TREATMENT OF SYNTHETIC GREY WATER BY USING BANANA, ORANGE AND SAPODILLA PEELS AS A LOW COST ACTIVATED CARBON

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Abstract

Adsorption technology is accepted worldwide because of its application in environmental engineering. Different fruit peels were used as activated carbon for the treatment of synthetic Grey water. The activated carbon was prepared from the peels of banana, orange and sapodilla. The fruit peels were collected from the three juice shops and fifteen houses of Surapet. Chennai Based on one-month data, the fruit waste generation was calculated per day, per week and month. The treatment of synthetic Grey water using fruit peels as an adsorbent and the treatment efficiency of orange peels adsorbent, banana peels adsorbent, and sapodilla peels adsorbent were observed. The peels were first segregated and washed several times to remove dirt, and other impurities then dried in an oven at a temperature of 105˚C for 24 hours to remove the moisture content. The synthetic Grey water was prepared by different constituents to check its physicochemical parameters. The activated carbon agent phosphoric acid was used to prepare activated carbon then it was used as a coagulant for the removal of different impurities present in synthetic Grey water. An effort has been made to give a brief idea of an approach to wastewater treatment, particularly discussing and highlighting, in brief, the low-cost alternative adsorbents to utilize these waste/low-cost materials.

Introduction

Water is the basic need for survival of human beings. The scarcity of fresh water is increasing day by day. Fruit wastes (like Banana, Orange, etc.) are agricultural waste which is discarded as a waste material in all over the world [1]. The grey water is the waste water that is generated in the offices buildings, household and from streams without fecal contamination. Grey water also called as sullage and it contains lesser pathogens as compared to domestic wastewater. Water from sinks, laundry showers, baths, washing machine and kitchen are the sources of Grey water. It is generally easier to treat, safer to handle and reuse onsite for landscape or crop irrigation. The reuse of Grey water also reduces the demand for fresh water supply. Water pollution is a global problem and its control has become increasingly important in recent years [2]. Grey water treatment and reuse is becoming a significant field of research in a worldwide context of increasing water shortage. Dissolved pollutants (organic and inorganic) of water can be removed through an effective adsorption technique. Activated carbon (AC) is very familiar with all types of adsorbents due to high adsorption capacity. The adsorption frequency of activated charcoal relates to its great surface area, high pores distribution, and rapid grade of external reactivity [3]. Activated carbons are mostly extracted from raw materials in an environment through carbonization and followed by the activation process of the charcoal material. The activation process can be carried out by chemical or physical activation [4]. Activated carbon technology treats mostly the organic pollutants like VOCs etc. The US Environmental Protection Agency cited the activated carbon adsorption as one of the

best control technologies Baloch et al., J. Mater. Environ. Sci., 2019, 10 (10), pp. 966-986 967 available.[5] The wastewater consists of different types of waste like organic substances (Proteins, carbohydrates and lipids), total solids, nitrates, metals, etc. [6]. There are many technologies to treat the water, bio-adsorption technique is also one of them. Wastewater treatment plants concerning cost involvement and these plants have also problems related to disposal [7]. To overcome this issue fruit waste is used as an adsorbent for the treatment of wastewater. Adsorption is that type of technique which is the most economic and efficient and does not require any type of energy for the treatment of wastewater; this technology is environment-friendly[8]. Various agro wastes and fruit waste are used as adsorbents for the treatment of water, such as banana peel [9,10], orange peel [11], pomegranate [12], caulerpa lentillifera [13,14] Corn Cob [15-17] and agricultural wastes [18-20]. As fruit waste is easy to available and biodegradable material, which may cause leachate when it is discarded in an open atmosphere. Adsorption is the process in which matter is extracted from one phase and concentrated at the surface of a second phase [21]. Nowadays, the population of Pakistan burgeoning day by day and industries have also been increased, which has caused a severe problem regarding the availability of fresh water in the country [22]. Various researchers have conducted studies on drinking water quality throughout the different regions of Pakistan. In, Pakistan, 20% population have access to safe drinking water [22], which is an alarming situation for the future generation that's why it was decided to treat the wastewater using such technology which should be economical, cost effective and efficient for the removal of physicochemical parameters of Grey water. The scope of this research is to compare the treatment efficiency of different fruit peels used as an adsorbent for the treatment of domestic Grey water. As fruit waste is dumped openly in our country which may cause leachate and leachate will degrade our earth. The lab study on the treatment of domestic Grey water from fruit peels will give the idea for the treatment of domestic wastewater at large scale.

Materials & Methods

Preparation of Domestic Grey water

Grey water is a type of wastewater used for various activities like washing purpose, kitchen, and showers etc. excluding excreta arise from toilets. Hair's traces food constituents, household products and dirt can be observed in the composition of Grey water. It may even appear unclean, but at the same time in some cases, it can be valuable for plants. The availability of nutritious elements in Grey water released from homes are the basic cause of pollution, and these nutritious elements can be a productive fertilizer for plants [23]. In this study, the synthetic Grey water was prepared from components usually present in Grey water. The constituents including 85 mg/L of dextrin, 75 mg/L of ammonium chloride, 70 mg/L of yeast extract, 55 mg/L of soluble starch, 30 mg/L of washing powder, 11.5 mg/L of sodium dihydrogen phosphate, 4.5 mg/L of Potassium sulphate, 10 ml/L of settled sewage and 0.1 ml/L of shampoo and oil as shown in Table 1. The domestic Grey water recipe was prepared by the following constituents [24]

Table 1 Synthetic Wastewater Preparation Recipe SR# Substances Concentration mg/L & ml/L

SR#	SUBSTANCES	Concentration mg/L & ml/L	Formula
1	Dextrin	85mg/L	$(C_6H_{10}O_5)n$
2	Ammonium Chloride	75mg/L	NH_4Cl
3	Yeast Extract	70mg/L	N-A
4	Soluble Starch	55mg/L	$C_{12}H_{12}O_{11}$
5	Sodium Carbonate	55mg/L	Na2CO3
6	Washing powder	30mg/L	N-A
7	Sodium di-hydrogen phosphate	11.5mg/L	NaH_2PO_4
8	Potassium sulphate	4.5mg/L	K_2SO_4
9	Settled Sewage	10ml/L	N-A
10	Shampoo	0.1ml/L	N-A
11	Waste Cooking oil	0.1ml/L	N-A

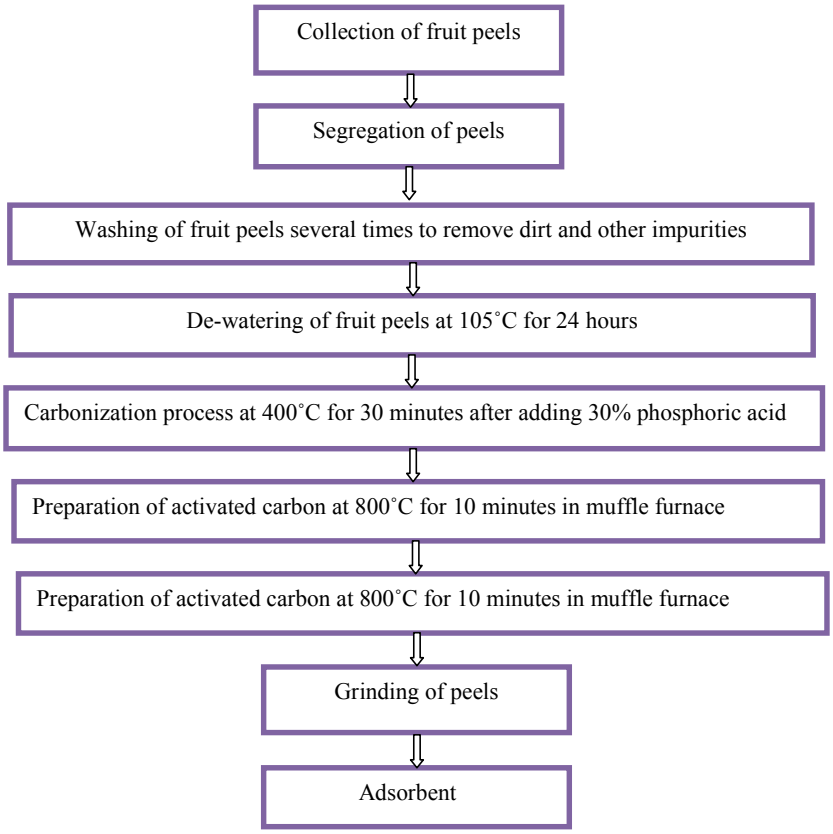
Preparation of Adsorbent

Mixed fruit waste was collected from 15 houses and three juice shops of Surapet Chennai as shown in figure 1. After the collection of fruit waste, the waste was separated and peels were collected of required fruit waste after the separation, fruit peels were washed several times to remove dirt and other impurities, then dried for 24 hours into oven at a temperature of 105˚C to remove the moisture content. Banana peels Orange peels Sapodilla peels.

Figure 1 Fruit waste was collected from houses and juice shops

Making of Activated Carbon from Fruit Peels (Carbonization Process)

Carbonization with Phosphoric Acid H3PO4: The material was soaked in 30% solution of phosphoric acid for 24 hours. After saturation, the liquid portion was drawn off and then dried. The dried mass was subjected to carbonization process at 400˚C, powdered well and finally activated at 800˚C for 10 minutes [8].



Batch Adsorption Experiment

This experimental work was carried out in the batch study, in which different samples were taken in conical flasks to measure the adsorption capacity of the adsorbent. 100 ml samples of domestic Grey water were taken with 1.0g of banana, orange and sapodilla adsorbents [25] and were shacked at 180 rpm in mechanical shaker at different the stirring times (i.e. contact time) from 30 min, 1 h, 2 h, 4 h, 6 h. After shaking, the samples were filtered with Whatman filter paper No.42 to separate the adsorbent and water sample; then the sample was stored to analyze the different physio-chemical parameters before and after the adsorbent used. [21]. 2.5 Adsorbent Dosages The study was carried out at different dosages of fruit peels adsorbent to get the maximum removal efficiency of physicochemical parameters removal which were present in domestic Grey water. The dosage of banana, orange and sapodilla peels in this study different dosage were taken 0.5, 1, 1.5 and 2g in four sets of the 100ml conical flask and these flasks were shaken for 1 hour with 180 rpm at a 25o C temperature [25]. 2.6 Laboratory Analysis Different physicochemical parameters of domestic Grey water were analyzed. Turbidity were analyzed by nephloturbidimeter method, Total Suspended Solids were analyzed by DR 2000 Spectrophotometer Method, Chemical Oxygen Demand were analyzed by APHA 5220 D (Closed Reflux, Colorimetric Method), Biochemical Oxygen Demand were analyzed by US-EPA 5210 B (5 days BOD Method), lead and chromium were analyzed by

Atomic Absorption Spectrophotometer (AAS). Physicochemical parameters with their equipment name and method as shown in Table 2.

Table 2 Physio Chemical Parameters with their Equipment Name and Method

SR#	Parameter	Standard Method
01	Turbidity	Nephloturbidimeter Method
02	Total Suspended Solids	DR 2000 Spectrophotometer Method
03	Chemical Oxygen Demand	APHA 5220 D (Closed Reflux, Colorimetric Method)
04	Biochemical Oxygen Demand	US-EPA 5210 B (5 days BOD Method)
05	Lead	Atomic Absorption Spectrophotometer (AAS)
06	Chromium	Atomic Absorption Spectrophotometer (AAS)

Turbidity

Turbidity is the physical parameter of water quality and it is the cloudiness or dirtiness of water which is caused by fine suspended solid particles like silt, clay organic and inorganic matter etc. These fine solid particles are invisible to our naked eyes. This parameter of water is measured by nephloturbidimeter method. Turbidity is measured in Nephlo Turbidity Unit (NTU), according to NEQS the standard value of turbidity in drinking water must not be exceeded to 5 NTU. It is used to measure the presence of turbidity in domestic Grey water. The main purpose of this parameter to analyze in water is to stop the growing of different micro-organisms which grow due to the turbid water. The turbid water effects not only on human health but also effects aquatic life like fish, plankton, zooplankton, etc.

Total Suspended Solids

The suspended particles are those particles which may not pass through filter paper. TSS is also called as conventional pollution according to US EPA clean water act. According to SEQS, the wastewater can be used as effluent if it has TSS up to 200 mg/L. TSS can be analyzed by two methods, one is the gravimetric method, and the other one is a colorimetric method. In this research work, TSS were analyzed through Baloch et al 970 Colorimetric (DR 2000 Spectrophotometer) method. TSS may include a wide variety of silt, clay, animal decaying and industrial waste which may cause serious problem for aquatic life and water streams.

Chemical Oxygen Demand

The Chemical Oxygen Demand (COD) is the amount of oxygen consumed by organic matter in a solution. In this research work, the closed reflux / colorimetric method was used to determine the amount of COD in domestic Grey water before and after adsorbent. According to SEQS, the COD of effluent must be less than 150 mg/L. In closed reflux / colorimetric method, first of all, sample is digested through COD digester at 150◦ C for a time duration of 2 hours and cool it at room temperature and analyze the COD of the sample through COD photometer.

Biochemical Oxygen Demand

The Biochemical Oxygen Demand is the amount of oxygen required to microorganisms for the decomposition of organic matter present in wastewater. In this research work, the BOD was analyzed by 5 – days BOD method. According to SEQS the BOD of effluent must be less than 80 mg/L.

Lead

Lead is the heavy metal which is generally present in wastewater. The main sources of lead into wastewater are lead-acid batteries, ceramics and leather industries. The standard method of lead analysis is Atomic Absorption Spectrophotometer method. According to SEQS, the lead of effluent must be less than 0.5 ppm.

Chromium

Chromium is also a type of brittle, hard metal. The major source of chromium is ores of chromite. The chromium is also called as carcinogenic heavy metal [26]. According to SEQS, the chromium of effluent must be less than 0.1 ppm. 3. Results & Discussion

Fruit Waste Generation in Surapet Chennai

A survey was conducted in Surapet to check generation of fruit waste. In this survey 3 juice shops and 15 houses with three categories like upper class, middle class and lower class houses. From fruit juice shops, the data was collected seven days continuously, and it was calculated per day and per week. Fruit Juice Center Surapet Fruit waste generation data from fruit juice center was collected in seven days, and the total fruit waste was also calculated with each type of waste. Table No. 3 shows the total fruit waste generation Apple which 14.6 Kg/week, Banana waste 107.13 Kg/week, 71.1Kg / week and sapodilla waste 10.44 Kg/week. The average weight of Apple waste generation per day will be equal to 2.087 Kg, The average weight of Banana waste generation per day was equal to 15.30 Kg, the average weight of Orange waste generation per day was equal to 10.15 Kg and the average weight of sapodilla waste generation per day was equal to 1.49 Kg. While the average weight of Fruit waste generation of shop per day was equal to 29.027 Kg.

Table 3 Fruit waste Generation of Fruit Juice Center

Name of Fruit	Units	Day 1	Day 2	Day 3	Day4	Day 5	Day 6	Day 7	Total weight
Banana	Kg	17.4	15.8	12.5	14.23	15.4	19.5	12.3	107.13
Orange	Kg	10.4	11	13.	15.8	12.4	8.8	9.6	71.1
Sapodilla	Kg	1.75	2.25	1	0.65	1.57	1.35	1.87	10.44

Al – Shahbaz Juice Center Surapet Chennai

From this fruit juice shop, the data of fruit waste generation were collected for seven days. As shown in table no. 4 the generation of total fruit waste of apple was 9.9 Kg, banana waste was 37 Kg, orange waste 28.3 Kg and sapodilla waste was 5.26 Kg.

Table 4 Fruit Waste Generation of Al - Shahbaz Juice Center

Name of Fruit	Units	Day 1	Day 2	Day 3	Day4	Day 5	Day 6	Day 7	Total weight
Banana	Kg	2.3	7.8	5.3	2.7	5.4	6.2	73	37
Orange	Kg	6.1	2.1	3.3	6.1	5.1	3.4	2.2	28.3
Sapodilla	Kg	0.56	1.1	1.24	0.87	0.5	0.32	0.67	5.26

The average fruit waste of Al – Shahbaz juice center per day was estimated 11.48 kg/day. The average weight of Apple waste generation per day was equal to 1.41 Kg, the average weight of Banana waste generation per day was equal to 5.28 Kg, the average weight of Orange waste generation per day was equal to 4.04 Kg and the average weight of sapodilla waste generation per day was equal to 0.75 Kg.

Fruit waste generation of lower class houses Fruit waste generation from lower class houses also was done by the same procedure as in upper and middle-class house. In this class of houses only two weeks data was collected and in the third week, no any data was obtained. Table no.5 .shows the fruit waste generation of lower class houses.

Table 5 Fruit waste Generation of Lower Class Houses 1st Week

House No.	Units	Orange	Apple	Sapodilla	Banana	Total
01	Kg	0.2	-	0.1	0.2	0.5
02	Kg	0.1	-	0.1	0.28	0.48
03	Kg	0.1	0.1	-	0.2	0.4
04	Kg	0.13	-	0.1	0.15	0.38
05	Kg	0.2	-	0.1	0.3	0.6

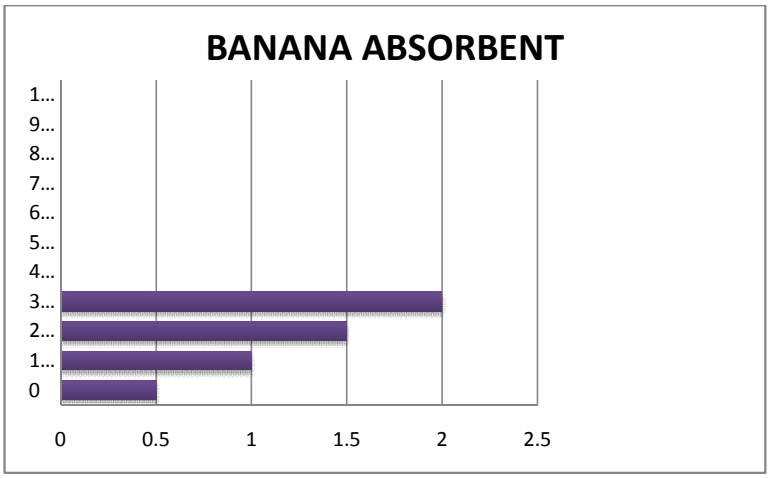
Treatment of Domestic Grey water by using Activated Carbon as an Adsorbent

The general water quality parameters like Turbidity, Total Suspended Solids, COD, BOD, Chromium and Lead were tested for domestic Grey water before and after adsorbent. For the analysis of different physicochemical parameters, 12 samples of synthetic wastewater were prepared under different experimental conditions.

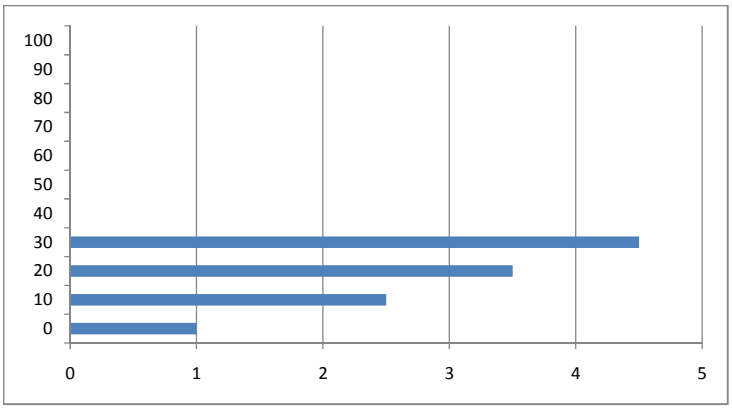
Effect of Bio-adsorbent Dosages Various dosage of the prepared banana peels, orange peels and sapodilla peels bio-adsorbent used to treat the domestic Grey water.

The parameters such as Turbidity, TSS, BOD, COD, Chromium and Lead have been changed with the increase in the bio-adsorbent dosage. The effects of adsorbent dosage were varied from 0.5 to 2 g for banana peel, orange peel and sapodilla peel individually. Hence 1 g was found to be the optimum dosage in treating the domestic Grey water for banana and orange adsorbent.[27]

Removal of Turbidity concentration using Banana powder with various dosages Turbidity is the cloudiness or dirtiness of water. This parameter was analyzed by turbid meter equipment. The turbidity removal was observed by using various dosages of banana powder as adsorbent. The maximum removal efficiency was observed at 1 g of dosage. The removal percentage of turbidity at 1g of banana adsorbent is 90%, the removal percentage of turbidity from orange adsorbent is 86% and from sapodilla adsorbent is 83%.



ORANGE ABSORBENT



Removal of Total Suspended Solids concentration using Banana powder with various dosage

Total Suspended Solids are those particles present in wastewater which are not filterable. The maximum removal of TSS is at 1 g of each adsorbent. From banana adsorbent, the removal of TSS is 88%, from orange adsorbent the removal of TSS is 87% and from sapodilla adsorbent the removal of TSS is 75%.

Removal of Biochemical Oxygen Demand (BOD) concentration using Banana peels with various dosage

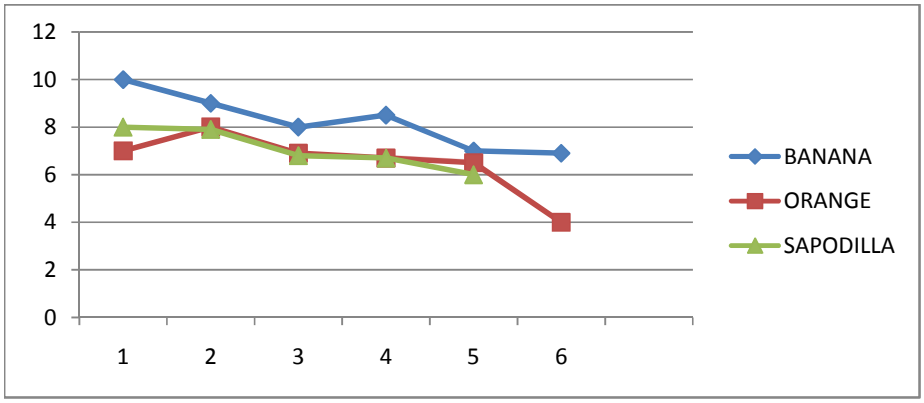
Biochemical Oxygen Demand is the amount of oxygen required to microorganisms to decompose the organic matter. The average maximum removal of BOD was at 1.5 g of each adsorbent, but not in orange adsorbent. The removal percentage of Biochemical Oxygen Demand by using Orange powder as an adsorbent in domestic Grey water. In orange adsorbent the maximum removal efficiency is obtained at 1 g dosage which is shown in following figure. From banana adsorbent the removal of BOD was 89%, from orange adsorbent the removal of BOD was 93% and from sapodilla adsorbent the removal of BOD was 70%.

Removal of Chromium concentration using Banana, Orange and Sapodilla peels with various dosages

For the analysis of chromium from domestic Grey water, 10 ppm solution of chromium was prepared and was analyzed after adsorbent through Atomic adsorption spectrophotometer .The maximum removal of chromium was obtained at 1.5 g except for banana adsorbent, which was maximum 68% at 1 g, and the maximum removal of chromium from orange and sapodilla adsorbent were 55% and 54%

Effect of Contact Time

The effect of contact time was observed for the analysis of heavy metals to check the maximum removal at a particular duration of time. The eighteen samples were run with different time duration range 0 to 6 hours. The maximum removal of chromium and lead were observed at 1 hour using banana, orange and sapodilla as an adsorbent with a constant amount 1 g. After six hours, the phenomenon of adsorption takes place where further removal of any contaminant stops.



Conclusion

There are many technologies to treat the water, bio-adsorption technique is also one of them. Fruit wastes (like Banana, Orange, etc.) are agricultural waste which is discarded as waste material in all over the world. Two objectives were set, the first objective was to determine the generation of fruit waste in surapet Chennai city while the second objective was related with the treatment of domestic Grey water using fruit waste as an adsorbent. Three fruit wastes were selected for adsorption which includes Banana, Orange and Sapodilla waste. Activated carbon was prepared from these fruit wastes and then were used for adsorbent to check the different physic-chemical parameters of domestic Grey water. Six physicochemical parameters like Turbidity, TSS, COD, BOD, Chromium and Lead were analyzed and their removal efficiency by using three adsorbent at different dosages and different time period were observed. The optimum dosage of adsorbent was selected 1g. At 1g of adsorbent dosage the removal of these six parameters were greater than 65% which was suitable for effluent according to Environmental Protection Agency. The activated carbon technology is the branch of nanotechnology which is the advanced technology nowadays for future generation. The main advantage of this activated carbon is that this technology treats mostly the organic pollutants like VOCs etc. In industrial wastewater huge quantity of VOCs and other organic pollutants are present which may be easily removed by activated carbon, therefore for the treatment of industrial wastewater activated carbon is the best technology for the removal of organic matter. In future this technology can be used in filtration process of the influent which is coming from industries.

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