



INDUSTRIAL EFFLUENT TREATMENT BY ADSORPTION

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ABSTRACT

Discharge of untreated pulp & paper effluent creates a serious wastewater problems. Adsorption of activated carbon is a mutual method for removal of color industrial effluent. In this study is to exam the effectiveness of BT an absorbent in removal of colour in contaminated water. Activated carbon were prepared from Banana Trunk using chemical activation. Characterization of adsorbents were analyzed with TGA, FTIR. The effects of pH, dosage and time of contact were studiedfor batch experiments. Maximum percentage removal (89.3%) of color was obtained at optimized pH 6, contact time (tc) of 180 mins, dosage (dc) of 3mg, respectively. The maximum percentage removal of pollutants was at acidic pH 6 (BT). At pH 6 the removal of COD, TDS, TSS and colour were observed to be 93.2%, 86%, 82.6% and 89.3%.

KEYWORDS: Banana Trunk, adsorbent, Effluent, Adsorption.

INTRODUCTION

The Pulp and Paper industries consumed enormous amount of water (905.8 million m³) and discharged around 695.7 million m³ of waste water per year (NPC, New Delhi, 2006) which denote the seriousness of the problems caused by this sector. Water system in India is greatly contaminated by paper mill effluents. During the past few decades, this activity has experienced a significant improvement in global and it is estimated to increased by 77% from 1995 to 2020 (OECD, 2001). Pulp and paper mill liberate heavily loaded waste in to surrounding environment (Anonymus, 1999; Baruah and Das, 2001) which are mainly come out from pulping and bleaching process.

Pulp and paper mill industry generates a significant amount of wastewater containing high concentration of lignin causing brown color and COD (Environmental Technology Office, 2000). Survey conducted by NEERI, Nagpur that nearly 70% of water in India is polluted (Martin, 1998). Thermal and Steel industries are the highest purveyors to annual industrial wastewater discharge. The Pulp and Paper industry occupy the third rank it is among the 20 high polluting industries (Bajpai and Bajpai, 1997). The present study deals with the treatment of wastewater from paper industry.

2. MATERIAL AND METHODS

Standard solutions of Disodium Ethylene Diamine Tetra Acetate Hydrate (Fisher Scientific) (0.1M), Buffer solution (pH 4.0, 9.2 and 10.0), Eriochrome black T indicator (Fisher Scientific), HCl (Fisher Scientific)

(0.1N), Starch (SLR), sodium thio- sulphate (Ranbaxy), Sodium hydroxide NaOH (Fisher Scientific) (0.5M) and Phosphoric acid (Fisher Scientific), Sulphuric acid (RFCL), Acetic acid (Merck), Iodine (Spectrum), Methyl Violet (CDH), Methylene Blue (CDH), Ferrous ammonium sulphate (Merck) and Double distilled water (Model distillery) were purchased. The Banana Trunk (BT) was collected from local market Saidapet, Chennai.

2.1. PREPARATION OF BIOMASS

Banana Trunk were collected, several times washed with de-ionized water and dried in hot air oven at 110°C for 24 hours. The samples were grounded to fine powder and sieved to mesh size of 100µm. The prepared biomass further used for chemical activation.

2.2. PREPARATION OF ACTIVATED CARBON

Activated carbon was prepared by carbonization method. For this, the test samples biomass were divided into three parts (BT). The first part of Banana Trunk (BT) mixed with 10% phosphoric acid (H₃PO₄) (100 g sample + 100 mL of H₃PO₄, (wt /v) and the second part of Banana Trunk mixed with 10% sulphuric acid (H₂SO₄) (100 g sample+100 mL of H₂SO₄) and third part of Banana Trunk mixed with 10% Acetic acid (CH₃COOH) (100 g sample+100 mL of CH₃COOH). The treated samples were carbonized at 350°C (BT) for 2 hours in an electric muffle furnace. After activation, the mixture was taken from the furnace and allowed to cool at room temperature. The obtained carbon washed several times with de-ionized hot water until a neutral pH was achieved. Later the wet carbon was dried in an electric

oven at 110°C for 24 hours [P. Sugumaran, et al., (2012)].

2.3. COLLECTION OF EFFLUENT

Raw effluent was collected from the paper mill Gobichettipalayam. The effluent was collected in 5litre plastic container and preserved at 4°C to prevent any change. Physicochemical characteristics of the effluent such as pH, total solids, Hardness, colour, BOD and COD was analyzed.

3. RESULTS AND DISCUSSION

3.1. CHARACTERIZATION OF PAPER EFFLUENT

The effluent generated from the paper mill industry consists of white water from stock preparation, paper machine and from the bleach section etc. This study has been carried out by collecting the colored effluent in which pH, COD, BOD, TDS, TSS and Hardness were analyzed before treatment and it was compared with the standard values. The obtained results were exited the permissible limit.

Table: 3.1 Preliminary properties of effluent

PARAMETER	PERMISSIBLE LIMIT	OBTAINED VALUES
Colour absorbance at 751nm	-	3.5
Turbidity (NTU)	30 NTU	562 NTU
pH	5.5 to 9	5.72
Hardness	100 mg/l	861.68 mg/l
TDS	2100 mg/l	15,842 mg/l
TSS	5 mg/l	9000 mg/l
Electrical conductivity	-	22.4 μ s/cm
COD	250 mg/l	39360 mg/l
BOD	50 mg/l	2500 mg/l

Table: 3.2.CHARACTERIZATION OF ACTIVATED CARBON

PARAMETERS	VALUES
Carbon yield	56%
Moisture content	7 %
Ash content	1.7 %
Volatile matter content	5.138 %
Fixed carbon	86.162
Methylene blue	120 mg/g
Methyl violet	30 mg/g
Iodine No	986.2 mg/g
Zero potential charge	4

3.3. THERMO GRAVIMETRIC ANALYSIS

Thermo gravimetric analysis was carried out by using TA instrument (SDT Q 600, M/S TA Instruments, USA). Figure 3.1 revealed that a sharp thermal transition in the temperature range of 313.88°C and start to decrease 340.31°C. Banana trunk (BT) weight lost by 8.196%, 43.17%, 7.276% and 21.189% at 191.72°C, 313.88°C, 456.55°C and 630.64°C respectively.

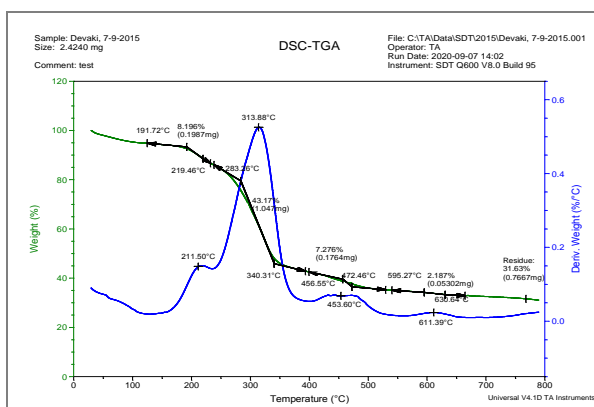
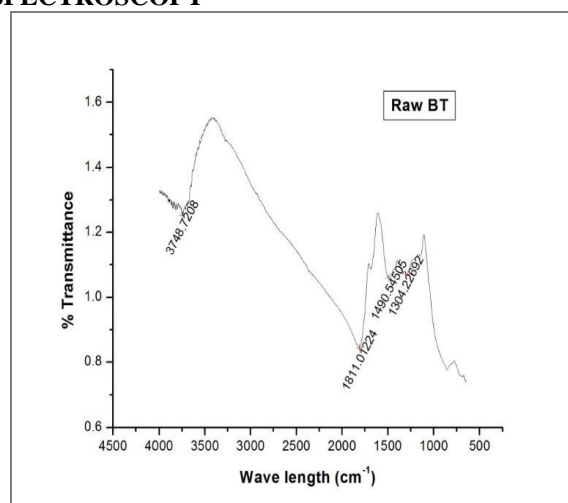


Fig: 3.1 TGA/DTG analysis for biomass sample (BT)

3.4 FOURIER TRANSFORM INFRARED SPECTROSCOPY



FTIR spectrum of banana trunk biomass shown in Fig 3.2 (a). In Banana Trunk biomass wave length at 1490.54505 cm^{-1} and 1304.2262 cm^{-1} are stretched in C-C stretch and C-O stretch.

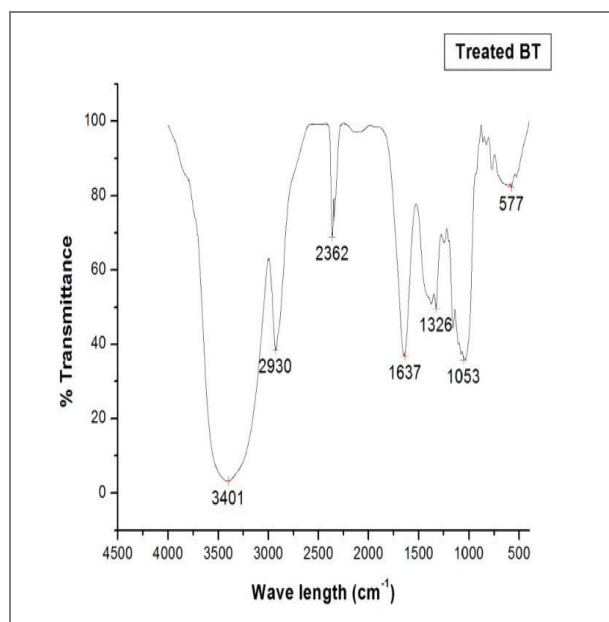


Fig: 3.2 (b) FTIR spectrum of banana trunk (H_3PO_4)

Based on the FTIR spectrum of banana trunk shown in Fig 3.2 (b), there were three different absorption peaks were detected. The peak at 2930 cm^{-1} represents the O-H functional group. The absorption band at 3401.2 cm^{-1} and 1637 cm^{-1} occurred for primary amine N-H functional group while the carboxylic acid (-COOH) group were detected at 1053 cm^{-1} wavelength. The peak at 1326 cm^{-1} represents the C-N stretch. Previous study (Nurzulaif Shaheera, et al.,) had stated that hydroxyl and carboxylic acid groups played a major role in the adsorption process. According to (Nurzulaif Shaheera, et al.,) study the hydroxyl group and carboxylic acid groups are highly effective towards adsorption rate and efficient through the removal. Meanwhile, the carboxylic acid group is relatively high absorption rate due to the presence of more negatively charged groups on its surface.

3.6. BATCH ADSORPTION EXPERIMENT

3.6.1. EFFECT OF CONTACT TIME

The contact time among the pollutant and the adsorbent is of substantial requirement for the treatment of waste water by adsorption. Adsorption studies reveal that the uptake of adsorbate species is fast at the initial stages of the contact period, and afterwards, it becomes gentler near the equilibrium. The effect of contact time on COD, TDS, TSS and colour removal at constant adsorbent dosages were studied. At this the pH of the wastewater was measured as 5.72 and their results were represented in Fig 3.3 – 3.7. From the below shows the result, it is evident that the optimum contact time for adsorption was found to be 3 hours.

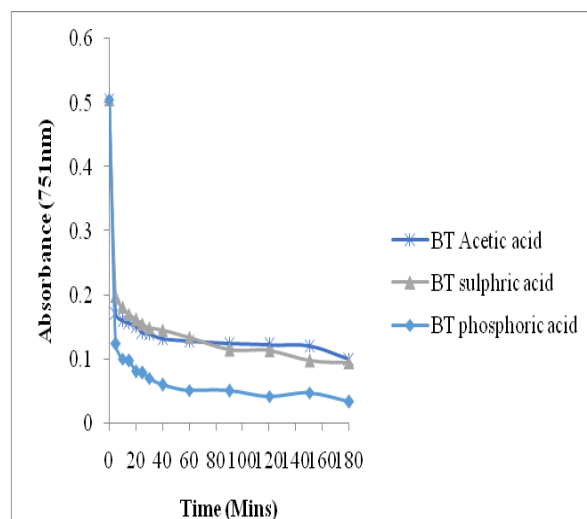


Fig: 3.3 Effect of contact time on color removal (Condition: carbon dosage 0.5, contact time 0-3 hours and agitation speed 110 rpm)

Fig 3.3 shows between Absorbance Vs time. An effect of contact time on color removal when increase the contact time the absorbance also increased. The removal of color in contact time on BT(H_3PO_4), BT(H_2SO_4), BT(CH_3COOH) were 93.3%, 88%, 81.2%, 70%, 67% and 62.5%.

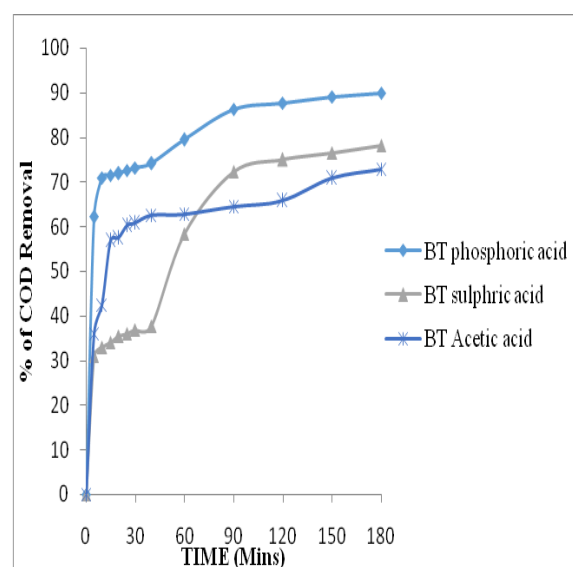


Fig: 3.4 Effect of contact time on % of COD removal (Condition: carbon dosage 0.5g, contact time 0-3 hours and agitation speed 110 rpm)

Fig 3.4 shows between percent of COD removal Vs time. An effect of contact time on % of COD removal when increase the contact time the % removal also increased. The removal of COD in contact time on BT(H_3PO_4), BT(H_2SO_4), BT(CH_3COOH), were 90%, 78%, 65%.

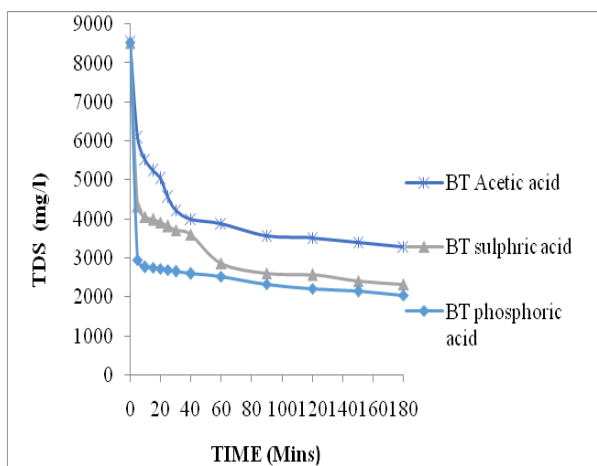


Fig: 3.5 Effect of contact time on TDS removal (Condition: carbon dosage 0.5g, contact time 0-3 hours and agitation speed 110 rpm)

Fig 3.5 shows between TDS Vs time. An effect of contact time on TDS removal when increase the contact time the TDS also increased. The removal of TDS in contact time on BT(H_3PO_4), BT(H_2SO_4), BT(CH_3COOH), were 76.1%, 72.7%, 71.2%.

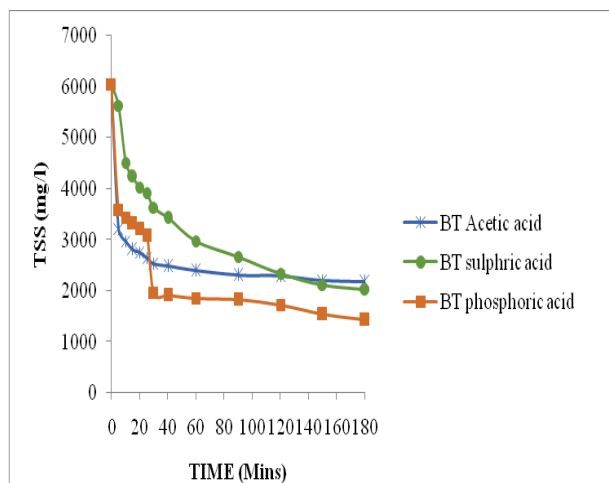


Fig: 3.6 Effect of contact time on TSS removal (Condition: carbon dosage 0.5g, contact time 0-3 hours and agitation speed 110 rpm)

Fig 3.6 shows between TSS Vs time. An effect of contact time on TSS removal when increase the contact time the TSS also increased. The % removal of TDS in contact time on BT (H_3PO_4), BT(H_2SO_4), BT(CH_3COOH), were 76.4%, 71.4%, 66.5.

By comparing the above activating agents, phosphoric acid enhances the adsorption capacity with other acids. So Phosphoric acid was treated to develop active sites in carbon and it is used for further experiments.

4.4.2 EFFECT OF ADSORBENT DOSAGE

In this studies, dosage of an adsorbent is avital factor as it determines the capacity of the adsorbent to engage the pollutants. The adsorption capacity was found to increase by increasing the adsorbent dosage. The experimental

results of COD, TDS, TSS and color removal at varying dosages of adsorbent (0.5 - 3g) at an optimum contact time of 3 hours without pH adjustment (5.72) are represented in the graphs (Fig 3.7 - 3.10) for BT (H_3PO_4).

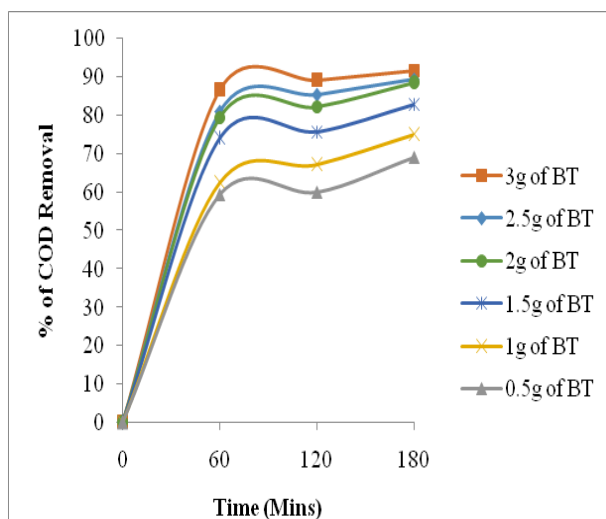


Fig: 3.7 Effect of dosage on % of COD removal (Condition: carbon dosage 0.5g - 3g, contact time 3 hours and agitation speed 110rpm)

Fig 3.7 shows between % of COD removal Vs time. An effect of dosage on % of COD removal when increase the dosage rate the % removal also increased. The removal of COD at 3g on BT was 91.6%.

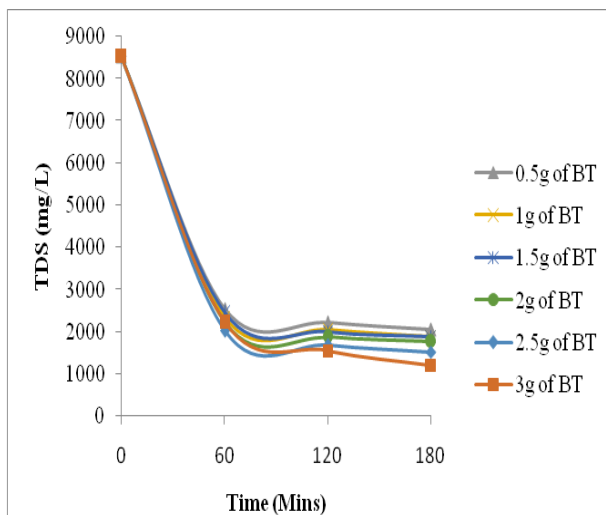


Fig: 3.8 Effect of dosage on TDS removal (Condition: carbon dosage 0.5g - 3g, contact time 3 hours and agitation speed 110rpm)

Fig 3.8 shows between TDS removal Vs time. An effect of dosage on TDS removal when increase the dosage rate the % removal also increased. The removal of TDS at 3g on BT was 85.9%.

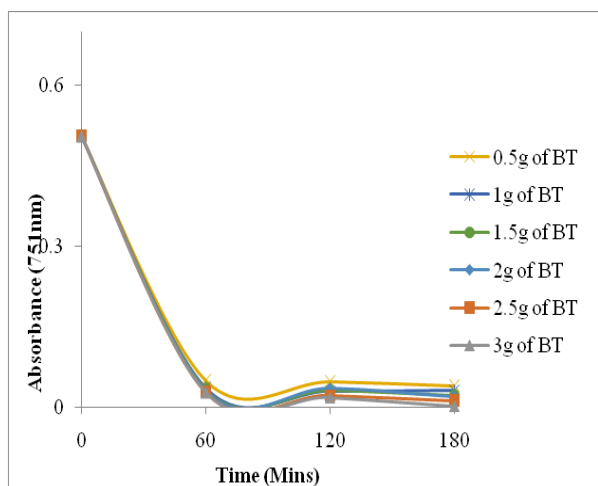


Fig: 3.9 Effect of dosage on color removal (Condition: carbon dosage 0.5g – 3g, contact time 3 hours and agitation speed 110 rpm)

Fig 3.9 shows between color removal Vs time. An effect of dosage on color removal when increase the dosage rate the % removal also increased. The removal of color at 3g on BT was 99.6%.

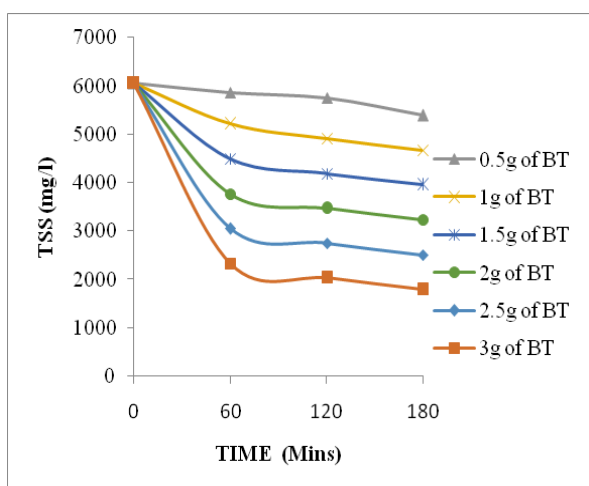


Fig: 3.10 Effect of dosage on TSS removal (Condition: carbon dosage 0.5g – 3g, contact time 3 hours and agitation speed 110 rpm)

Fig 3.10 shows between TSS removal Vs time. An effect of dosage on TSS removal when increase the dosage rate the % removal also increased. The removal of color at 3g on BT was 70.4%.

4.4.3 EFFECT OF pH

pH is also an key parameter to be considered during adsorption studies. pH affects adsorption by regulating the adsorbent surface charge as well as the degree of ionization of various pollutants present in the solution. Change of pH affects the adsorption process through separation of functional groups on the adsorbent surface active sites. The adsorption of pollutants by BT and BEFB were studied over a pH range of 2-12 and studies were carried out for 3 hour and 3 gram of activated carbon. The maximum percentage removal of pollutants was at acidic pH 6 (BT).

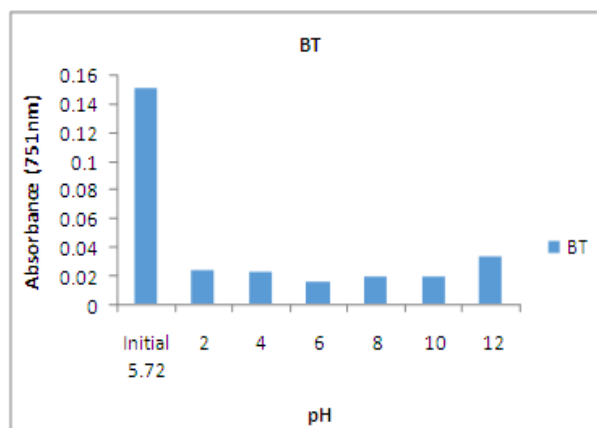


Fig: 3.11 Effect of pH on color removal (Condition: carbon dosage 3g contact time 3 hours pH 2-12 and agitation speed 110rpm)

Fig 3.11 shows between color removal Vs pH. An effect of pH on color removal when depending up on the pH. The removal of colour at 3g pH 6 on BT was 96.8.

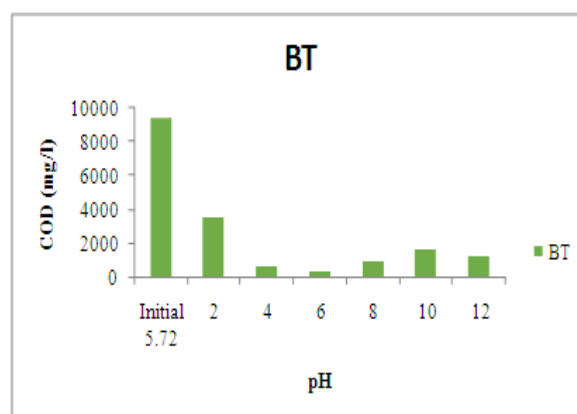


Fig: 3.12 Effect of pH on COD removal (Condition: carbon dosage 3g, Contact time 3 hours, pH 2-12 and agitation speed 110 rpm)

Fig 3.12 shows between COD removal Vs pH. An effect of pH on COD removal when depending up on the pH. The removal of COD at 3g pH 6 on BT was 96.57%

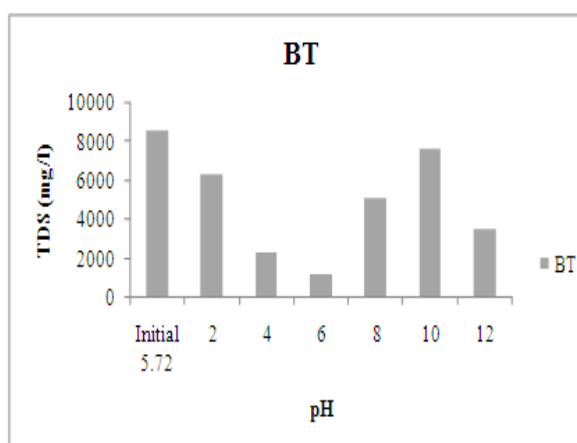


Fig: 3.13 Effect of pH on TDS removal (Condition: carbon dosage 3g, contact time 3 hours, pH 2-12 and agitation speed 110 rpm)

Fig 3.13 shows between TDS removal Vs pH. An effect of pH on TDS removal when depending up on the pH. The removal of TDS at 3g pH 6 on BT was 86% and BEFB.

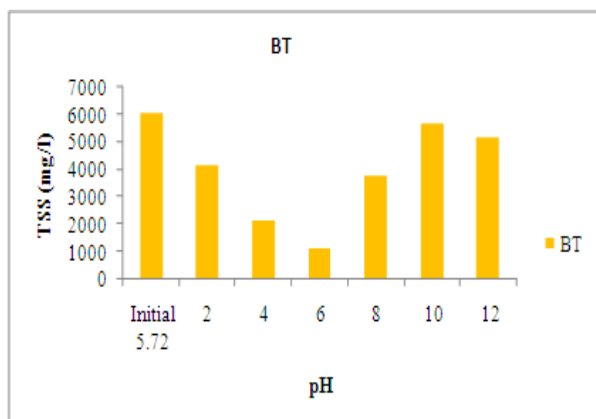


Fig: 3.14 Effect of pH on TSS removal (Condition: carbon dosage 3g, contact time 3 hours, pH 2-12 and agitation speed 110 rpm)

Fig 3.14 shows between TSS removal Vs pH. An effect of pH on TSS removal when depending up on the pH. The removal of TSS at 3g pH 6 on BT was 82.6

The above results confirm that the carbon impregnated with H_3PO_4 for BT has higher performance compared with BEFB. As in above case BT shows good performance in acidic condition and BEFB shows higher performance in alkaline condition.

CONCLUSION

Activated carbons were prepared from the carbonization of banana trunk at $350^\circ C$ by chemical activation with H_3PO_4 , H_2SO_4 and CH_3COOH . Batch adsorption experiments were carried out and the maximum the removal of COD, TDS, TSS and color were observed to be 96.57%, 86%, 82.6% and 96.8% with the dosage of 3mg/50ml in 180 minutes at pH 6. All physical-chemical parameters almost attain the permissible limits. Thus it can be concluded that adsorption method for removal of color is quite efficient methods and can be applied for the removal of color from effluent successfully and economically.

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