Optimization of Activated Charcoal Process At Tertiary Treatment of Effluent With Higher COD

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Abstract- *A treatability study on reduction of COD is to be carried out using Activated Charcoal. Activated charcoal holds an important role in tertiary treatment for the reduction of the waste water parameters. The two main principal mechanisms by which activated carbon reduces the contaminants from the waste water are adsorption and catalytic reduction, out of which our area of interest is adsorption. We are focusing more on the reduction of the refractory COD from the effluent as its presence tends to reduce the efficiency of the tertiary treatment units. Experimental set up for fixed bed adsorption unit consisting of Powdered Activated Charcoal (PAC) and Granular Activated Charcoal (GAC) was been carried out. Different grades of Activated charcoal were checked for the optimum grade. Finally, we optimized it with different the operating parameters like flow rate, bed height and contact time for getting the best COD reduction. Activated carbon adsorption method is found to be an effective method for reduction of COD. On an average the percentage COD reduction is found to be in the range of 75-80%. And along with COD reduction in NH_3-N is also found which is in the range of 49-51% along with slight increase in the value of pH. And as we are using activated carbon, reduction in colour is must.*

Keywords- COD, Adsorption, Efficiency, contaminants, activated charcoal

I. INTRODUCTION

Since the end of the last century a large amount of products, such as medicines, disinfectants, contrast media, laundry detergents, surfactants, pesticides, dyes, paints, preservatives, food additives, and personal care products, have been released by chemical and pharmaceutical industries threatening the environment and human health. Currently there is a growing awareness of the impact of these contaminants on groundwater, rivers, and lakes. Therefore the removal of emerging contaminants of concern is now as ever important in the production of safe drinking water and the environmentally responsible release of wastewater. Hence it is imperative that it should be treated to an environmental acceptable limit [3].

Chemical oxygen demand (COD) is defined as the amount of a specified oxidant that reacts with the sample under controlled conditions. Both organic and inorganic components of a sample are subject to oxidation, but in most cases the organic component predominates and is of the greater interest. If it is desired to measure either organic or inorganic COD alone, additional steps must be taken to distinguish one from the other. COD is a defined test; the extent of sample oxidation can be affected by digestion time, reagent strength and sample COD concentration. COD often is used as a measurement of pollutants in wastewater and natural waters [22].

Although very little investment has been made in the past on water treatment facilities, typically water supply and treatment often received more priority than wastewater collection and treatment. However, due to the trends in urban development along with rapid population increase, wastewater treatment deserves greater emphasis. Several research studies showed that, treated wastewater, if appropriately managed, is viewed as a major component of the water resources supply to meet the needs of a growing economy. The greatest challenge in implementing this strategy is the adoption of low cost wastewater treatment technologies that will maximize the efficiency of utilizing limited water resources and ensuring compliance with all health and safety standards regarding reuse of treated wastewater effluents [11]. Treatment options which are typically considered for the removal of emerging contaminants from drinking water as well as wastewater at tertiary level includes adsorption, Advanced Oxidation Processes (AOPs), ion exchange, electrochemical process, biological operations, cementation, chemical precipitation, solvent extraction, multi effect evaporators, Nanofiltration (NF), and Reverse Osmosis (RO) membranes. The adsorption processes do not add undesirable by products and have been found to be superior to other techniques for wastewater treatment in terms of simplicity of design and operation, and insensitivity of toxic substances. Among several materials used as adsorbents, Activated Carbons have been used for the removal of different types of emerging compounds in general but their use is sometimes restricted due to high cost. Furthermore when Activated Carbon has been exhausted, it

can be regenerated for further use but regeneration process results in a loss of carbon and the regenerated product may have a slightly lower adsorption capacity in comparison with the virgin-activated carbon. This has resulted in attempts by various workers to prepare low cost alternative adsorbents which may replace activated carbons in pollution control through adsorption process and to overcome their economic disadvantages. Recently natural materials that are available in large quantities from agricultural operations have been evaluated as low cost adsorbents and environmental friendly.
Moreover the utilization of these waste materials as such directly or after some minor treatment as adsorbents is becoming vital concern because they represent unused resources and cause serious disposal problems. A growing number of studies have been carried out in recent years to evaluate the behavior of emerging adsorbents such as agricultural products and by-product for emerging contaminants removal. On the other hand industrial wastes, such as, fly ash, blast furnace slag and sludge, black liquor lignin, red mud, and waste slurry are currently being investigated as potential adsorbents for the removal of the emerging contaminants from wastewater [12, 13].

This review presents the state of art of wastewater treatment by adsorption focusing in special way on removal of emerging contaminants like refractive COD [6].

Higher COD levels means greater amount of oxidizable organic material in the sample which accounts for the reducing DO levels in the water. This reduction in DO leads to anaerobic conditions which can be deleterious to the higher aquatic life forms. Low (generally >3 mg/L) dissolved oxygen, causes reduced cell functioning, disrupts circulatory fluid balance in aquatic species and can result in death of individual organisms, as well as large “dead zones”. Hypoxic water can also release pollutants stored in sediments. Also the presence of refractory COD in the effluent tends to accelerate bacterial growth in the rivers and consumes the oxygen levels in the river and reduces the efficiency of the other tertiary treatment units [2, 4].

Many conventional treatment methods have been used for COD reduction such as ion exchange, reverse osmosis, membrane filtration, etc. but the cost involved in all these methods have been reported to be very high. Of the tertiary treatment methods existing, adsorption has been proven to be effective due to the lesser land requirement and flexibility in raw material use. Adsorption involves utilization of several agricultural or industrial materials which if not properly disposed, adds to pollution; for the development of suitable carbonaceous substances which are to be used for treating water and waste water [1].

II. MATERIALS USED

For COD measurement-

- Effluent from the overflow of the secondary clarifier Activated Charcoal (GAC & PAC)
- Distilled Water
- Mercuric Sulphate
- Sulfuric Acid
- Potassium Dichromate
- Ferrous Ammonium Sulphate
- Ferroin Indicator

For Ammonical Nitrogen measurement-

- Mixed Indicator solution
- Boric acid
- H_2SO_4 solution
- NaOH solution
- Borate buffer

III. APPARATUS

- Round bottom flask
- Measuring cylinder
- Conical Flasks & Beakers
- Burette & Pipette
- Spatula
- Refluxing flasks
- Glass column
- Heating mantle
- Water condenser
- Pump
- COD digester
- Distillation apparatus
- Weighing balance

IV. PROCEDURE

1. Firstly, we have selected two types of Activated Charcoal according to its size i.e. granular and powdered form, for reduction of COD.
2. Then we mixed both of the Activated Charcoals for experimental work in order to get better reduction efficiency.
3. Experiments were performed at different conditions.
4. 1st Condition- Performing the experiment for determining COD values at a fixed Bed height of 50 cm & at varying flow rates, so after the calculations and result analysis we can get the optimum flow rate for efficient reduction of COD.

5. 2nd Condition- Performing the experiment for determining COD values at a fixed Flow rate of 0.3 m^3/hr & at varying bed heights, so after the calculations and result analysis we can get the optimum bed height for efficient reduction of COD.
6. 3rd Condition- Performing the experiment for determining COD values at fixed optimum Bed height & at fixed optimum flow rate, so after the calculations and result analysis we can get the overall percentage reduction of COD at optimum parameters by taking samples for testing at an interval of every 30 minutes.
7. 4th Condition- Performing the experiment for determining NH_3-N values at fixed optimum Bed height & at fixed optimum flow rate, so after the calculations and result analysis we can get the overall percentage reduction of NH_3-N at optimum parameters by taking samples for testing at an interval of every 30 minutes.
8. 5th Condition- Performing the experiment for determining COD values after recycling the effluent for various times to check for better reduction of COD and exhaustion of the bed.
9. 6th Condition- Performing the experiment for determining COD values at varying Flow rates and varying bed heights, so after the calculations and result analysis we can get the optimum flow rate for the bed height for efficient reduction of COD.
   The basic aim of the study is to get the value of COD under its discharge limit i.e. <250 mg/lit. Thus, determining the optimum flow rate for a given height for getting the best COD reduction.
10. Hence, after performing the experiments at the different conditions we can calculate the COD concentrations and through result analysis we can the optimum range for different parameters and we can also find the overall reduction efficiency of this treatment technology.

V. OBSERVATION TABLES

1st condition- Burette Readings for determining COD values at a fixed Bed height of 50 cm & at varying flow rates

Table-1 Observation table for 1st condition

Sr. No.	Flow Rate (m^3/hr)	Burette Reading (FAS) for Initial COD (ml)	Burette Reading (FAS) for Final COD (ml)
1.	0.30	12.1	17.9
2.	0.35	12.1	17.5
3.	0.40	12.1	16.9

2nd condition- Burette Readings for determining COD values at a fixed Flow rate of 0.3 m^3/hr & at varying bed heights

Table-2 Observation table for 2nd condition

Sr. No.	Bed Height (cm)	Burette Reading (FAS) for Initial COD (ml)	Burette Reading (FAS) for Final COD (ml)
1.	50	12.4	17.4
2.	60	12.4	18.2
3.	70	12.4	19.0
4.	80	12.4	20.1

3rd condition- Burette Readings for determining COD values at a fixed Flow rate of 0.3 m^3/hr & at fixed Bed height of 80 cm

Table-3 Observation table for 3rd condition

Sr. No.	Time (min)	Burette Reading (FAS) for COD value (ml)
1.	0	12.1
2.	30	16.4
3.	60	17.4
4.	90	19.1
5.	120	20.1
6.	150	20.2

4th condition- Burette Readings for determining NH_3-N values at a fixed Flow rate of 0.3 m^3/hr & at fixed Bed height of 80 cm

Table-4 Observation table for 4th condition

Sr. No.	Time (min)	Burette Reading (H_2SO_4) for NH_3-N value (ml)
1.	0	7.6
2.	30	6.6
3.	60	5.7
4.	90	5.2
5.	120	4.4
6.	150	3.7

5th condition- Burette Readings for determining COD values at different number of cycles

Table-5 Observation table for 5th condition

Sr. No.	No. Of cycles	Burette Reading (FAS) for COD value (ml)
1.	1	18.2
2.	2	19.6
3.	3	19.7
4.	4	19.7

6th condition- Burette Readings for determining COD values at varying Bed heights and varying flow rates

Table-6 Observation table for 6th condition

Sr. No.	Bed Height (cm)	Flow rate (m^3/hr)	Burette Reading (FAS) for Initial COD (ml)	Burette Reading (FAS) for Final COD (ml)
1.	80	0.3	12.1	18.1
		0.2	12.1	18.4
		0.1	12.1	18.7
2.	70	0.2	12.1	17.8

VI. CALCULATIONS

For COD measurement-

$$COD\ as\ mg/L\ of\ O_2\ consumed = \frac{(A-B) \times Normality\ of\ FAS \times 8000}{Vol.\ of\ sample\ taken\ (ml)}$$

Where,
A = ml of FAS used for titration of blank
B = ml of FAS used for titration of sample

For NH_3-N measurement-

$$Amonical\ Nitrogen\ (mg/L) = \frac{Burette\ reading \times 280}{ml\ of\ sample}$$

VII. RESULT ANALYSIS

1st condition- COD concentrations at a fixed Bed height of 50 cm & at varying flow rates

Table-7 Result analysis for 1st condition

Sr. No.	Flow rate (m^3/hr)	Initial COD concentration (mg/L)	Final COD concentration (mg/L)
1.	0.30	880	410
2.	0.35	880	445
3.	0.40	880	490

As we have got the maximum COD reduction at the least flow rate, we can say that the optimum flow rate for better COD reduction would be, **Q = 0.3 m^3/hr**.

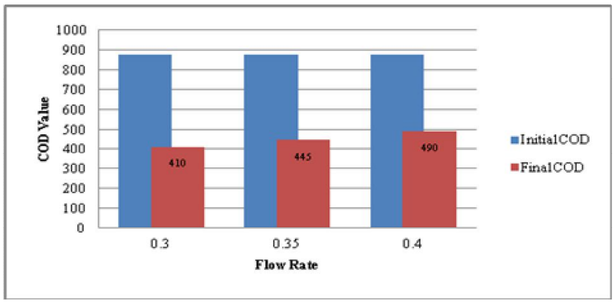

Fig-1 Result analysis for 1st condition

2nd condition- COD concentrations at a fixed Flow rate of 0.3 m^3/hr & at varying bed heights

Table-8 Result analysis for 2nd condition

Sr. No.	Bed Height (cm)	Initial COD concentration (mg/L)	Final COD concentration (mg/L)
1.	50	850	450
2.	60	850	390
3.	70	850	315
4.	80	850	240

As we have got the maximum COD reduction at the maximum bed height as it gets sufficient contact time to react with the contaminants, we can say that the optimum bed height for better COD reduction would be, **H = 80 cm.**

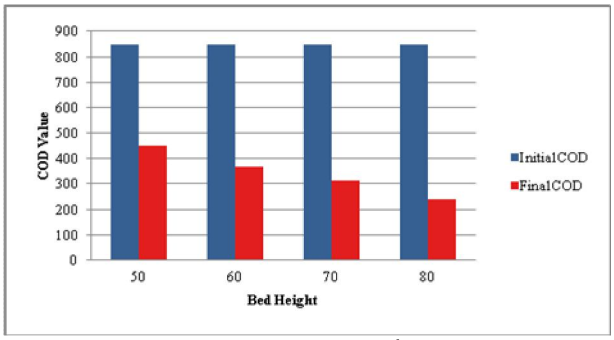

Fig-2 Result analysis for 2nd condition

3rd condition- COD values at a fixed Flow rate of 0.3 m^3/hr & at fixed Bed height of 80 cm

Table-9 Result analysis for 3rd condition

Sr. No.	Time (min)	COD concentration in the effluent (mg/L)
1.	0	880
2.	30	535
3.	60	450
4.	90	320
5.	120	240
6.	150	235

At optimum flow rate and bed height we get quite good overall COD reduction which is approximately **73-75 %**.

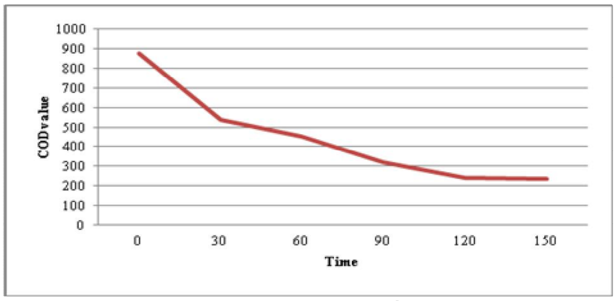

Fig-3 Result analysis for 3rd condition

4th condition- NH_3-N values at a fixed Flow rate of 0.3 m^3/hr & at fixed Bed height of 80 cm

Table-10 Result analysis for 4th condition

Sr. No.	Time (min)	NH_3-N concentration in the effluent (mg/L)
1.	0	43
2.	30	37
3.	60	32
4.	90	29
5.	120	25
6.	150	21

At optimum flow rate and bed height we get quite good overall NH_3-N reduction which is approximately **49-51 %**.

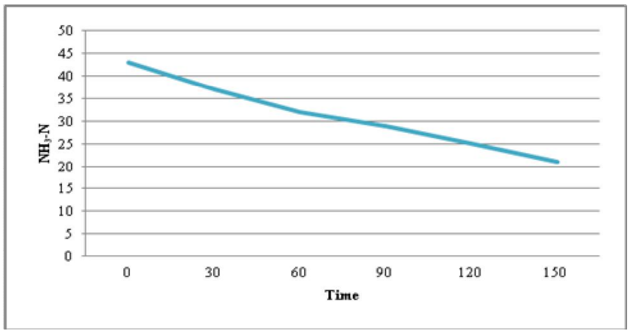

Fig-4 Result analysis for 4th condition

5th condition- COD values at different number of cycles

Table-11 Result analysis for 5th condition

Sr. No.	No. Of cycles	COD concentration in the effluent (mg/L)	COD reduction (%)
1.	1	390	54
2.	2	275	68
3.	3	260	70
4.	4	257	71

The initial COD concentration of the effluent was found to be 850 mg/L and we can see change in the COD concentration after the number of cycles by recycling the effluent back into the column and making a system act as a continuous system.

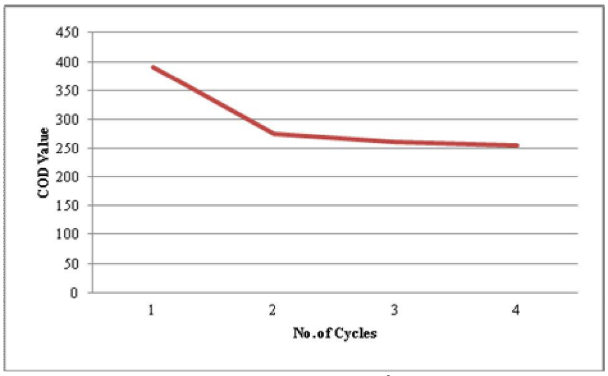

Fig-5 Result analysis for 5th condition

6th condition- COD concentrations at a fixed Flow rate of 0.3 m^3/hr & at varying bed heights

Table-12 Result analysis for 6th condition

Sr. No	Bed Height (cm)	Flow rate (m^3/hr)	Initial COD concentration (mg/L)	Final COD concentration (mg/L)	Overall COD Reduction (%)
1.	80	0.3	880	250	72
		0.2	880	228	74
		0.1	880	205	77
2.	70	0.3	880	315	64
		0.2	880	277	68

The maximum reduction of COD and getting it in the discharge limit of <250 mg/L we need to keep the flow rate as low as possible. For bed height of 80 cm it is achieved at flow rate of 0.1 m^3/hr and for the bed height of 70 cm we couldn't find the COD reduction within its discharge limit at flow rate of 0.2 m^3/hr.

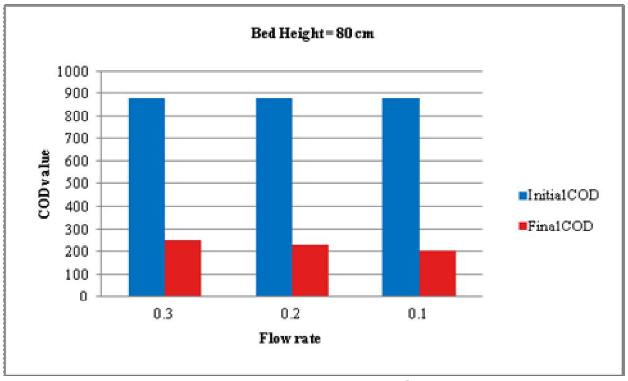

Fig-6A Result analysis for 6th condition

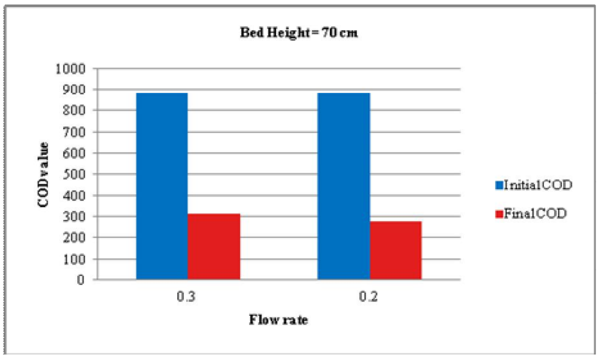

Fig-6B Result analysis for 6th condition

VIII. CONCLUSION

The treatability study for reduction of COD was done and the conclusion is presented here. Many grades of activated charcoals were tested and one amongst them was fixed. Then the different types of effluents were tested with the activated charcoal for calculating the COD reduction. Then we had tried for optimizing the different operating parameters like flow rate which was found to be around 0.3 m^3/hr, bed height which was around 80 cm and the number of cycles that was found to be 2-3 on experimental level.

We have also concluded that for getting the effluent COD within the discharge limits i.e. <250 mg/L at the optimum bed heights we need to keep the flow rate as low as possible for enhancing the contact flow time for best reduction.

Hence, we can conclude that we get the best COD reduction when we have the minimum flow rate of the effluent and optimum bed height so as to provide enough contact time to the effluent to react with the activated carbon. Thus, we can state that flow rate is inversely proportional and bed height is directly proportional to the COD reduction.

Activated carbon adsorption method is found to be an effective method for reduction of COD. On an average the percentage COD reduction is found to be in the range of 75-80%. And along with COD reduction in NH_3-N is also found which is in the range of 49-51% along with slight increase in the value of pH. And as we are using activated carbon reduction in colour is must.

There is still scope for research in order to reduce physico-chemical parameters economically by using low cost adsorbent. The activated charcoal adsorption technique is also quite effective method in reduction of refractive COD from the waste water.

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