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Comparison studies on treatment of automobile wash wastewater by filtration techniques using alum sugarcane bagasse and wood dust

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ABSTRACT

Fast urbanization has boosted the automotive sector in cities. Two service stations collected car wash water, which was analyzed thoroughly. pH, total suspended solids, total dissolved solids, oil & grease, chemical oxygen demand (COD), biochemical oxygen demand, chlorides, and sulfates were measured. Chemical treatment used alum, while physical treatment used sawdust and sugarcane bagasse. Sample A contains wash water from 2- and 4-wheelers, while sample B has only 4-wheeler wash water. The empirical results show that physical treatment filter bed porosity, surface area, and height affect substance sorption. COD reduction for wood dust and sugarcane in sample A is 91.59% and 90.70%, while in sample B it is 81.40% and 86.70%. COD and oil & grease concentration were measured at 3, 6, and 9 cm filter columns. The percentage reduction in COD and oil & grease was related to filter material penetration. COD, oil, and grease removal effectiveness increases with filter bed depth. Alum's COD reduction is 89.10 in sample A and 87.50 in sample B, according to coagulant dosage. Alum removes 92.40% and 93.20% of oil & grease in samples A and B. Sample A used sugarcane bagasse and sawdust to remove 94.31% and 93.40% of oil & grease. Removal percentages in sample B were 92.67% and 93.80%. Sugarcane and wood dust reduces COD and oil & grease more in sample A than sample B. Sample A had a lower alum removal rate than sample B.

Keywords: Automobile wash wastewater; Alum; Wood dust; Sugarcane bagasse; Oil & grease; Chemical oxygen demand

1. Introduction

The growing urban population is causing freshwater resources to disappear, which worries ecologists [1,2]. A car wash at home can require 80–140 gallons (300–530 L) of water, but a car wash in a garage will only require approximately 30–45 gallons (115–170 L), according to the International Car Wash Association. Water will be utilized to clean the flooring and wash the equipment after the automobiles are cleaned [3,4]. There is a lot of water wasted every day on car upkeep and washing. According to Gregory [4], there are two basic phases in the coagulation–flocculation process: (i) The stabilized colloid is destabilized in addition to the coagulant. (ii) An aggregate is created when the colliding particles come together. [5–7]. This wash water contains heavy metals, paint, oil, grease, hydrofluoric acid, phosphates, and ammonium bifluoride products [8,9]. A summary of membrane, chemical, biological, and physical treatments

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for wastewater treatment was presented by Ahmadun et al. [10] and Alqahtani et al. [11]. The review states that there are two or more methods for treating water that can be utilized sequentially, and the selection of technology is determined by the intended use of the water. According to a comparative study by Mazumder and Mukherjee [12], alum chemical coagulation, alum mixed with bentonite powder, ferrous sulfate, and calcium chloride in the presence of bentonite powder, is utilized to totally remove oil & grease [13,14].

The car wash, one of the most important urban services, generates a large volume of wastewater with a high chemical oxygen demand (COD) and turbidity [15]. The season and the features of the car wash location affect the wastewater quality [16–18]. Numerous approaches have been employed to remove different toxins from wastewater from automobile washes, which poses a significant risk to the environment [19]. The principal constituents of car wash wastewater, which can be quantified as COD on a normative basis, are fine sand, slick oil, suspended solids, and surfactants. The average removal rates of suspended solids and COD are approximately 81% and 43%, respectively. Reclaimed water can be more expensive than current technology while still covering operating costs because of the single-unit cyclo-flow filtration system [20–22].

The results of this extensive investigation show that the most common chemical process utilized to clean wastewater from car washes is coagulation (66%) [23–25]. Even so, chemical methods can reduce turbidity and COD by more than 80%. The characteristics of carwash wastewater necessitate chemical pretreatment for processes such as membrane technology [26,27]. The two main factors to take into account when selecting a chemical process for car wash wastewater treatment are the energy intake and sludge volume, notwithstanding the rapid and highly efficient treatment capabilities of chemical wastewater treatment procedures [28,29].

Many vehicle wash facilities are in operation in the Indian State of Kerala, and these facilities produce a sizable volume of wastewater. Even though there are several ways to handle this kind of wastewater, most gas stations don’t have treatment facilities, therefore the untreated wastewater ends up in the dump. This leads to serious pollution problems [30,31].

2. Methodology

2.1. Sample collection

The location of the current investigation was determined to be in the city of Bangalore. For the purpose of the study, there were determined to be two authorized service shops, designated A and B, both of which cleaned, maintained, and repaired automobiles. Even though all of the work on the vehicles was completed in the service stations, the largest portion of the contribution to the automobile effluent came from the washing of the vehicles. During that time, service station B was focused entirely on cleaning 4-wheelers. There was neither a separate sump system nor a drainage system directly connected to either of the service stations’ sump systems in either of the two service stations. The images that are displayed in Fig. 1 are of the sample that was collected for the research.

2.2. Materials used

During the process of physical treatment, it is evaluated whether or not natural materials such as sawdust and sugarcane bagasse are appropriate for removing COD as well as oil & grease. The comprehensive treatment procedure will be broken down for you in the next sections of this article. During the chemical treatment process, alum is applied so that COD as well as oil & grease can be removed. Fig. 2 shows the types of components that can be used, and they include sawdust, sugarcane bagasse, and alum. Sawdust and sugarcane bagasse were two examples of the organic materials that were used to construct the 50 by 50 mm filter beds that were used for filter media that ranged in height from 3 to 6 to 9 cm. Both of the textiles were allowed to properly dry in the sun before the test was performed. In order to prevent the filter bed from being

SAMPLE A SAMPLE B

Fig. 1. Photography of sample collection.

dislodged from the wooden box in which it was created, a plastic net was attached to the bottom of the box. The filter bed that was utilized for the physical treatment may be seen in the picture that is shown in Fig. 3.

2.3. Methods

Various methods are available for the treatment of wastewater generated from automobiles, encompassing both physical and chemical processes. This study investigates the effectiveness of different treatment systems in reducing COD and oil & grease levels. The performance of these systems is evaluated and compared based on numerous factors. Alum is utilized in chemical treatment, whilst the adsorption principle and the gravimetric approach are employed for physical treatment. The subsequent sections present an overview of the all-encompassing therapy procedure. Tables 1 and 2 present the characteristics of raw samples A and B, respectively. It has been shown that sawdust exhibits a higher number of voids and a larger exposed surface area relative to its volume. The filtrate water underwent testing for COD and oil & grease content subsequent to its passage through the filter medium.

During the characterization tests that were performed on the automotive effluent, the amounts of oil & grease were relatively high when compared to the requirements that were set by the Central Pollution Control Board (CPCB) [2]. In compliance with the IS regulations, measurements were taken of the following: pH, total and dissolved solids, turbidity, conductivity, chlorides, sulfates, total hardness, oil & grease, COD, and biochemical oxygen demand. The findings of the tests on samples A and B are summarized in Tables 1 and 2, and those results are compared to the general standards that the CPCB established in 1986 for the discharge of environmental contaminants. Sample B is more turbid than sample A and has higher values for all of the physical features, despite the fact that both samples have an alkaline pH, the findings of the characterization demonstrate that sample B has the higher values overall.

3. Results and discussions

3.1. Effects of chemical treatment with alum

The formation of flocs is induced by the introduction of alum into the effluent, followed by agitation with a

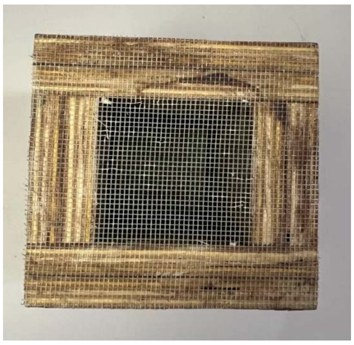
Fig. 3. Wooden box filter bed.

ALUM SUGARC ANE BAGASSE SAWDUST

Fig. 2. Materials used for physiochemical treatment.

Table 1
Characteristics of raw sample A (2-wheeler + 4-wheeler)

S. No.	Parameters	Unit	Results	Tolerance limits for treated outlet as per TNPCB	Test method
1.	pH value at 25°C	–	7.00	5.5 to 9.0	APHA 23rd ed.: 2017 4500 HM + B
2.	Total suspended solids	mg/L	140	100	IS:3025:P.17:1984: R.2017
3.	Total dissolved solids	mg/L	1,220	2,100	IS:3025:P.16:1984: R.2017
4.	Chemical oxygen demand	mg/L	5,186	250	APHA 23rd ed.: 2017 5220 B
5.	Biochemical oxygen demand at 27°C for 3 d	mg/L	1,150	30	IS:3025 P.44 1993 R.2019
6.	Chlorides as Cl	mg/L	320	1,000	APHA 23rd ed.:2017 4500 Cl B
7.	Sulfates as SO_4	mg/L	88.0	1,000	APHA 23rd ed.:2017 4500 SO_4 2-E
8.	Oil & grease	mg/L	380	10	IS 3025 P.39 1991 R.2019

flocculant. The experimental procedure resulted in the sample exhibiting a pH range of 7.2–7.5. Filtration is employed as a means of eliminating flocs, with subsequent evaluation of the filtrate's COD and oil & grease concentration. The fraction of these parameters that were eliminated from the filtrate is presented in Table 3. The data presented indicates a positive correlation between the dosage of alum and the removal efficiency of COD and oil & grease, whereby an increase in alum dosage results in a higher percentage of removal for these contaminants.

3.2. Effects of physical treatment with sawdust and sugarcane bagasse

Tables 4 and 5 include data on the efficacy of natural materials in the removal of COD and oil & grease, across different filter or column heads composed of these materials. The results unequivocally demonstrate that both sawdust and sugarcane bagasse exhibit comparable efficacy in the removal of pollutants, displaying similar levels of effectiveness. Sawdust has been found to be effective in the removal of COD as well as oil & grease contaminants. This phenomenon may be attributed to the presence of sawdust above sugarcane bagasse, which effectively enhances the surface area available for adsorption. Sawdust exhibits a reduced particle size within a given volume, hence augmenting the surface area available for adsorption.

3.3. COD and oil & grease removal treated with alum

When alum was utilized as a coagulant in the wastewater sample, the oil & grease components were effectively separated. The percentage removal of oil & grease, as well as the COD, were assessed for both samples A and B after treatment with alum. The application of a higher dosage of coagulant leads to an increase in the percentage of COD, as well as an increase in the concentration of oil & grease. The optimal dosage of coagulant was determined to be 225 mg/L. The elimination percentages for oil & grease and COD are depicted in Figs. 4–7.

3.4. Removal of oil & grease, COD removal by sugarcane bagasse and wood dust

The objective of this study is to investigate the influence of filter bed depth on the removal efficiency of oil & grease

Table 2
Characteristics of raw sample B (4-wheeler)

S. No.	Parameters	Unit	Results	Tolerance limit for treated outlet as per TNPCB	Test methods
1.	pH value at 25°C	–	7.05	5.5 to 9.0	APHA 23rd Ed.:2017 4500 HM + B
2.	Total suspended solids	mg/L	590	100	IS:3025:P.17:1984: R.2017
3.	Total dissolved solids	mg/L	930	2,100	IS:3025:P.16:1984: R.2017
4.	Chemical oxygen demand	mg/L	72,240	250	APHA 23rd ed.: 2017 5220 B
5.	Biochemical oxygen demand at 27°C for 3 d	mg/L	18,150	30	IS:3025 P.44 1993 R.2019
6.	Chlorides as Cl	mg/L	325	1,000	APHA 23rd ed.:2017 4500 Cl B
7.	Sulfates as SO_4	mg/L	84.0	1,000	APHA 23rd ed.:2017 4500 SO_4 2-E
8.	Oil & grease	mg/L	2,890	10	IS 3025 P.39 1991019

Table 3
Chemical oxygen demand and oil & grease removal for samples A and B treated with alum

Sample name	Coagulant dose (mg/L)	Concentration of chemical oxygen demand (mg/L)		% Removal	Concentration of oil & grease (mg/L)		% Removal
		Initial	Residual		Initial	Residual	
A	100	5,186	4,231	18.40	380	56.10	85.30
	125		3,381	34.80		49.80	86.90
	150		2,603	49.80		44.90	88.20
	175		1,685	67.50		36.10	90.50
	200		565	89.10		28.90	92.40
B	100	72,240	41,465	42.60	2,890	494	85.90
	125		31,208	56.80		367	87.30
	150		25,790	64.30		312	89.20
	175		18,927	73.80		243	91.60
	200		9,030	87.50		197	93.20

Table 4
Comparison on percentage removal of chemical oxygen demand by sugarcane bagasse and sawdust

Sample	Depth of filter bed (cm)	Concentration of chemical oxygen demand (mg/L)	Sugarcane bagasse		Sawdust	
			Residual chemical oxygen demand (mg/L)	% Removal	Residual chemical oxygen demand (mg/L)	% Removal
A	3	5,186	3,205	38.19	3,070	40.80
	6		1,758	66.10	2,105	59.40
	9		436	91.59	482	90.70
B	3	72,240	40,671	43.70	42,188	41.60
	6		25,197	65.12	28,664	60.32
	9		13,436	81.40	9,607	86.70

Table 5
Comparison on percentage removal of oil & grease removal by sugarcane bagasse and sawdust

Sample	Depth of filter bed (cm)	Concentration of oil & grease (mg/L)	Sugarcane bagasse		Sawdust	
			Residual oil & grease (mg/L)	% Removal	Residual oil & grease (mg/L)	% Removal
A	3	380	45.22	88.10	38.34	89.91
	6		32.26	91.51	34.54	90.91
	9		21.62	94.31	24.85	93.46
B	3	2,890	457	84.18	315	89.10
	6		332	88.51	277	90.41
	9		211	92.69	179	93.80

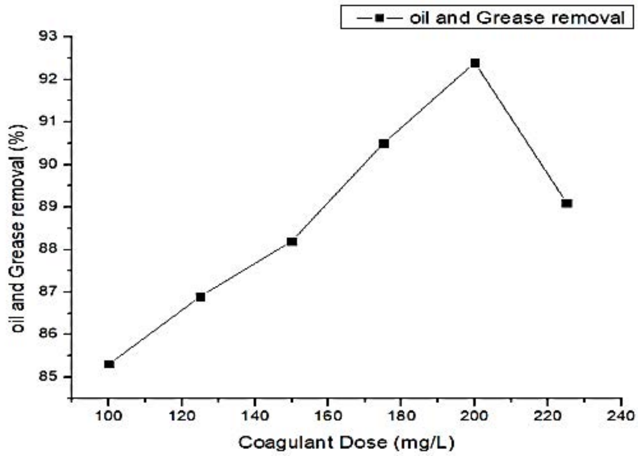

Fig. 4. Oil & grease removal with alum sample A.

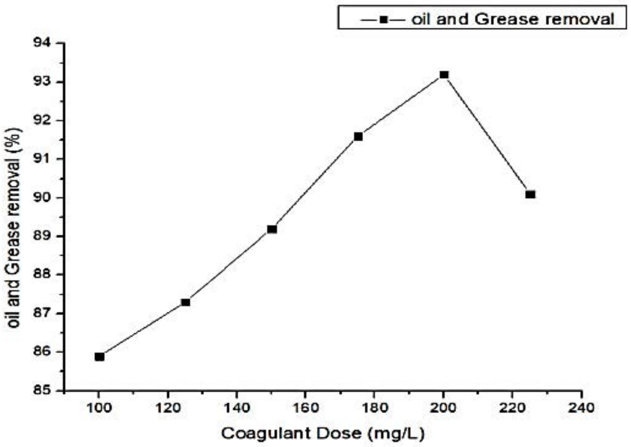

Fig. 5. Oil & grease removal with alum sample B.

and COD in samples A and B. The filter media employed in this experiment are sugarcane bagasse and wood dust. The removal of oil & grease, as well as the removal of COD, exhibit an increasing trend with the elevation of the filter bed depth. The data presented in Figs. 8–15 illustrate the percentage of COD and oil & grease removal.

4. Conclusions

In the context of natural approaches, there was an observed increase in the proportion of clearing as the designated area expanded. Consequently, wood dust exhibited superior performance in comparison to sugarcane bagasse. Bio adsorbents are cost-effective and easily accessible within the surrounding vicinity. Sample A exhibited a removal efficiency of 91.59% and 90.70% for sugarcane and sawdust, respectively, while sample B demonstrated removal efficiencies of 81.40% and 86.70% for the same materials. Sample A was able to remove 89.10% of the alum, whereas sample B had a removal rate of 87.50%. The relative percentages of alum removed by oil & grease in samples A and B are 92.40% and 93.20%. Sample A exhibited removal rates

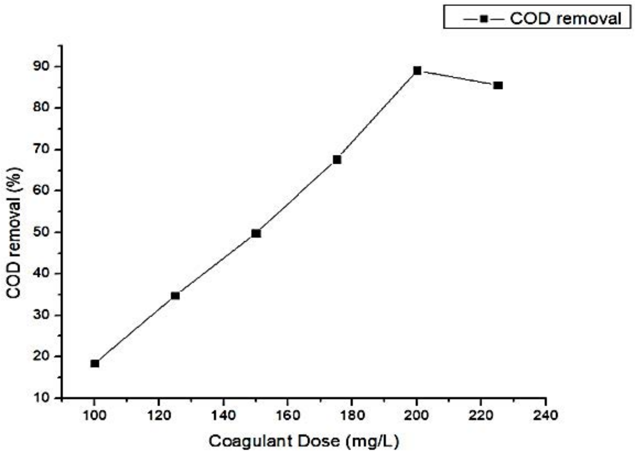

Fig. 6. Chemical oxygen demand removal with alum sample A.

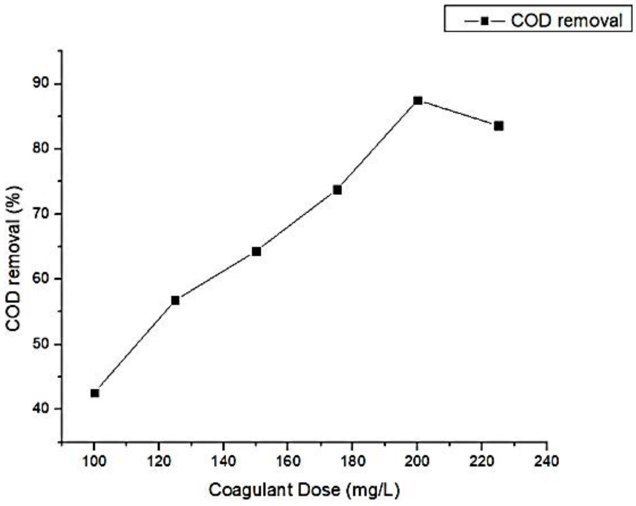

Fig. 7. Chemical oxygen demand removal with alum sample B.

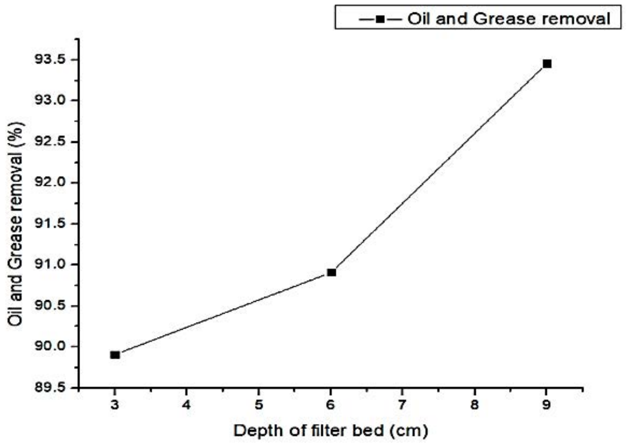

Fig. 8. Oil & grease removal by using sugarcane bagasse sample A.

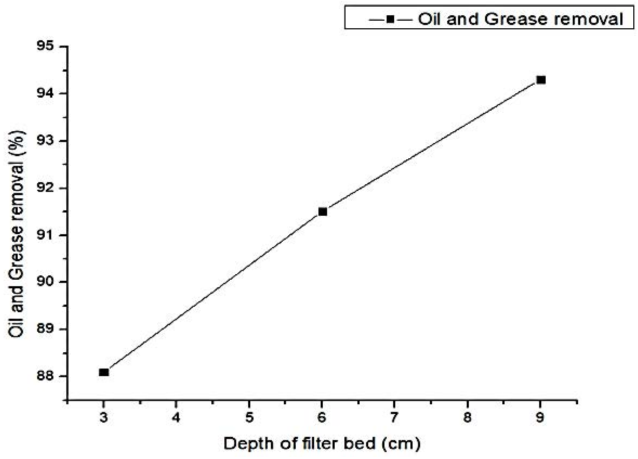

Fig. 9. Oil & grease removal wood dust sample A.

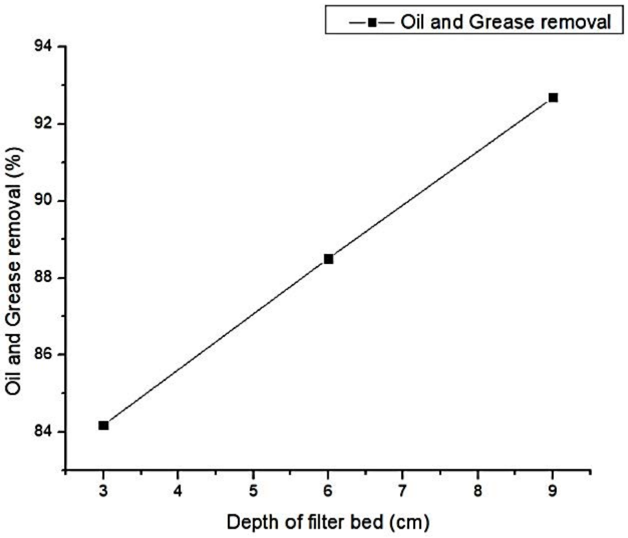

Fig. 10. Oil & grease removal using sugarcane bagasse sample B.

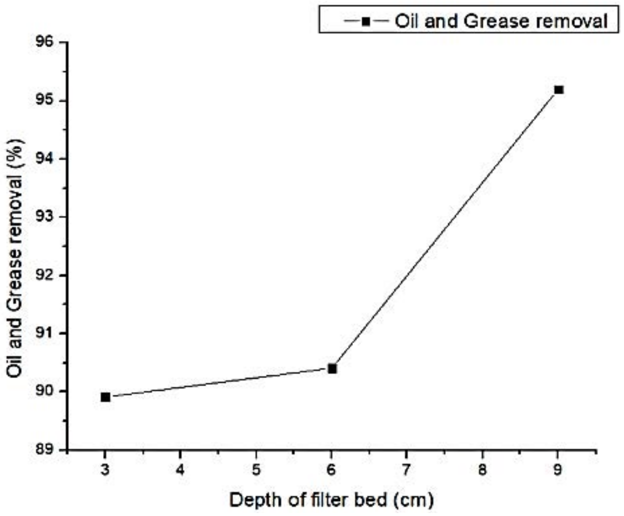

Fig. 11. Oil & grease removal by using wood dust for sample B.

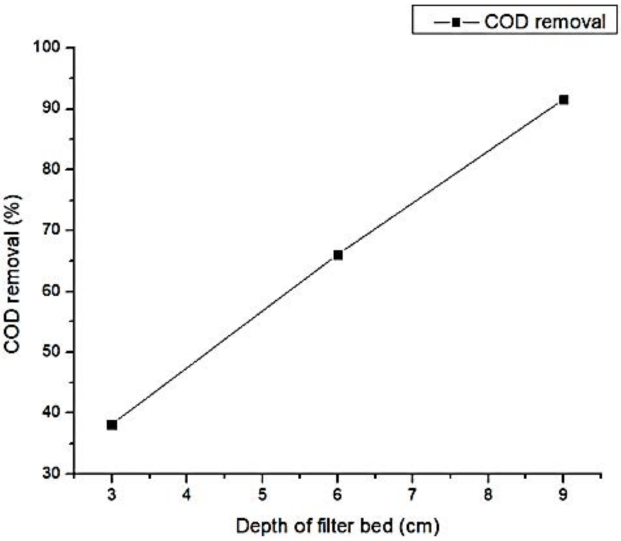

Fig. 12. Chemical oxygen demand removal by sugarcane bagasse for sample A.

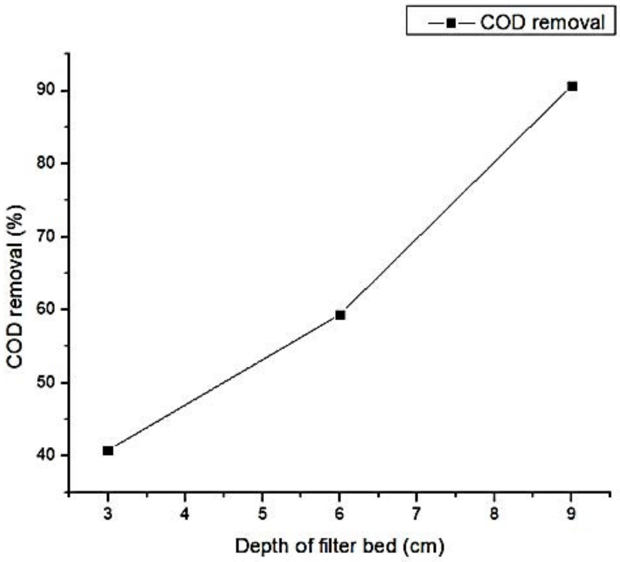

Fig. 13. Chemical oxygen demand removal by wood dust for sample A.

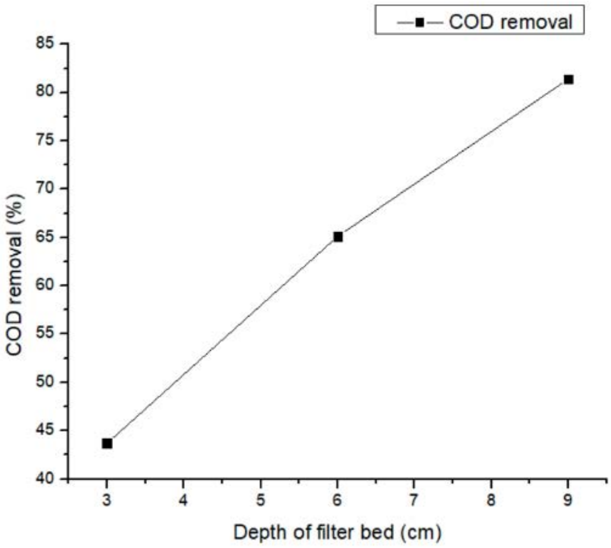

Fig. 14. Chemical oxygen demand removal by sugarcane bagasse for sample B.

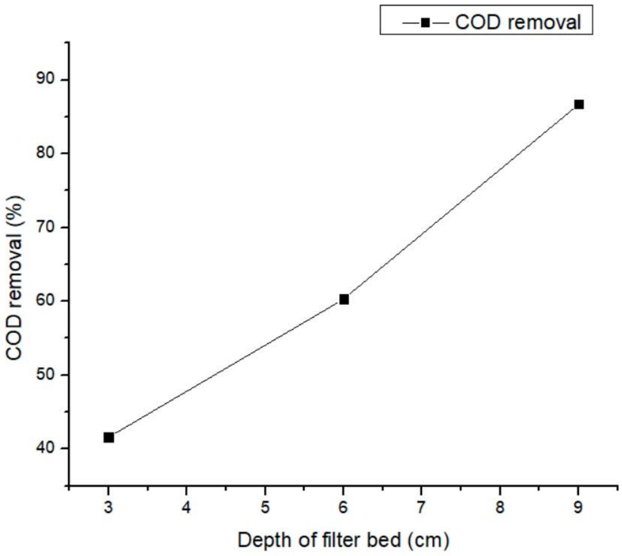

Fig. 15. Chemical oxygen demand removal by wood dust for sample B.

of 94.31% and 93.40% for sugarcane bagasse and sawdust, respectively. Conversely, sample B show removal rates of 92.67% and 93.80% for the same constituents. This article elucidates the methodologies employed in the characterization and remediation of wastewater generated by the automotive industry. The most significant characteristics identified in the automotive wastewater were the COD and the presence of oil & grease. This study investigated the utilization of sugarcane bagasse and sawdust as substrates, employing chemical and physical treatment techniques, across different column heights. A cost-effective bio adsorbent has the potential to effectively eliminate COD, oil, and grease across a broad spectrum of concentrations. The rise in alum concentration resulted in an increase in the removal percentages of COD and oil & grease. The effectiveness of both the natural treatment mode and the elimination of COD and oil & grease increased with the augmentation of bed depth.

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