.3 Sample Calculation

Molarity of FAS = 0.1 M

- For Waste water before sterilization

COD = (A-B)*M*8*1000 / Volume of the sample used ---------- (2)

(Source-APHA standard method for examination of water and wastewater, 20th edition, Method 5220C)

Where;

A = Volume of FAS for blank = 13.4

B = Volume of FAS for sample = 3.0

M = molarity of FAS solution = 0.1 M

Volume of the sample used = 20ml

COD = 416 mg/ml

- For waste water after sterilization

COD measured = 380 mg/ml

3.5 BOD Analysis

3.5.1 Materials Required:

1. Potassium hydrogen phosphate (KH_2PO_4)
2. Di-potassium hydrogen phosphate (K_2HPO_4)
3. Di-sodium hydrogen phosphate ($Na_2HPO_4.7H_2O$)
4. Ammonium chloride (NH_4Cl)
5. Magnesium sulphate hepta-hydrate ($MgSO_4.7H_2O$)
6. Calcium chloride ($CaCl_2$)
7. Ferric Chloride ($FeCl_3$.6H2O)
8. Sodium sulphite (Na_2SO_3)
9. Distilled water
10. Glassware's (test tubes, beaker, conical flask)

3.5.2 Procedure for preparation of solution:

1. Phosphate buffer solution

8.5 g of KH_2PO_4, 21.75 g of K_2HPO_4 , 33.4 g of Na2HPO4.7H2O and 1.7 g of NH4Cl was dissolved in 500 ml distilled water and diluted it to 1000ml . Make sure that the pH is adjusted to 7.2.

2. Magnesium Sulphate solution

22.5g $MgSO4.7H_2O$ was dissolved in distilled water and dilute it to 1 litre.

3. Calcium Chloride solution

27.5 g of CaCl2 was dissolved in 1000ml distilled water.

4. Ferric Chloride solution

0.25 g of Ferric chloride solution was dissolved in 1000ml of distilled water.

5. Sodium sulphite solution

1.575 g of sodium sulphite is dissolved in 1000ml of distilled water.

NOTE: All the solutions must be prepared daily because they are not stable.

3.5.3 Procedure:

1. The 20 ml sample was kept in 1 litre flask.
2. Then 1 ml magnesium sulphite solution ,1 ml calcium chloride solution and 1 ml ferric chloride solution was added to 1 litre of distilled water.
3. If the solution are acidic or alkaline then it must be neutralised before use and it can be done by adding sodium thio-sulphate solutions to it to destroy residual chlorine.
4. The sample must be diluted as follows:

- ✓ Strong water = 0.1 , 0.5 , or 1 %
- ✓ Settled domestic sewage = 1, 2.5 , or 5%
- ✓ Treated effluents = 5, 12.5 or 25 %
- ✓ River water = 25 to 100%

5. The sample was diluted with distilled water and mixed nicely.
6. The diluted sample was the taken in two BOD bottles.
7. The DO of diluted water and diluted wastewater was taken immediately.
8. The other two bottles were kept at 20 degree C for 3 – 5 days and the sample was incubated.
9. After 3 days the DO of sample was taken.
10. The procedure for DO analysis follows this.

3.5.4 Procedure for Dissolved oxygen analysis:

1. The two BOD bottles were taken and 2 ml of alkali –iodize-azide was added to it below the liquid level.
2. The bottle must completely air tight so that no air should enter into it. The sample was mixed properly. The presence of oxygen is indicated by the appearance brownish – orange cloud of precipitate or floc. This floc can be disappeared by turning the bottle upside down and allowing it to settle.
3. Then 2 ml of sulphuric acid was added to it via a pipette holding it just above the surface of the sample. Again the bottle is inverted after carefully plugging the stopper into it to dissolve the floc. Then the sample is kept for 8 hr.
4. Filled the burette with sodium thiosulfate solution.
5. 2 ml starch solution was added so a blue colour forms.
6. The sample was titrated slowly till the end point .And end point is determined when the blue colour disappears.
7. The concentration of dissolved oxygen can be determined by the number of millilitres titrant used. As each ml of sodium thio-sulphate added equals 1 mg/l dissolved oxygen.

3.5.4 Sample Calculation for BOD

Initial DO of diluted sample, Do = 8.2

DO at the end of 3 day , D_3 = 6.08

Blank correction, BC = 0.2

Volume of sample diluted ,Vd = 500 ml

Volume of sample taken , Vs = 20 ml

BOD = (Do – D_3- BC)*Vd/Vs ---------- (3)

(Source: APHA standard method for examination of water and wastewater,20th edition, Method 5220C)

= (8.2 – 6.08- 0.2) *500/20

= 48mg/ml

CHAPTER - 4

RESULT AND DISCUSSION

4.1 For non-sterilized wastewater after treatment with Chlorella Scenedesmus at Vb/Vr = 0.5

Initial Value of COD before treatment is 416 mg/ml, pH = 6.7

After treatment the pH is 8.5 at the end of 192 hr

Table – 3: Variation of COD with time for non-sterilized wastewater

S.No:	Number of Hours of operation	COD in mg/ml
1	0	416
2	6	400
3	24	346
4	48	277
5	72	236
6	168	149.76
7	192	146.6

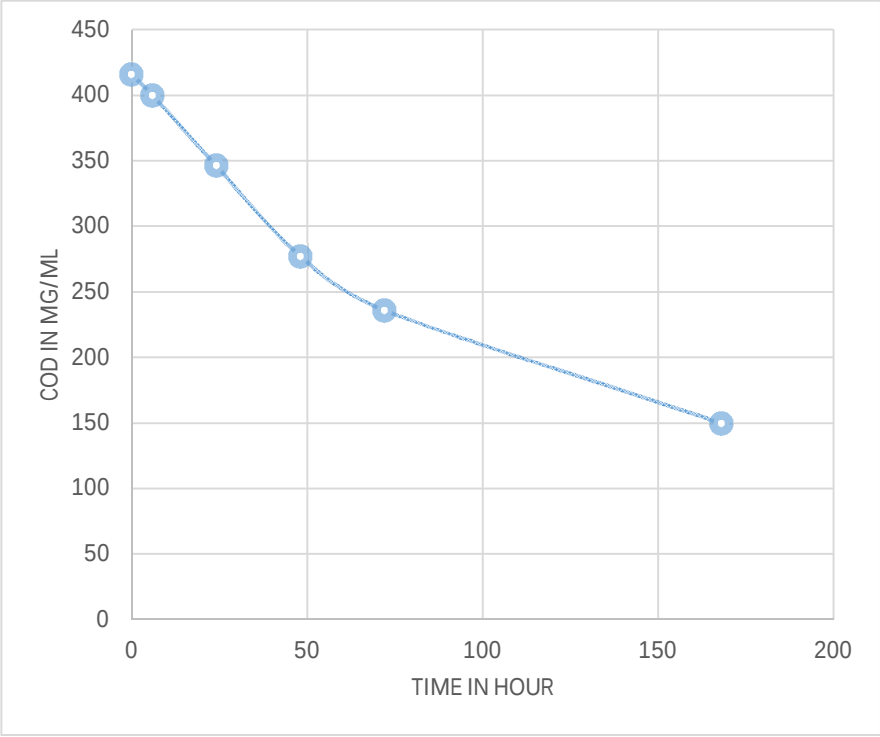

Figure –7: Variation of COD with time for non-sterilized wastewater

Table -4 : BOD analysis of non-sterilized wastewater

S. No.:	Number of hours of operation	BOD in mg/ml
1	0	48
2	72	28
3	144	15

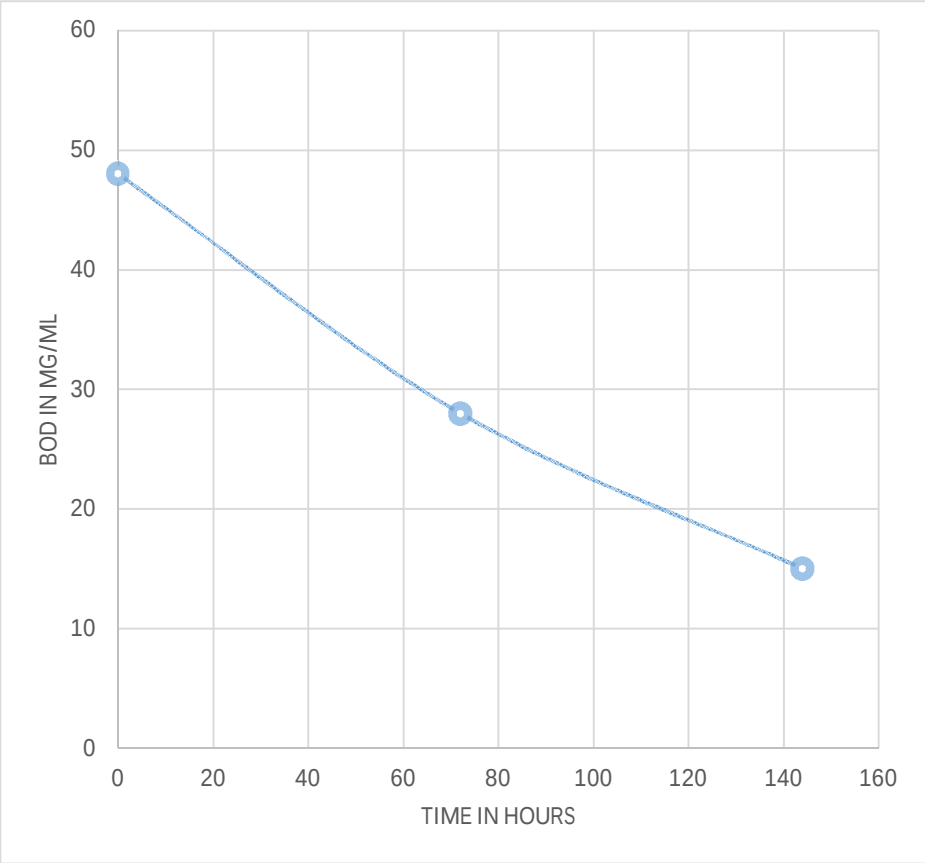

Figure -8: BOD vs time for non-sterilized wastewater

4.2 For wastewater (sterilized) after treatment with Chlorella sp. at Vb/Vr = 0.5

Initial value of pH before treatment is 8.3 and after treatment

After treatment pH was 8.9 for the total time duration of 192 hours.

Table -5: Variation of COD with time for sterilized wastewater

S. NO	Number of hours of operation	COD in mg/ml
1	0	380
2	6	368
3	24	310
4	48	246.4
5	72	195.4
6	168	126
7	192	114

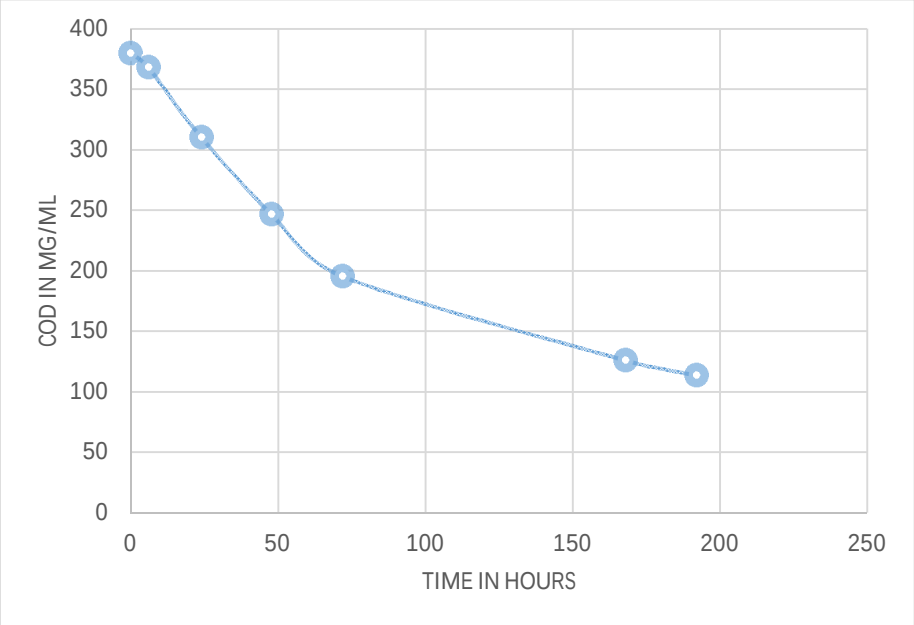

Figure – 9: COD vs time for sterilized wastewater

Table -6: BOD vs time for sterilized wastewater

S.NO.	Number of hours of operation	BOD in mg/ml
1	0	44
2	72	23
3	144	13

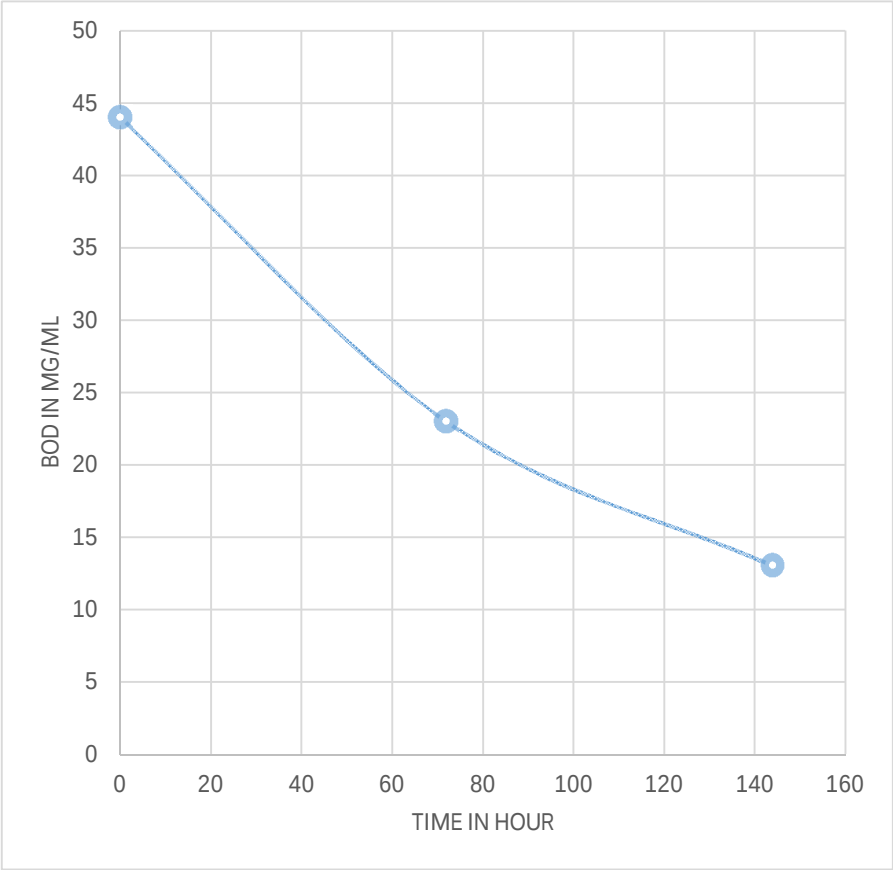

Figure -10 BOD vs time for sterilized wastewater

Calculation of percentage reduction in COD and BOD after treating it with algae

% Reduction in COD for non-sterilized wastewater	= [(initial value of COD- final value of COD)/ initial value of COD] * 100 = (416 – 146.67 /416) *100 = 65 %
% Reduction in COD for sterilized wastewater	= [(initial value of COD- final value of COD)/ initial value of COD] * 100 = ((380 – 114) / 380) * 100 = 70 %
% Reduction in BOD for non-sterilized wastewater	= [(initial value of BOD- final value of BOD)/ initial value of BOD] * 100 = ((48 – 15) /48)*100 = 68.75 %
% Reduction in BOD for non-sterilized wastewater	= [(initial value of BOD- final value of BOD)/ initial value of BOD] * 100 = ((44-13)/44) * 100 = 70.5 %

Table –7: % Reduction in COD and BOD of Chlorella Scenedesmus with other species of Algae

S.No.	Name of the Algae species	% Reduction of BOD	% Reduction of COD
1	Nostoc Muscorum (Ref. : 3)	---	20–57.1
2	Chlorella. Pyrenoidosa (Ref. :5)	92	86
3	Euglena (Ref -12)	96	80
4	Chlorella sp (Ref – 4)	------	50.8
5	Chlorella Scenedesmus (Species used for this project)	68.75	70

4.3 Algae Identification

Algae Name: Chlorella Scenedesmus

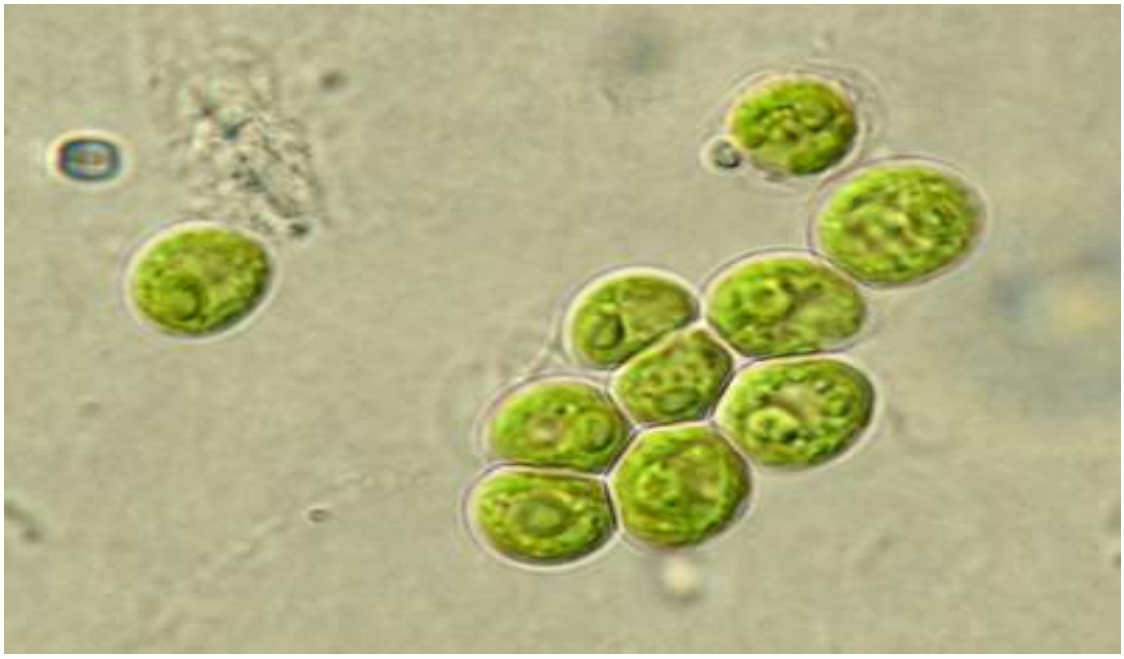

Figure -11 :Chlorella(Microscopic view of chlorella viewed in the range of 10 micro m)

Figure – 12: Scenedesmus (Microscopic view of chlorella in the range of 10 micro m)

CHAPTER 5

CONCLUSION

COD and BOD analysis of wastewater is one of the basic step which is needed to set up any wastewater treatment plant and to control losses to the sewer system. Many ways of chemical treating wastewater has been proved to be very expensive and produces harmful end product which is very necessary to be avoided in today's century. This study which includes treatment of steel plant waste water with the most abundantly available resource i.e., algae shows a new pathway to achieve two major goals of any wastewater treatment plant first being the economy and second being the efficiency in reduction of harmful components present in industrial , domestic or municipal wastewater. Treatment in inverse fluidisation unit is very economical as it very cheap to procure, easy to handle and require low power to operate and in addition to this using Algae in it for degradation of hazardous components sorts out problems such as cost of oxygen supply needed for conversion of organic compounds and moreover algae can further be used as a source of biofuel and diet supplementary as some of the species are very effective for it. Continuous mixing with the help of solid particles in fluidization unit helps Algae to grow on its surface. Thus, this type of study is necessary before setting up any wastewater treatment plant.

FUTURE WORK:

1. Measurement of the COD and BOD content of the outlet stream from the inverse fluidization unit by varying parameter such as :

- Gas flow rate
- Concentration of effluent in water
- Different strains (Spirulina and mix)
- Ration of volume of bed and volume of the reactor

2. Comparing this method of using algae with other biological methods.
3. Comparing it with other conventional method for waste water treatment.
4. Analysing the bio-hydrogen evolution from biomass under anaerobic condition

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