Comparative Study on Removal of Oil And Grease By Adsorption Using Banana Pith And Honeycomb As Adsorbent

Yashas S R[1], Pavithra P[2], Arpitha B S[3], Mohammad Sufiyan[4], Jayantha K S[5]
[1, 2, 3, 4, 5] Dept of Civil Engineering
[1, 2, 3, 4, 5] Malnad College of Engineering, Hassan, Karnataka, India.

Abstract- *Eco toxicity specifically from water sources, on living organisms has become a prime concern for the last few decades. Oil field is responsible for more than 60% of daily produced water waste generated worldwide, and is one of the burning issues which need to be given highest priority in order to save the mankind from serious water borne diseases. The present study is an attempt to exhibit the adsorption phenomena of two naturally occurring, easily available and cost effective bio sorbents which are honey comb and banana pith in the process of removal of oil and grease from the synthetic wastewater sample which resembles the wastewater composition obtained from the automobile service stations. This study employs fabricated adsorption column analysis of the synthetic wastewater and tests to evaluate residual oil and grease along with pH, Turbidity, and TDS. The efficiency of oil and grease removal by bio sorbents is monitored for various heights of adsorbent with constant flow rate with respect to time in the continuous flow system. The potency of these two adsorbents in the effective removal of oil and grease from the synthetic wastewater is examined and results are analyzed. This concept has found to be successful, which has explored a new approach of development in the field of wastewater treatment through cheaper, environmentally benign and economic 'green bio sorbents'. The maintenance incurred is very low compared to other systems. Close study of its economic viability, this can be conveniently employed in the treatment of wastewater from automobile service stations, restaurants, kitchens, oil mills and other industries as pre-treatment unit.*

Keywords- Adsorption, Banana pith, Honeycomb, Oil and grease, wastewater.

I. INTRODUCTION

It is observed that wastewater from vehicle service stations which are run by state and private agencies contribute significantly to pollution. Improper and unscientific methods adopted in the disposal and treatment has resulted in excessive pollution. This has become matter of great concern over the years. In addition there are no efforts being made to treat this wastewater efficiently to the maximum extent and save it and reuse for different purposes. Since oil is virtually insoluble in water, it floats and spreads rapidly and forms thin film on the water surface which prevents oxygen transfer from the atmosphere and leads to low dissolved oxygen levels in the water due to microbial oxidative attack on hydrocarbon molecules. If present in excess it may interfere with aerobic and anaerobic biological process, leading to decreased wastewater treatment efficiency. Present day techniques to remove oil and grease are to use skimming tanks, oil and grease traps and interceptors in treatment plants.

In this present study attempt has been made to compare the adsorption capability of the two bio sorbents namely banana pith and honey comb in removing the oil and grease present in wastewater.

II. MATERIALS AND METHODS

A. Banana pith and Honey comb as adsorbents

Banana pith was procured from the farm near by Hassan city, Karnataka India. It is the pith of the plant collected once the crop is harvested, which is merely a waste and used for composting. Present study has identified banana pith as an adsorbent for this study based on the literatures which reveals it as a cellulose rich material which show high inclination towards the adsorption. The principle constituents of banana pith are cellulose, hemi-cellulose and lignin which are the triggering factor for oil and grease adsorption. Also banana pith is cost effective, eco-friendly and biodegradable material. The banana pith is washed to remove the dirt and debris of soil. It is then cut to small pieces approximately less than 1 cm cubes. It is stored in a cool place and should be used within a day once it is cut. The honeycomb was collected from nearby places after the bees have left the hive but the honeycomb structures are retained as such. The unique hexagonal structure and the property of lower pressure drop in honeycomb helps in entangling oil and grease in wastewater.

Honeycomb is an easily available material and the structure as such provides greater surface area for adsorption in its raw form. Figure 1 and Figure 2 shows the materials used in study.

Fig 1. Raw form of banana pith and honeycomb

Fig 2. Banana pith cut into small pieces

B. Preparation of synthetic wastewater

Since this project deals with the new approach for the adsorption of oil and grease in the wastewater with two new bio sorbents, the adsorption studies were carried out with generating the synthetic wastewater. The waste oil generated after the engine oil change process or repairs of the automotive parts is collected from the automobile service stations, which would wash away after the water wash of the vehicle. The dosage of the oil and grease was varied to see the performance of the adsorbents. Total of four different concentration of oil and grease was adopted namely, 75ml/liter, 100 ml/liter, 125 ml/liter, and 150 ml/liter. Calculated amount of tap water was taken to which the calculated amount of oil and grease was added and stirred constantly for the column studies.

C. Fabrication of the Adsorption column

A column was fabricated to carry out the adsorption process in a controlled manner. A PVC pipe of 1.5 inch of length 0.5m with one end sealed was made. A tap was fitted at the sealed end to collect the sample after passing through the adsorbent and grated metal plate was inserted at the bottom of pipe to prevent the blockage at inlet of tap inside the column. The pipe was marked of different height like 10cm, 20cm, up to 50cm. Two containers of 25 liter capacity were used. One of which was the feed tank and other was the buffer tank to maintain the constant head for the column study. The tap opening positions were marked for the constant discharge from the feed tank. The exact experimental set up is as shown below in Figure 3.

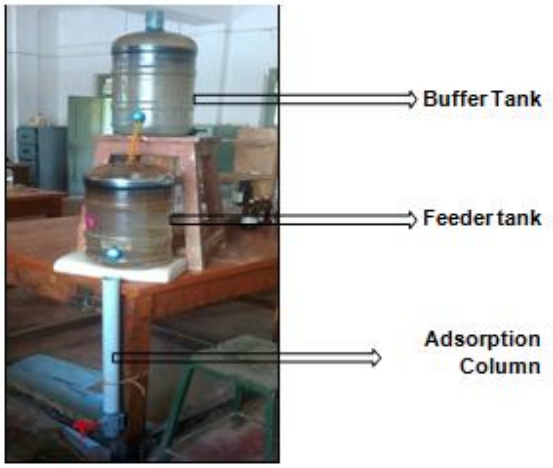

Fig 3. Experimental setup for the adsorption studies carried out

D. Procedure for estimating oil and grease

1. Collect 100 ml of test sample.
2. Add Sulphuric acid (1:2) to make the pH between 3.0 - 4.0 (acidic)
3. Add 100ml of petroleum ether to the sample and transfer it to a 250ml separating funnel.
4. Mix the contents well and allow it to settle for 5 minutes. The water layer and the petroleum ether layer separate out.
5. Collect the petroleum ether layers in a clean pre-weighed beaker using the filter paper to remove the suspended solids.
6. Evaporate solvent by heating on a water bath. Dry the dish and weigh the beaker for knowing the residual oil and grease in it.

Calculations: Oil and Grease in the Given Sample of Sewage,

$$C_L = \frac{(W_2 \quad W_1) * 1000}{V}$$

Where= Differential weight (g) and V= Volume of sample taken (ml).

Calculation of: Percentage (%) removal of oil and grease,

$$C_1 = \frac{(C_0 - C_1) * 100}{C_0}$$

Where, C_0= initial concentration of oil and grease (g/l) and C_1= final concentration of oil and grease (g/l).

III. RESULTS AND DISCUSSIONS

The experiment was conducted with an aim to find out percentage removal of oil and grease by banana pith and honeycomb. For this, different heights of adsorbent material i.e. 10cm, 20cm, 30cm, 40cm and 50cm were taken with constant discharge of 315 ml/min and varying dosages of 75ml/liter, 100ml/liter, 125ml/liter, and 150ml/liter. Further the test samples were collected at every 40 seconds interval i.e. 40 to 200 seconds in a continues flow system and analyzed for concentration of the oil and grease by the above mentioned procedure. Based on the observations, graphs of time versus percentage removal of oil and grease were generated and analyzed. pH, turbidity, and Total Dissolved Solids (TDS) were found using digital pH meter, nephelo turbidity meter, digital TDS meter respectively.

1. *Results for 75ml/liter i.e. (67.425 g/l) of initial oil and grease dosage.*

1.1 Study with banana pith as adsorbent.

Form Table.1, the results for 67.425g/l of initial oil and grease concentration with 10 cm of adsorbent material in the column, the maximum percentage removal was found to be 73.52 for first interval i.e.40 seconds. As the time passed, removal efficiency decreased and adsorbent material got saturated. The active adsorption sites got engaged. It was 40.67% of removal at 200th second in a continuous flow system.

Table 1. Results for 10 cm height of banana pith.

Time interval in sec	pH	TDS in ppm	Turbidity in NTU	Concentration of oil in g/l	% removal
40	6.8	386	10	17.85	73.526
80	6.9	378	9	18.4	72.7
120	7	369	10	24.8	63.2
160	7	370	9	33.4	50.46

With the same initial concentration of oil and grease, trails were conducted for 20 cm height of adsorbent material in the column and results are tabulated in Table. 2. We obtained 76.89% removal efficiency and it gradually reduced with respect to time. Here, when height was increased by 10 cm of previous trial, observed an increase percentage removal by 3.37.

For 30 cm adsorbent material, there was maximum removal of oil and grease of 80% which further reduced to 54.9% at 200th second as mentioned din Table. 3. The percentage fall in the removal was 25.1.

Table.2 Results for 20 cm height of banana pith.

Time interval in sec	pH	TDS in ppm	Turbidity in NTU	Concentration of oil in g/l	% removal
40	7	388	11	15.58	76.89
80	7.1	399	10	17.55	73.97
120	7.1	389	10	24	64.4
160	6.9	385	10	31.25	53.65

Table.3 Results for 30 cm height of banana pith.

Time interval in sec	pH	TDS in ppm	Turbidity in NTU	Concentration of oil in g/l	% removal
40	7.1	386	9	13.5	80
80	7.1	368	9	15.08	77.63
120	7.2	387	10	21.21	68.54
160	6.9	395	10	24	64.4
200	7	400	9	30.4	54.9

For 40 cm (Table 4) of banana pith the removal was 81.96% which was appreciable than for previous trials with lower heights. The percentage fall was reduced by 11.04 which mean that banana pith is consistent in adsorbing oil and grease up to 200 seconds for this particular initial concentration of oil and grease.

Table.4 Results for 40 cm height of banana pith.

Time interval in sec	pH	TDS in ppm	Turbidity in NTU	Concentration of oil in g/l	% removal
40	7.1	402	11	12.16	81.96
80	6.9	385	11	12.6	81.31
120	6.8	398	10	14.2	78.9
160	6.9	379	11	15.8	76.5
200	7	385	11	21.6	67.9

Results for trial conducted for 50 cm of banana pith are as shown in the Table .5. It indicates that as height increases, adsorption also increases. There obtained an 87.8% removal of oil and grease.

Table.5 Results for 50 cm height of banana pith.

Time interval in sec	pH	TDS in ppm	Turbidity in NTU	Concentration of oil in g/l	% removal
40	6.9	390	10	7.5	87.8
80	6.9	386	10	11.6	82.8
120	6.8	387	11	13.6	79.83
160	7	390	10	16.13	76
200	7	390	11	19.7	70.78

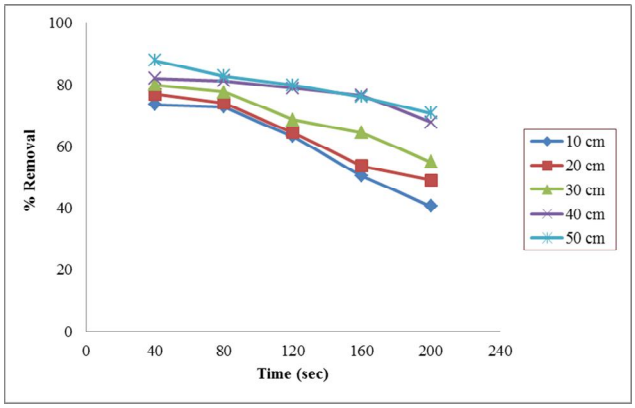

Fig 4. Graph showing variation with respect to different height of banana pith.

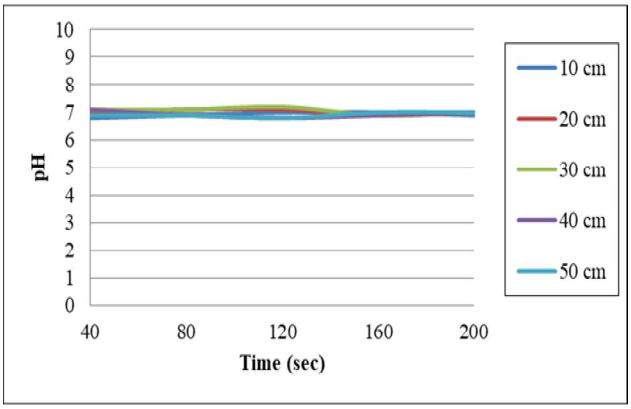

Fig 5. Graph showing variations with respect to different pH values.

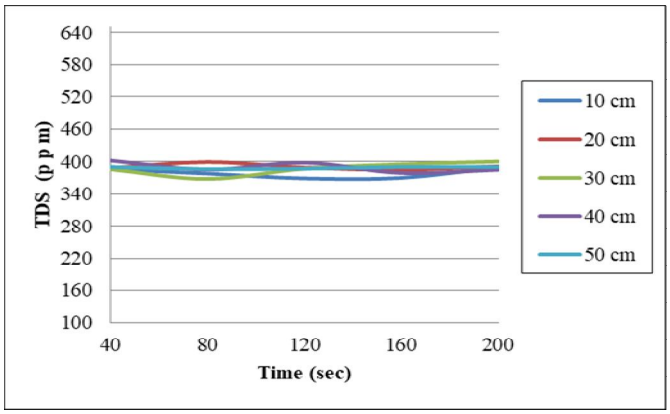

Fig 6. Graph showing variation with respect to TDS.

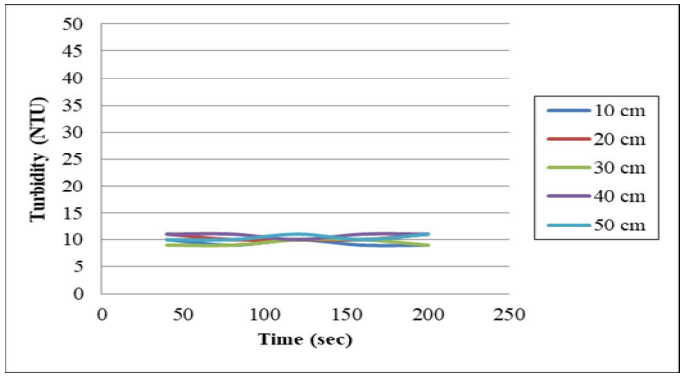

Fig 7. Graph showing variations with respect to different Turbidity.

The Figure 4-7, depicts the tabulated values of the experiment in the form of the graphs for better understanding. It is observed from the figure 4 that plot for 50 cm and 40 cm are at the top indicating the maximum removal of oil and grease. The plot for 10 cm height is below all other lines indicating its lower potential in adsorption. Percentage removal of oil and grease decreases as the time increases and at the same time as the height of the adsorbent material increases percentage removal increases. It is clearly evident that as the height of the adsorbent material increases i.e., surface area of contact increases, contact time increases, and results in higher percentage of removal. As the pith gets saturated, its efficiency to adsorb oil and grease decreases with respect to time.

It is observed from the figure 5 that the pH remains within the range of 6.80 to 7.20 for all heights of adsorbents and time for same initial oil and grease concentration. It may be further suggested that introducing banana pith as adsorbent, will not impart variation in pH of the test sample. From the figure 6 obtained for TDS with respect to time, it can be inferred that TDS is not very fluctuating when banana pith is used as adsorbent in removal of oil and grease from wastewater. The TDS fall well within the range of 360 to 410 ppm. Turbidity also remains same throughout the experiment for the same initial concentrations of oil and grease which can be evidently seen in figure 7 hence, it can be told that turbidity will not be get affected by the adsorption with presence of banana pith.

1.2 Study with honeycomb as adsorbent

Studies were carried by replacing the adsorbent by honeycomb and rest all the conditions were kept constant. The results obtained for honeycomb as an adsorbent with initial oil and grease concentration of 67.425 g/l are shown in Table.6.

There was maximum removal of 38.74 percent which was very less compared to banana pith for same conditions. The sample analyzed for 200th second (5th interval) showed only 10.86% removal which was very poor. The percentage fall of removal of oil and grease was very significant i.e. 27.88%.

Table 6. Results for 10 cm height of honeycomb.

Time interval in sec	pH	TDS in ppm	Turbidity in NTU	Concentration of oil in g/l	% removal
40	7	395	11	41.3	38.74
80	7.1	384	11	45.8	32.07
120	7.1	394	10	47.53	29.5
160	6.9	389	10	53.84	20.15

For the adsorption carried for 20 cm (table 7) of honeycomb, it registered a maximum removal of 69.44% which was greater than that of previous but the percentage fall in removal is 32.77%. This can infer that the removal rate is not regular when compared to banana pith.

Table 7. Results for 20 cm height of honeycomb.

Time interval in sec	pH	TDS in ppm	Turbidity in NTU	Concentration of oil in g/l	% removal
40	7	396	9	20.6	69.44
80	7	369	9	23.65	64.9
120	7.1	378	10	29.8	55.8
160	7.2	381	10	35.8	46.9

The trend further showed unsatisfactory adsorption capability compared to banana pith viz., honeycomb was able to remove 76.44% of oil and grease from test sample collected at 40th second but it showed a decrease up to 51.8% where the fall in percentage removal was 24.64% little less than previous trial for 30 cm height of adsorbent. It is again suggesting an irregular behavior for adsorption.

There is an appreciable removal of 78.5% initially which came down to 54.5% at 200th second. The percentage fall in removal was 24%which is slightly less than previous case. 40 cm of adsorbent is comparably showing a better adsorption of oil and grease for this particular initial concentration. For 50 cm height of the honeycomb, 79.35% was the maximum oil and grease removal. The fall in percentage of removal is 19.35% which suggests that under this condition, there can be maximum adsorption and it can show better removal rate even after 200 seconds. If compared to results obtained for 50 cm banana pith, honeycomb has less potential for adsorption.

It is clear that percentage removal is more in case of banana pith compared to honey comb for same initial concentration of oil and grease. The maximum removal is 87.8% for 50 cm banana pith but 79.35% for honeycomb under same conditions. Looking at the least removal, 40.67% for banana pith whereas 10.86% for honeycomb for 10 cm height of absorbent material respectively. Hence it can be inferred that, for 67.425 g/l of initial oil and grease concentration, banana pith shows better performance than honeycomb. The adsorbent material in case of honeycomb is getting saturated and all the active sites of adsorption are engaged for lesser time period. It is observed that the pH remains within the range of 6.80 to 7.20 for all heights of adsorbents and time for same initial oil and grease concentration of 67.425g/l. It may be further suggested that introducing honeycomb as adsorbent, will not impart variation in pH of the test samples. Also, TDS is not fluctuating when honeycomb is used as adsorbent in removal of oil and grease from wastewater. Finally, turbidity also remains same throughout the experiment for the same initial concentration of oil and grease.

2. *Results for 100ml/liter i.e. (89.9 g/l) of initial oil and grease dosage.*

Table 8, shows the percentage removal of oil and grease for the initial dosage of 89.9 g/l for different heights of banana pith analyzed at five intervals at 40 second interval of time. Results for any interval of time shows an increasing pattern in removal efficiency with respect to increasing height of the adsorbent material. It is observed from the Figure 8, that percentage removal of oil and grease decreases as the time increases and at the same time as the height of the adsorbent material increases percentage removal increases. So the graph (Fig 8) shows the linear decrease from 74.97% to 38.38% for the height of 10 cm adsorbent material and it is also observed from the graph that, the line showing variation with respect to 10 cm height is at the bottom and 50 cm is at the top, it is clearly evident that as the height of the adsorbent medium increases i.e., surface area of contact increases percentage removal increases, as the pith get saturated it's efficiency to adsorb oil and grease decreases..

It is clearly evident from the Fig.9 that the honey comb is not effective in the removal of oil and grease it shows unsystematic variation. For some trials it exceeds the limit and not showing considerable results for 120th second and beyond that. So it is found that honey comb will not act as a good adsorbent in the removal of oil and grease.

Table 8. Results for 100ml/liter initial oil and grease dosage with Banana Pith.

Time interval in sec	Percentage Removal of Oil And Grease				
	10 cm	20 cm	30 cm	40 cm	50 cm
40	74.97	83.74	88.97	91.32	99
80	56.89	62.88	68.95	74.86	88.21
120	56.06	59.65	62.54	70.96	76.08
160	52.85	53.28	58.34	65.2	75.52
200	38.38	47.63	53.7	62.8	73.86

Table 9. Results for 100ml/liter initial oil and grease dosage with honeycomb.

Time interval in sec	Percentage Removal of Oil And Grease				
	10 cm	20 cm	30 cm	40 cm	50 cm
40	30.47	66.11	76.64	90.1	92.73
80	7.67	42.66	74.97	88.87	89.04
120	-	30.47	73.52	59.73	71.07
160	-	27.77	72.08	55.5	61.4
200	-	-	61.17	48.38	54.17

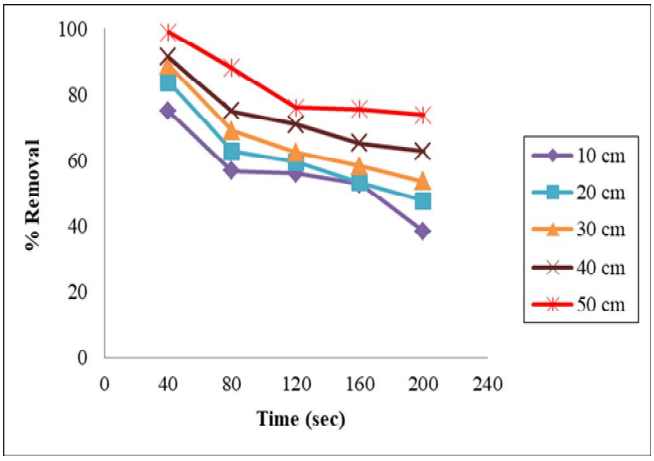

Fig 8. Graph showing variations with for different heights of banana pith.

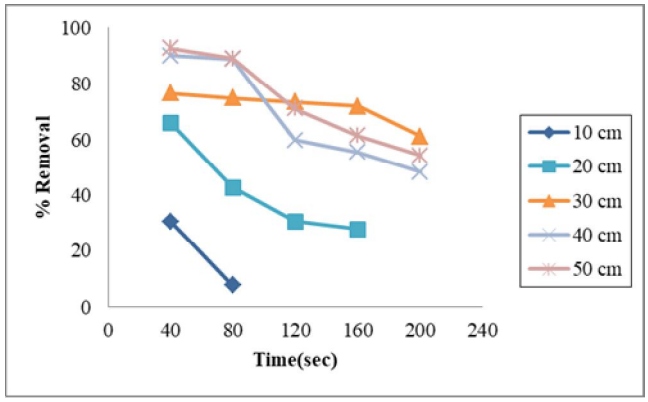

Fig 9. Graph showing variations with for different heights of honeycomb.

3. *Results for 125ml/liter i.e. (112.375 g/l) of initial oil and grease dosage.*

It is observed from the Fig.10 that percentage removal of oil and grease decreases as the time increases and at the same time as the height of the adsorbent material increases percentage removal increases. So the graph shows the linear decrease from 74.37% to 46% for the height of 10 cm adsorbent material and it is also observed from the graph (Fig.10) that, the line showing variation with respect to 10 cm height is at the bottom and 50 cm is at the top, it is clearly evident that as the height of the adsorbent medium increases i.e., surface area of contact increases percentage removal increases, as the pith get saturated it's efficiency to adsorb oil and grease decreases.

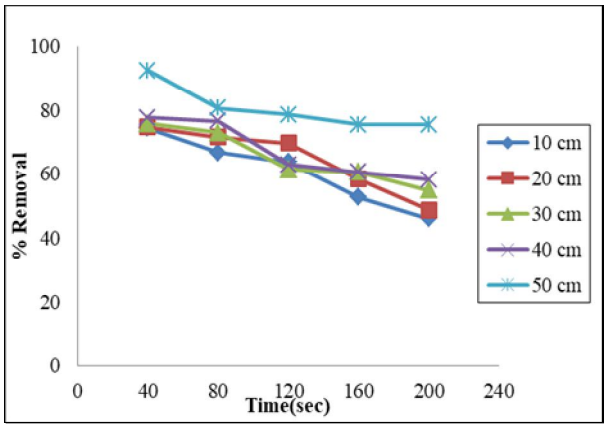

Fig 10. Graph showing variation for different heights of banana pith.

4. *Results for 150 ml/liter i.e. (134.85 g/l) of initial oil and grease dosage.*

It is observed from the Fig.11 that percentage removal of oil and grease decreases as the time increases and at the same time as the height of the adsorbent material

increases percentage removal increases. So the graph shows the linear decrease from 63.29% to 46.39% for the height of 10 cm adsorbent material and it is also observed from the graph that, the line showing variation with respect to 10 cm height is at the bottom and 50 cm is at the top, it is clearly evident that as the height of the adsorbent medium increases i.e., surface area of contact increases percentage removal increases, as the pith get saturated it's efficiency to adsorb oil and grease decreases.

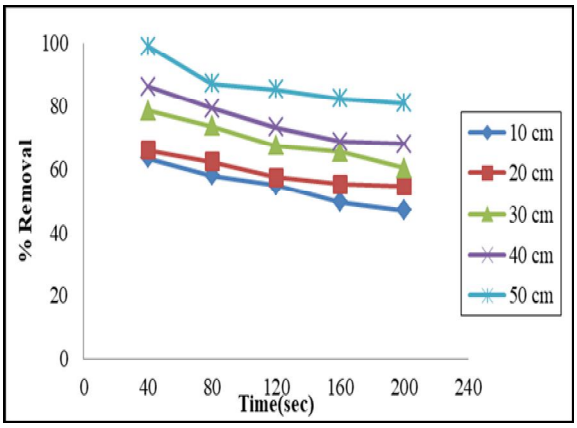

Fig 11. Graph showing variation for different heights of banana pith.

5. *Performance analysis based on fall in percentage removal of Oil and Grease.*

Analysis with respect to percentage fall in removal is the difference between percentage removal of oil and grease at 40th second and 200th second in a continuous flow system. From the table 10, it is evident that percentage fall in removal of oil and grease decreases as the height of adsorbent material increases. As the height of adsorbent material increases, it facilitates larger surface area, more contact time and increased active sites for adsorption. Same behavior has been registered for all the dosages.

Table. 10 Percentage fall in removal observed for banana pith as adsorbent

Height of adsorbent material (cm)	% Fall in removal for different dosages of Oil and Grease			
	Dosage of oil and grease (ml/liter)			
	75	100	125	150
10	32.85	36.59	28.37	16.39
20	27.89	36.11	25.83	11.34
30	25.1	35.27	20.82	18.25
40	14.04	28.52	19.49	18.2
50	17.02	25.14	16.91	18.1

IV. CONCLUSIONS

This article has highlighted the use of banana pith and honeycomb as the potential bio-sorbent for removal of oil and grease from wastewater. Further it is clearly inferred that banana pith is more efficient than honeycomb. This has given a good foundation to carry out further experimentations and analysis with banana pith as adsorbent. Based on the data monitored in this experiment, the following conclusions are drawn, viz.; the potentiality of Banana pith and Honeycomb in the removal of oil and grease has appeared in relation with depth of the adsorbent and varying dosages of oil and grease. Banana pith proved to be efficient, the column study reveals that the percent removal increases with respect to depth of column and increase in available surface area plays a major role in adsorption, though the quantity of water treated was found to be less for the given column size, the treated water can be fed to secondary treatment unit without being subjected to primary treatment as such it reduces load on secondary treatment unit, for the synthetic sample the essential parameters like pH, Turbidity, and TDS remains constant for all heights and dosages and the maintenance and expense incurred are very low as compared to other systems.

REFERENCES

[1] H. Ajith Hebbar, and K. S. Jayantha. "Oil and Grease Removal from Wastewater Using Laterite as an Adsorbent Material", in IJETAE, vol. 3, no. 5, pp. 654-657. May 2013.

[2] Abass O. Alade, Ahmad T. Jameel, Suleyman A. Muyubi, Mohamed I. Abdul Karim and Md. Zahangir Alam, "Removal of Oil And Grease as Emerging Pollutants of Concern (EPC) in Wastewater Stream", IIUM Engineering Journal, vol. 12, no. 4: Special Issue on Biotechnology, pp. 161-169, 2012.

[3] George Z. Kyzas and Margaritis Kostoglou, "Green Adsorbents for Wastewaters: A Critical Review", Materials, vol. 7, pp. 333-364, January 2014,

[4] I.M. Muhammad, U.A. El-Nafaty, S. Abdulsalam and Y.I. Makarf, "Removal of Oil from Oil Produced Water Using Eggshell", Civil and Environmental Research, vol. 2, no. 8, pp. 52-63, 2012.

[5] U.M. Aliyu , U.A. El-Nafaty and I.M. Muhammad, "Oil removal from crude oil polluted water using banana peel as sorbent in a packed column", Journal of Natural Sciences Research, vol. 5, no.2, pp. 157-162, 2015.

[6] Prof. Dr. Eckhard Worch, Book on Adsorption Technology in Water Treatment, Dresden University of Technology Institute of Water Chemistry, Germany, 2012

[7] S. Yasin, T. Iqbal, Z. Arshad, M. Rustam and M. Zafar, Environmental Pollution From Automobile Vehicle

Service Stations, Journal of Quality and Technology Management, vol. 8, no. 1, 2012.