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COMPARATIVE STUDY OF ADSORPTION PROPERTIES OF HUMAN HAIR AND ACTIVATED CARBON IN WASTE WATER

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Abstract - *An adsorption study in a batch and column was carried out by using human hair and activated carbon as bio-adsorbents for the removal of oil and grease from automobile service center waste water. In batch study the adsorbent dosage, contact time, pH and temperature are considered. The batch study shows that 24 grams of human hair can remove 76 % of oil and grease from the waste water in contact time of 60 minutes and 40 grams of activated carbon can remove only 50 % of oil and grease from waste water in contact time of 80 minutes so these values is taken to be the optimum in the batch study. The maximum removal efficiency 81% of oil obtained at pH of 7.5 and 80% at 21^{0}C temperature with 24 g/l of human hair in 60 minutes time of contact. On the basis of batch the column study was conducted with adsorbent bed depth of 7.5 cm and 10.5 cm respectively and varying the rate of flow as 15 ml/min/cm^2 and 10 ml/min/cm^2. The combination mixture of human hair and activated carbon at 10.5 cm and rate of flow 10 ml/min/cm^2 shows the highest removal efficiency of 74% in column study. After that human hair adsorbent required regeneration. In which hibiscus leaf juice (Thaali) used for regeneration, and obtained about 80% of regeneration of oil content in the saturation point.*

Key words: Activated carbon, Adsorbent, Automobile service station, Batch, Human hair, Oil and Grease, Regeneration.

1.INTRODUCTION

Many people get their hair cut daily across the world, large quantities of human hair waste being produced in saloons. The hair waste is disposed of at landfills or incinerated, with negative effects on the environment. Incinerating hair leads to air pollution as hair has high composition of Nitrogen, Sulphur and other inorganic elements Burning of hair leads to the release of Nitrogen in the form of nitrous oxide (N_2O), Sulphur in the form sulphur dioxide (SO_2), and carbon dioxide (CO_2), into the atmosphere.

Water scarcity will be a key issue for the sustainable development of a country in future. Now India is facing a water crisis and coming years it is estimated that India's population will be affected adversely by severe water scarcity. Large quantity of water is wasted in service stations during the washing of vehicles. We have to consider the possibilities to recycle or reuse of the waste water generated from automobile service stations. Automobile service stations vary from authorized service centers to small scale service stations, which under taker pair, washing and servicing of vehicles. The speedy growth of car wash service centre has seriously increased the contribution of pollution in to bodies of water. The service station waste water represents one of the heavily contaminated wastes with high impurities. It was due to presence of sand and particles, oil and grease, surfactants, detergent, phosphates and hydrofluoric acid. Therefore, the direct disposal for waste water in to the drainage exacerbates the natural water pollution.

Industrial growth has accelerated the emission of various oily waste from the sources such a spectro chemical industries, metallurgical industries, automobiles & domestic sewage. These oily wastes are one of the major pollutant of the aquatic environment. Oil water separation processes using polymeric or inorganic membranes have been proposed as effective & cost competitive alternative to conventional oil removal technologies but in present the commercial use of membrane in waste water treatment is currently limited by their low efficiency as well as high capital & operating cost [1].

Hair is found to be a good adsorbent for oil. Oil pollution is the emerging threat to the environment. Thus utilization of waste hair in oil removal will leads to reduce the waste accumulated in environment. The main oil pollution threat rising from land based activities is due to service station and workshop wastewater. Two major sources of such oils are auto motive crank case oil and used oil from small garages and workshops. This gives high contribution to the oil pollution mainly technologically backward countries, due to low efficiency of equipments and machines [9].

2. MATERIALS AND METHODOLOGY

2.1 Adsorbent Used

The materials that are required for the adsorption and regeneration process are activated carbon, human hair as well as those used for the filter media has to be collected. The human hair is collected from saloons and activated carbon is purchased online and the hibiscus leafs (regenerant) collected from near by areas of college.

2.2 Adsorbent Preparation

Hair of different ages was collected from a barbershop and saloons in ulliyeri and properly separated by combing. The properly separated human hairs were soaked in hot water in one hour using detergent to ensure it is free from contamination. Then, they were rinsed with hot water and dried under natural sunlight for 48hrs after it is kept in a glass container.

Activated carbon is purchased online. Activated carbon is widely used as a adsorbent in water treatment plants. It is also widely available in developing countries, usually in granular size and generally called carbon. There are numerous ways to use carbon as an adsorbent, including to crushed it into a powder before adding it to water, stirring and decanting in the water for a few seconds and waiting for the solids to settle.

2.3 Sample Collection

The selected site is the service station near Ulliyeri, Kozhikode which is easily accessible after the comparison with other service stations in the nearby areas, this service station is selected for study. The major works that are carried out in the service are the repair and washing of vehicles, mainly heavy vehicles such as lorries. The sample is collected from the waste water pit in the automobile service station. The waste water coming from the service station is of varying concentration of the parameters. A clean plastic container is used for sampling and the sample is handled carefully, so that the characteristic does not change during the due course of storage.

2.4 Batch Study

To study the effect of various controlling parameters like adsorbent dosage, contact time, temperature, pH on the oil and grease removal capacity of human hair and activated carbon. The batch experiments were conducted using a sample volume of 250 ml for each. The adsorbent dosage is taken as 4 g/l, 8 g/l, 12 g/l, 16 g/l, 20 g/l, 24 g/l, 28 g/l, 32 g/l and 40 g/l and the contact time of 5 minutes, 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 60 minutes, 70 minutes, 80 minutes and 100 minutes and three different pH of 4.3, 7.5 and 10.48 and 21°C, 27°C, 32°C and 45°C are considered as the temperatures for this batch experiment.

2.5 Column Study

The column experiment for removal of oil and grease from the service centre waste water by human hair was performed using 5.5 cm diameter and 35 cm length column, and it is attached a flow control valve for adjusting the flow through the column. The adsorbent is placed between the layers of pebbles to prevent the loss of adsorbents in the column. In column study two types of adsorbent beds are prepared, one which contained only human hair and other one contained the combination mixture of activated carbon and human hair. The depth of adsorbents is considered as 7.5 cm and 10.5cm and two different flow rate of 10 ml/min/cm^2 and 15 ml/min/cm^2 .The waste water is allowed to pass through the adsorbents in the column and the sample were collected in four different times 45minutes, 50 minutes, 60 minutes and 75 minutes.

2.6 Regeneration Study

The environmental aspects, human hair negatively affect the environment because it contains different types of compounds so regeneration of adsorbent is important, we need to regenerate the adsorption capacity of human hair. Moreover, disposing of oil adsorbed hair is more dangerous to the environment that the original hair or oil being thrown in the open. Here we are using hibiscus leaf juice (Thaali) for regeneration. This solution passed through the column in the saturation point to find the removal of oil from the adsorbent bed.

3. RESULTS AND DISCUSSIONS

3.1 Batch Study

In the batch study adsorbent dosage, contact time, temperature and pH are the parameters mainly considered. The detailed results of parameters are included in the following sections.

(i)Effect of adsorbent dosage and contact time on human hair

The study of the effect of adsorbent dosage on the removal of oil and grease was carried out with the dosage of 4 g/l, 8 g/l, 12 g/l, 16g/l, 20 g/l, 24 g/l, 28 g/l, 32 g/l and 40 g/l and the contact time of 5 minutes, 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes,60 minutes, 70 minutes, 80 minutes and 100 minutes. The table 4.1 shows the amount of adsorbed oil (ml/l) in the human hair adsorbent with varying adsorbent dosage and contact time.

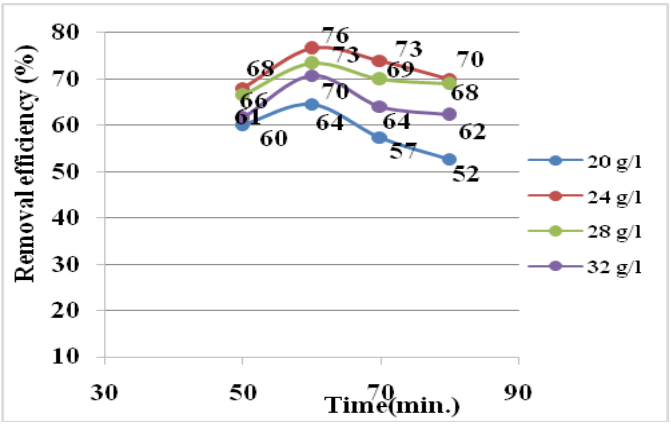

Fig- 1 Effect of Adsorbent Dosage and Contact Time on Oil Removal by Human Hair

Initially there is an increase in removal efficiency from 20 g/l to 24 g/l of adsorbent dosage at 50 minutes to 60 minutes of contact time. After 24 g/l of adsorbent dosage the efficiency will starts to decline. The maximum removal efficiency of oil (76%) obtained at 24 g/l of adsorbent dosage at 60 minutes of contact time. So it will be taken as the optimum point in batch by using human hair as the adsorbent. From the analysis it is clear that 24 g/l of human hair as the adsorbent shows better removal than the other dosage.

(ii)Effect of adsorbent dosage and contact time on Activated Carbon

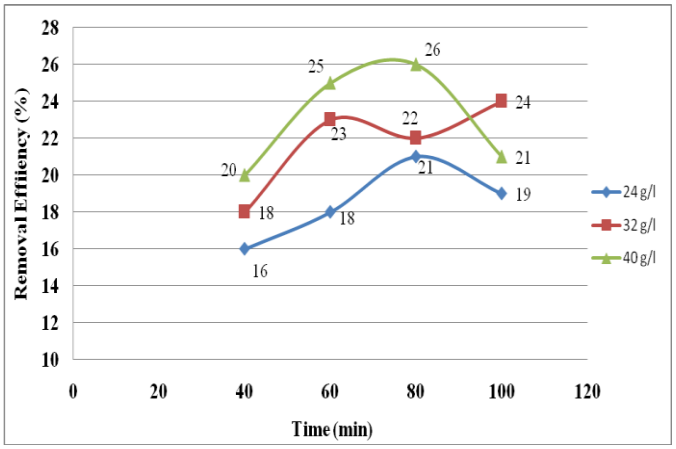

Fig-2 Effect of Adsorbent Dosage and Contact Time on Oil Removal by Activated Carbon

From this study we can see that the removal efficiency of activated carbon increases by increasing the adsorbent dosage. The 50% of removal efficiency is obtained at the dosage of 36 g/l of activated carbon in 80 minutes so it can be taken as the optimum value. Gradual increase in adsorption obtained initially after that removal efficiency is decreases to 42 percentage at 80 minutes contact time.

(iii)Effect of Temperature

The study of the effect of temperature on the removal of oil and grease was carried out by four varying temperature 21°C, 27°C, 32°C and 45°C keeping the adsorbent dosage as 24 g/ml, contact time of 60 minutes and initial oil concentration of 52.18 ml in 250 ml of waste water.

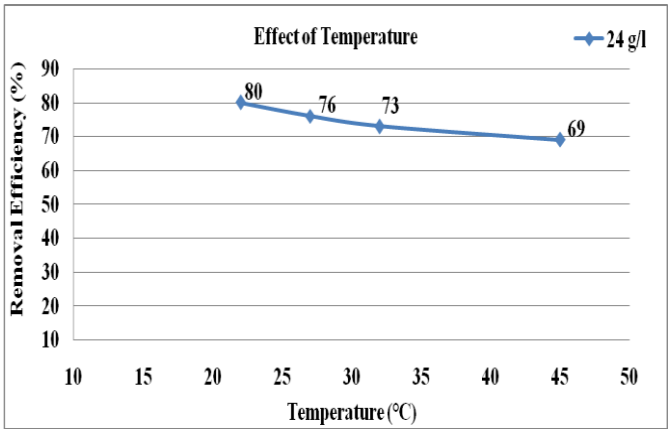

Fig -3 Effect of Temperature on Oil Removal by Using Human Hair as Adsorbent

The maximum removal 80 % obtained at 21°C and minimum removal of oil 69% in 45°C. As temperature increases the removal efficiency of oil from service center waste water by using human hair was decreases.

(iv)Effect of pH

The study of the effect of pH on the removal of oil and grease was carried out by three different pH of 4.3, 7.5 and 10.4 keeping the adsorbent dosage as 24 g/ml, contact time of 60 minutes and initial concentration of oil 52.18 ml in 250 ml of waste water.

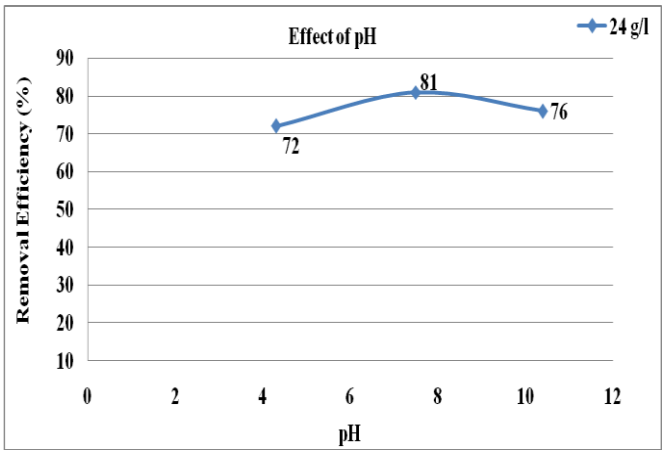

Fig-4 Effect of pH on Oil Removal by Using Human Hair as Adsorbent

Fig -4 shows the effect of pH on the removal efficiency of oil and grease by using human hair. In this experiment three different pH of 4.3, 7.5 and 10.48 samples are used. As pH increases adsorption capacity of hair was increases till the pH was 7.5, Then it was decreases to 76% at pH of 10.48. The gradual decrease in removal efficiency of oil level is observed after pH of 7.5. The 72% of oil removal obtained at pH of 4.5 keeping adsorbent dosage as 6 g/ml and contact time of 60 minutes.

3.2 Column Study

From the batch study we noted that human hair shows better performance than activated carbon and for an initial oil and grease content of 200 ml/l for 60 minutes at an adsorbent dosage of 24 g/l. In the column study we are mainly considering the parameters such as depth of adsorbent bed and the flow rate.

(i)Effect of Adsorbent Bed Depth

For this set of experiment the bed depth is taken as 7.5 cm and 10.5 cm and 200 mg/l of oily waste water is passed through the column. Samples are collected at an interval of 45 minutes, 50 minutes, 60 minutes and 75 minutes with rate of flows 15 ml/min and 10 ml/min. The combination mixture of human hair and activated carbon bed depth of 10.5 cm gives the highest removal efficiency 74 % at rate of flow 10 ml/min. At a rate of flow 15 ml/min. shows 72 % removal of oil. The human hair bed depth of 10.5 cm gives 71 % removal of oil and 70 % removal obtained in 7.5 cm bed depth respectively. From this study we can analyses that removal of oil from waste water using a combination of both adsorbents. The removal of oil increases by increasing in bed depth.

(ii)Effect of Flow Rate

In the column study 15 ml/min/cm^2 and 10 ml/min/cm^2 discharge is considered. The 10 ml/min/cm^2 flow rate shows better removal in all adsorbent bed depth considered. In 15 ml/min/cm^2 shows less removal, which is due to the time of holding the water in the adsorbent is less in higher flow rate and which is higher in low flow rate. For 10 ml/min/cm^2 the removal of oil is 56.17 mg/l. The maximum removal of oil obtained at 10 ml/min/cm^2 of discharge in 10.5cm of combination of two adsorbents bed depth and minimum removal obtained in 15 ml/min/cm^2 of flow rate in 7.5 cm human hair adsorbent bed depth. In 15 ml/min/cm^2 flow rate final oil content is 52.48 mg/l at 60 minutes. That is flow rate increases the adsorption decreases.

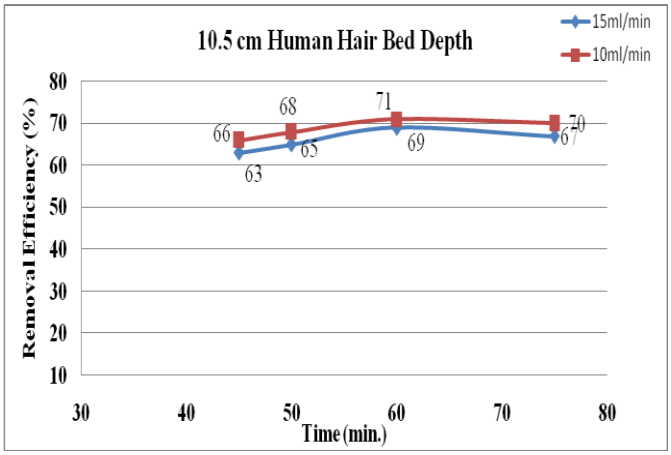

Fig- 5 Removal Efficiency of Oil at Adsorbent Bed Depth of 10.5 cm

Figure- 5 shows the maximum removal of 71% gets in 10.5 cm adsorbent bed depth at 10 ml/min/cm^2 flow rate. The minimum removal efficiency (69%) of oil at 10.5 cm bed depth in 15 ml/min/cm^2 flow rate. In the case of 10 ml/min/cm^2 flow rate initial removal efficiency is 66% at 45 minutes of contact time and it gradually increase till 60 minutes. After 60 minutes of contact time efficiency declined in to 70% and for 15 ml/min/cm^2 rate of flow initially it have 63 % removal efficiency and starts to increase till 60 minutes and declined to 67 % at 75 minutes contact time. So we concluded that 10.5 cm human hair bed depth can remove maximum amount (71%) oil from waste water.

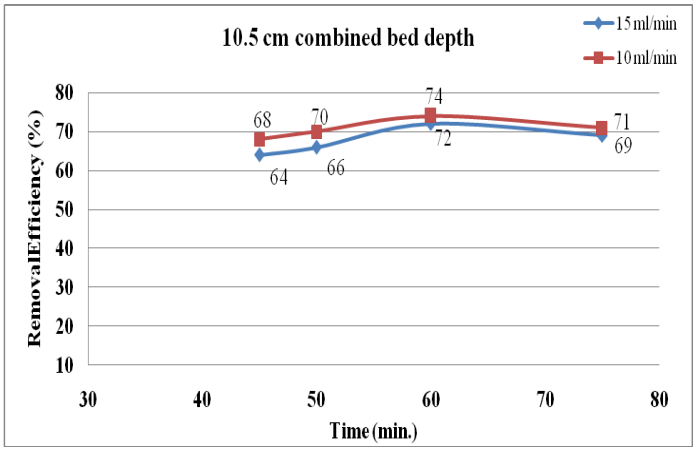

Fig - 6 Removal Efficiency of Oil in Adsorbent mix Bed Depth of 10.5 cm

From the figure 4.10 the maximum removal efficiency 74% is obtained in 10.5 cm combination mixture of human hair and activated carbon bed depth at 10 ml/min/cm^2 flow rate. At 15 ml/min/cm^2 flow rate in the 10.5 cm combined bed depth shows 72% removal efficiency. In this we concluded that the combination of two adsorbents in the column bed depth can increase the removal of oil from the waste water it is of 74%. While comparing the above graphs we can find that the removal efficiency gradually increases till 60 minutes contact time after that removal efficiency will decreases. We can see that saturation point obtained in 60 minutes after efficiency will decreases, this may due to the lack of active adsorption site in the adsorbents.

3.3 Regeneration Study

Regeneration study of the adsorbent is studied because after certain period the adsorbent is desorbed of the matter that it adsorbed. In this case human hair is likely to produce toxic elements when improper treatment is provided. So reusability of human hair is important and we need to check the possibility of regeneration of the adsorbent. Hibiscus leaves are traditionally used to remove oil from hair, which is taken as an idea for its use in the case. 200 ml of hibiscus leaf juice is passed through the 10.5 cm human hair adsorbent bed column and get 80% removal at 60 minutes.

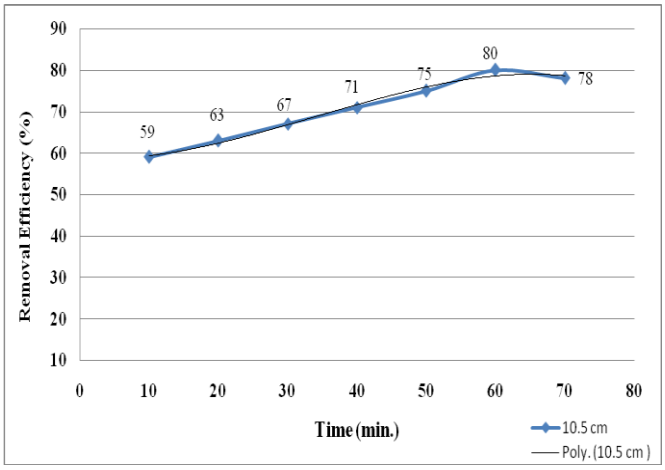

Fig - 7 Regeneration Study of Oil from Human Hair

In the above graph, initially a gradual increase in removal efficiency of oil from 10 minutes to 60 minutes. In 10 minutes the removal efficiency is 59% and it is increases to 63% at 20 minutes. In 30 minutes the removal efficiency again increases to 67% and at 40 minutes it will be 71%. In 60 minutes maximum regeneration is occurs,80% oil can desorbed from human hair. After 60minutes efficiency reduced to 78% this may due to the unavailability of adsorption site that cause the reduction of adsorption capacity of the regenerant. From the results of regeneration study we can analyse that hibiscus leaf juice (Thaali) used to regenerate the human hair and it is economical and eco-friendly regenerant.

4. CONCLUSIONS

The auto mobile service station waste water is mainly characterized by high amounts of oil and grease, high COD and high amounts of dissolved solids etc. The human hair and activated carbon as a bio adsorbents are used the removal of oil and grease from the automobile service station waste water, as they are commonly available materials, inexpensive and less toxic.

In this study batch study and column study are conducted. In batch study, the four parameters considered are Adsorbent dosage, Contact time, Temperature and pH. The adsorbent dosage is 4 g/l, 8 g/l, 12 g/l, 16 g/l, 20 g/l, 24 g/l, 28 g/l, 32 g/l and 36 g/l. The contact time 5 minutes, 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 60 minutes, 70 minutes, 80 minutes ,100 minutes and three different temperature and pH also considered. After the batch experiments with this parameter, we obtained high removal efficiency of oil and grease for adsorbent dosage 24 g/l at 60 minutes contact time by using human hair as the adsorbent. The optimum oil and grease removal of 76% obtained at temperature of 27°C and pH of 10.48 by using human hair keeping adsorbent dosage as 24 g/l. The maximum removal efficiency of 81% obtained at pH of 7.5 and 80% removal at temperature of 21°C. The 50 % removal of oil obtained by using activated carbon as adsorbent keeping adsorbent dosage as 36 g/l at time of contact 80 minutes. From the comparison of adsorption capacity of the two adsorbents used we can see that human hair is more efficient than the activated carbon.

On the basis of batch study result column study is conducted using 5.5 cm diameter and 35 cm height column, considering two types of adsorbent bed depth of 7.5 cm and 10.5 cm and two rate of flow 10 ml/min/cm^2 and 15 ml/min/cm^2. From this experiment we can find that maximum removal of 74% obtained in 10.5 cm combination mixture of human hair and activated carbon bed depth at a flow rate of 10 ml/min/cm^2. In this 10.5 cm bed made by equal amount of 15 grams of human hair and activated carbon in the column. The removal efficiency 71% obtained at 10.5 cm bed depth of human hair in10 ml/min/cm^2 flow rate. In column study shows the maximum removal of oil from the waste water obtained in the combination mixture of human hair and activated carbon bed depth 10.5 cm at 10 ml/min/cm^2 rate of flow than the human hair bed depth 10.5 cm at 10 ml/min/cm^2 rate of flow.

From the regeneration study using hibiscus leaf juice (Thaali), we find out that 80% of oil can removed from the human hair adsorbent, so this adsorbent can reused. There is a gradual increase in removal till 60 minutes after that efficiency will reduced in to 78% at a time of 70 minutes. The adsorption of oil on human hair is a surface phenomenon and it shows the regeneration property by using hibiscus leaf juice (Thaali) also used adsorbents and regenerant are inexpensive and eco-friendly.

FUTURE SCOPE

Regeneration of hair after adsorption of oil and grease is important in making use of the material for further adsorption and safe disposal of hair. Adsorption is a surface phenomenon where the adsorbate remain on the surface of absorbent. The adsorbate can be separated from the surface of the adsorbent by applying an external force on the adsorbent surface. The use of natural materials such as hibiscus leaf juice will make it eco-friendly. But the quantity of this material and water for regeneration requires to For this set of experiment the bed depth is taken as 7.5 cm and 10.5 cm and 200 mg/l of oily waste water is passed through the column. Samples are collected at an interval of 45 minutes, 50 minutes, 60 minutes and 75 minutes with rate of flows 15 ml/min and 10 ml/min. The combination mixture of human hair and activated carbon bed depth of 10.5 cm gives the highest removal efficiency 74 % at rate of flow 10 ml/min. At a rate of flow 15 ml/min. shows 72 % removal of oil. The human hair bed depth of 10.5 cm gives 71 % removal of oil and 70 % removal obtained in 7.5 cm bed depth respectively. From this study we can analyses that removal of oil from waste water using a combination of both adsorbents. The removal of oil increases by increasing in bed depth.

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