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Treatment of Sugar Factory Wastewater with Activated Carbon Produced from Plum Seed Shell

Mon Yi Myo Myint[1], Zin Marlar Tin San[2], Nway Nway Khaing[3]
monyimyomyint08@gmail.com[1], zinmarlar@gmail.com[2], nnkhaing.civil09@gmail.com[3]
[1,2]Yangon Technological University
[3]West Yangon Technological University

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Abstract

This study demonstrates that activated carbon produced from plum seed shells is an effective adsorbent for treating highly polluted sugar factory wastewater from the Yeni area. The raw effluent was strongly acid (pH 4.5) and contained elevated TSS, TDS, COD (1280 mg/L), and BOD; pH was corrected using sodium hydroxide coagulants 2 ml/ l prior to adsorption. The effluent of pre-treatment is absorbed by plum seed shell activated carbon AC_1, AC_2, AC_3 and AC_4 using 10 gm/l. Among them, AC_4 is the most effective and the percent removal of sugar factory wastewater parameters are turbidity (80.91%), TDS (42.86%), Colour (50%),COD (75%) and BOD (97.2%) respectively**.** The treated effluent met Myanmar's National Environmental Quality Guideline (NEQG) across all measured parameters, supporting the conclusion that plum seed shell activated carbon is both effective and sustainable for sugar factory wastewater remediation. The research may contribute to civil, enviromental engineering and related domains.

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A. Introduction

Water is an essential resource for drinking, domestic use, agriculture, and industrial processes. However, rapid population growth, urbanization, and industrial expansion have led to a sharp increase in wastewater generation, exacerbating global water scarcity, particularly in arid and semi-arid regions [1]. The study area, Yeni in Bago Division, Myanmar, is located in a dry zone that relies heavily on seasonal rainfall. In such water-stressed regions, effective wastewater treatment and reuse are crucial for sustainable water management. Among various industrial effluents, sugar factory wastewater is a significant pollutant due to its high organic load, suspended solids, and chemical oxygen demand (COD) [2]. The sugar mill in Yeni generates approximately 96,000 gallons of wastewater per day from clarifying and lime treatment processes. This effluent is highly acidic (pH ~4.5) and contains elevated levels of total suspended solids (TSS), total dissolved solids (TDS), color, COD (up to 1280 mg/L), and biochemical oxygen demand (BOD), posing serious risks to receiving water bodies and human health if discharged untreated.

Conventional treatment methods such as coagulation, flocculation and adsorption with activated carbon are commonly used, but they may be costly or generate secondary pollutants. Recently, adsorption using activated carbon has emerged as an effective and low-cost alternative. Activated carbon derived from agricultural wastes—such as coconut shells, rice husks, fruit seeds—has attracted attention due to its renewability and high adsorption capacity [3]. However, the use of plum seed shells as a precursor for activated carbon remains largely unexplored, especially for treating sugar factory wastewater.

Therefore, this study aims to fill this research gap by investigating the feasibility of activated carbon produced from plum seed shells (variants AC1–AC4) for the remediation of heavily polluted sugar factory effluent from Yeni. The specific objectives are: (1) to characterize the raw and pre-treated wastewater, (2) to compare the adsorption performance of four activated carbon variants at a dosage of 10 g/L, and (3) to evaluate the treated effluent's compliance with Myanmar's National Environmental Quality Guideline (NEQG).

B. Research Method

The methodology of this study is as shown in flow chart of the study in figure 1.

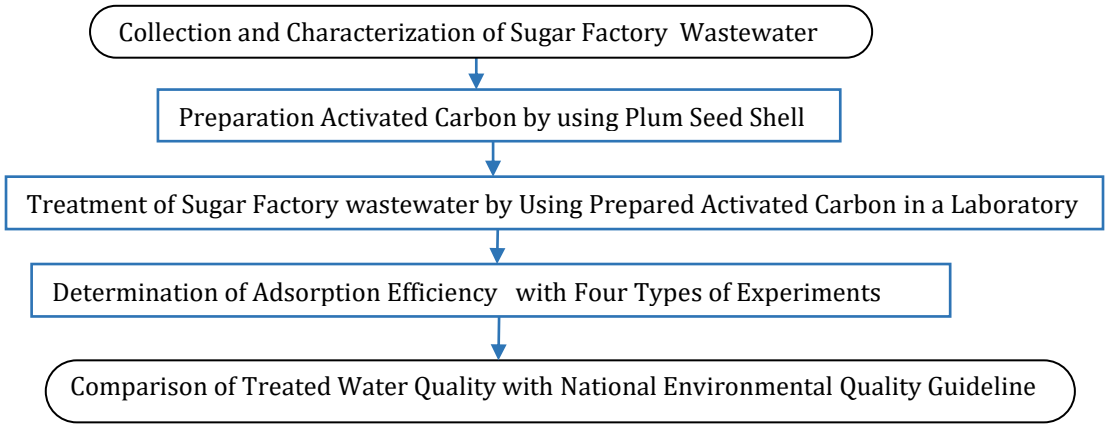


Figure 1. Flow Chart of the Study

B.1. Collection and Characterization of Sugar Factory Wastewater

Sugar factory wastewater is collected from sugar factory that is located at Yeni town, Bago Division. The following figure 2 shows the location of sugar factory where the sugar factory wastewater is collected in the process.

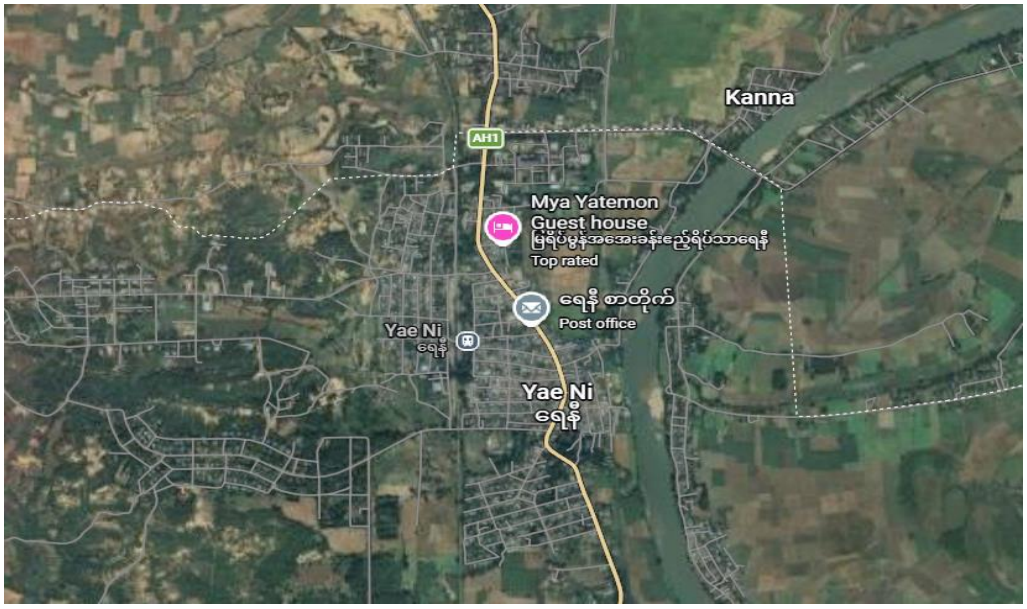


Figure 2. The Location of Study Area

B.2. Characterization of Sugar Factory Wastewater

The collection of sugar factory wastewater is shown in figure 2. The properties of sugar factory wastewater can be classified as two heads; physical characteristics and chemical characteristics. The most important physical characteristics of wastewater is its total solids content, odour, colour, turbidity, and so forth. Important chemical characteristics of sewage are: dissolved oxygen, chemical oxygen demand and biochemical oxygen demand and so forth. In sugar factory industry, the clarifying with lime process is produced wastewater. And then, sugar factory wastewater parameters are compared with maximum limit of sugar factory effluent value of National Environmental Quality Guidelines Myanmar [4],which is shown in table 1.

Table 1. Comparison of Concentration of Sugar Wastewater with NEQG Values

Sr.No.	Parameters	Effluent of Sugar Factory Wastewater	Maximum Limit of Textile Effluent Value (NEQG guideline)
1.	pH	4.8	6 – 9
3.	Total Suspended Solids(mg/l)	3090	50
4.	Total Dissolved Solids(mg/l)	840	80-110
5.	Chemical Oxygen Demand (COD)(mg/l)	1280	250
6.	Biochemical Oxygen Demond (BOD)(mg/l)	580	50

pH value leads to acid and that must be reduced to the limits of NEQG values. The total suspended solids is 3090 mg/l that is more than about 62 times of maximum limit of sugar factory effluent value of NEQG Myanmar. Similarly, the concentration of total dissolved solids, COD and BOD values are situated over 10%, 5% and 12 % the maximum limit of NEQG values. Directly discharged of sugar factory wastewater is impact to environment and emviromental resources pollution. Therefore, sugar factory wastewater is treated by using activated carbon in this study.

B.3. Preparation of Plum Seed Shell Activated Carbon

In central Myanmar, plums are grown in various soil . The plum jam, juice and plum seeds produces the plum seed shells, which are solids wastes from these production processes. These solid wastes are typically used as natural fertilizer, as a substitute for charcoal, or burned as fuel for production of fried potatoes snacks, among other uses. In this study, the solid wastes plum seed shells are converted into activated carbon and used in the textile wastewater treatment processes.

B.4. Carbonization of Plum Seed Shell

First, the plum seed shells are washed with water. They are then dried in sunray 2 to 3 days and placed in muffle furnace 1 hr at 500°C [6]. The processes of clean and dried process , carbonization of plum seed shells and using activator such as sulphuric acid and preparing steps are shown in figure 3.

B.5. Activation of Carbonize Plum Seed Shell

The surface area of plum seed shells naturally has some shrinkage, which may help filter suspended solids in wastewater. The carbonized plum seed shells were immersed in various normalities of concentrated sulphuric acid(H_2SO_4) as an activator. The activating agent was applied at sample-to-activator ratios of1:2,1:3 and 1:4 with the activation process, which is carried out over 24 hours. After activation, the immersed carbon is cleaned with distilled water to reach pH level 6 to 7 and that are placed in oven 30 minutes at 100°C.

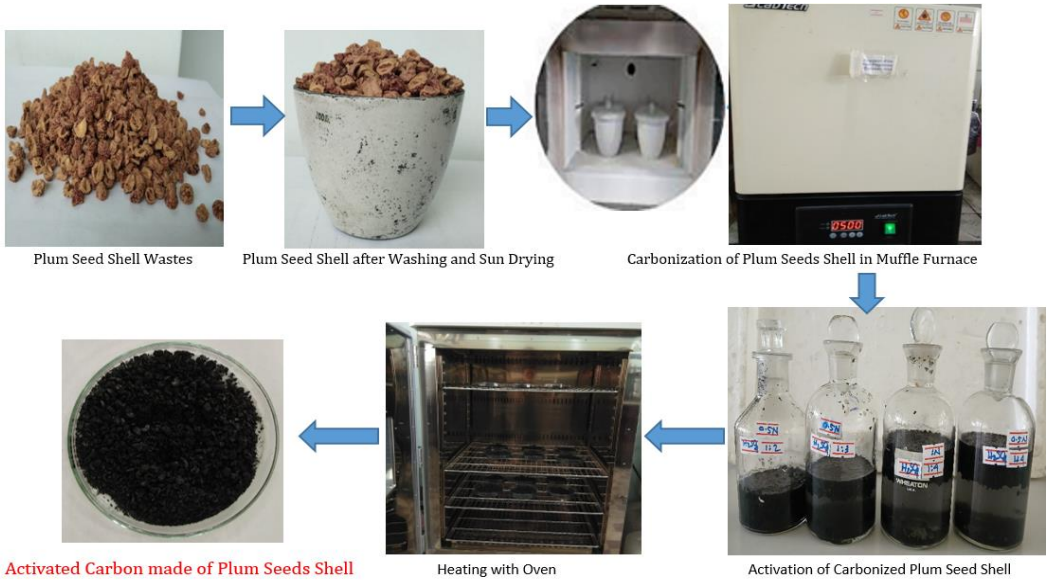


Figure 3. Preparation of Plum Seeds Shell Activated Carbon

Carbonization and activation processs of plum seed shell are described in table 2. Preliminary adsorption tests are conducted on activated carbon using four different activated carbon samples AC_1 to AC_4. The selection of the best activator is based on several normality 0.5N,1N and 2N of H_2SO_4 and weight ratio of activation is 1:2, 1:3 and 1:4 respectively. The total porosity and surface area of activated carbon is using Scanning Electron Microscope (SEM) test results is presented in figure 4. According to test results, the best activator is AC_4 . The surface porosity area from SEM results is shown in table 2.

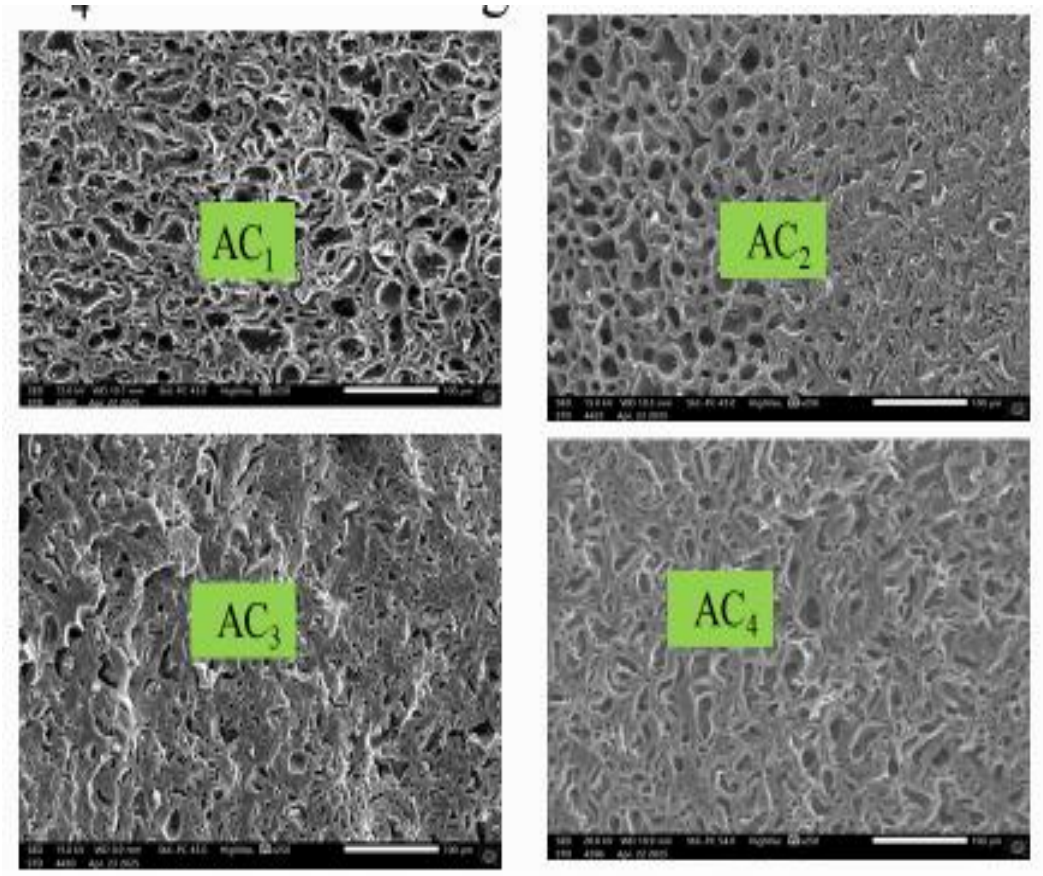


Figure 4. SEM Results of Surface Area for AC_1, AC_2, AC_3 and AC_4

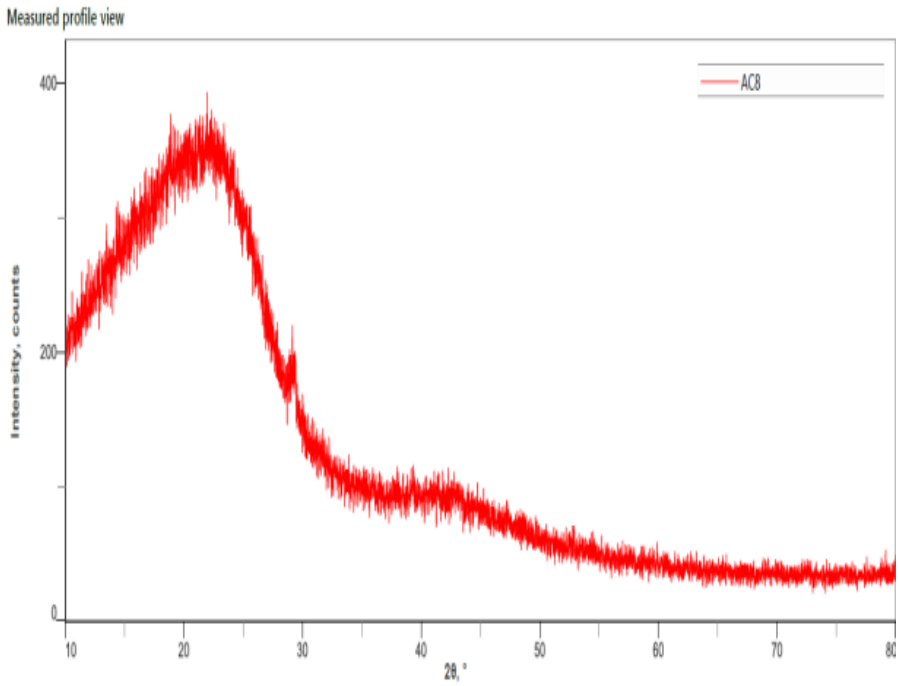
Table 2. Carbonization, Actvation and Area of Porosity for AC_1,AC_2, AC_3 and AC_4

No.	Carbonization of plum Seed Shell		Activation of Carbonized Plum Seed Shell	
	Time	Temperature	Normality	Ratio
AC_1	1 hr.	500°C	1 N	(1:4)
AC_2	1 hr.	500°C	0.5 N	(1:2)
AC_3	1 hr.	500°C	0.5 N	(1:3)
AC_4	1 hr.	500°C	0.5 N	

B.6. Porosity of Activated Carbon

The porosity of activated carbon is determined according to Scanning Electron Microscope (SEM) test results and the X-ray Diffraction XRD result, a broad diffraction peak at 2θ ranging between 20 and 30 was observed in the prepared composite, confirming the presence of activated carbon[1].

Determination of average surface porosity area by applying Image J and results are shown in figure 6, XRD results are shown in figure 5. results of porosity area of activated carbons are described in table 3.



Phase name	a,	Å b,	Å c,	Å α,	° β,	° γ, °
Carbon	4.90002	4.90002	3.88886	90.000	90.000	120.000

Figure 5. XRD Results of Activated Carbon (AC_4)

Table 3. Results of Percentage of Porosity Area in AC_1, AC_2, AC_3 and AC_4

No. of AC	Count	Total Area	Average Size	%Area of Porosity	Min Feret
AC_1	4763	12723	2.671	25	1.10
AC_2	6395	9209	1.44	21	0.68
AC_3	5026	13965	2.778	29	0.84
AC_4	2172	11150	5.134	31	0.78

B.7. Preliminary Treatment of Sugar Factory Wastewater

Characterization of sugar factory wastewater, concentrations of parameters are situated lower limit of maximum limit of sugar factory effluent value of National Environment Quality Emission Guidelines Myanmar. Therefore, sugar factory wastewater required to treat before disposed to receiving water bodies. Sugar factory wastewater is preliminary treated as coagulation and coagulants as sodium hydroxide solution. Optimum dosage of sodium hydroxide solution is 2 milligrams per liter of sugar factory wastewater according to test results. After preliminary treatment of water parameters and removal percentage are presented in table 4.

Table 4. Preliminary Treatment of Sugar Factory Wastewater

Wastewater with Alum Parameters	Sugar Factory Wastewater	Preliminary Treated Water
pH	4.8	6.5
TSS (mg/l)	3090	2980
TDS (mg/l)	840	760
COD(mg/l)	1280	1130
BOD (mg/l)	580	552

First, pH adjustment is carried out by mixing sugar factory wastewater with sodium hydroxide solution. Then, the optimum solution is 2 milligrams per litre of sugar factory wastewater according to Jar test. After mixing, the pH level of sugar factory wastewater nearly remains 6.5 which is suitable for the activated carbon used in this study. After the pH adjustments, the wastewater flows in beaker with 200 ml, which contains 10 gm/l of absorbent, contact time of wastewater and absorbents is 60 minutes.

C. Results and Disscusion

The adsorption process of the activated carbon on sugar factory wastewater is carried out in this process. This determination aims to find out the relationship between the number of substances adsorbed by the adsorbent and the concentration in the liquid phase at equilibrium. The determination of reducing concentration of parameters in the sugar factory wastewater is performed with various activated carbon and using mass is 10 gm/l respectively. The concentration of parameters for effluent is shown in table 4 and removal percentage of parameter concentrations is described in table 5. After preliminary treatment processes, effluent of water was absorbed by using activated carbon 10 gm/l such as AC_1, AC_2, AC_3 and AC_4.The absorption time is one hour, after treatment processes the parameters of treated water are reduced concentrations and compare with NEQG (Myanmar). The effluent of water treated with activated carbon processes is tested in laboratory. The removal percentage of each parameter by using various activated carbon are shown in table 5 to table 8. AC_4 is the most effective and the removal percentage is reached to available track parameters.

Table 5. Removal Percentage of Treated Water Parameter for AC_1

Parameters	Preliminary Treated of Sugar Factory Wastewater	Effluent by Using Absorbents (AC_1)	Removal Percentage
Total Suspended Solids	2980	120	82
Total Dissolved Solids	760	482.6	36.5
Chemical Oxygen Demand (COD)	1280	165	65
Biochemical Oxygen Demand (BOD)	552	72	97

Table 6. Removal Percentage of Treated Water Parameter Using AC_2

Parameters	Preliminary Treated of Sugar Factory Wastewater	Effluent by Using Absorbents (AC_2)	Removal Percentage
Total Suspended Solids	2980	102	96.58
Total Dissolved Solids	760	462	39.21
Chemical Oxygen Demand (COD)	1280	132	68.2
Biochemical Oxygen Demand (BOD)	552	62	88.77

Table 7. Removal Percentage of Treated Water Parameter Using AC_3

Parameters	Preliminary Treated of Sugar Factory Wastewater	Effluent by Using Absorbents (AC_3)	Removal Percentage
Total Suspended Solids	2980	89	97.01
Total Dissolved Solids	760	454	40.26
Chemical Oxygen Demand (COD)	1280	112	70.5
Biochemical Oxygen Demand (BOD)	552	58	89.49

Table 8. Removal Percentage of Treated Water Parameter Using AC_4

Parameters	Preliminary Treated of Sugar Factory Wastewater	Effluent by Using Absorbents (AC_4)	Removal Percentage
Total Suspended Solids	2980	62	97.92
Total Dissolved Solids	760	434.3	42.86
Chemical Oxygen Demand(COD)	1280	95	75.2
Biochemical Oxygen Demand (BOD)	552	42	97.02

Figure 7 to figure 10 are presented reducing parameters value respectively.

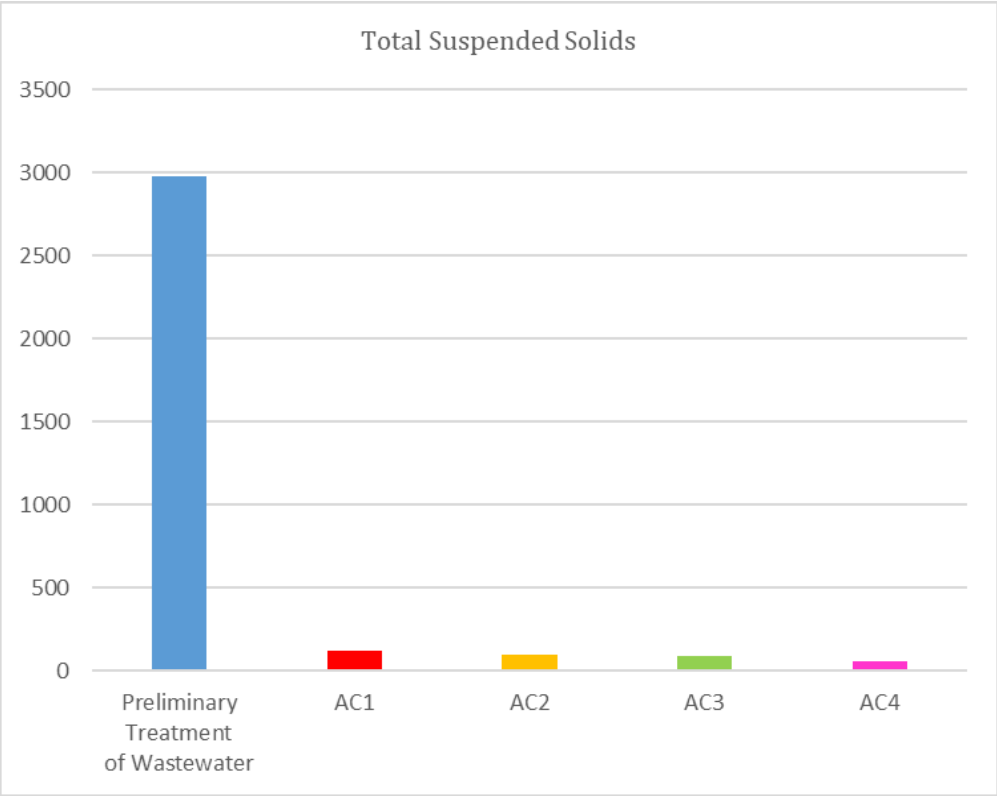


Figure 7. Value of TSS Compare with Sugar Factory Wastewater and Treated Water by Using Various Absorbents

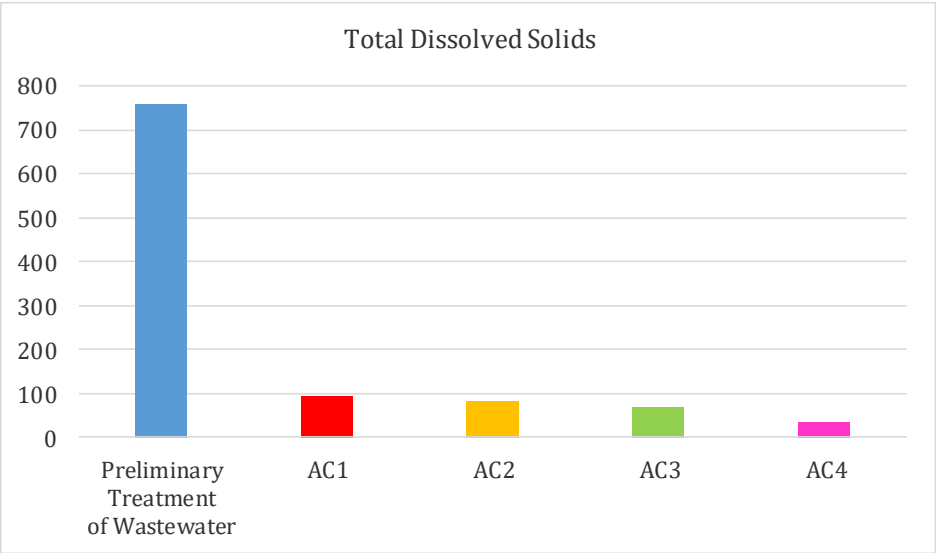


Figure 8. Value of TDS Compare with Sugar Factory Wastewater and Treate Water by Using Various Absorbents

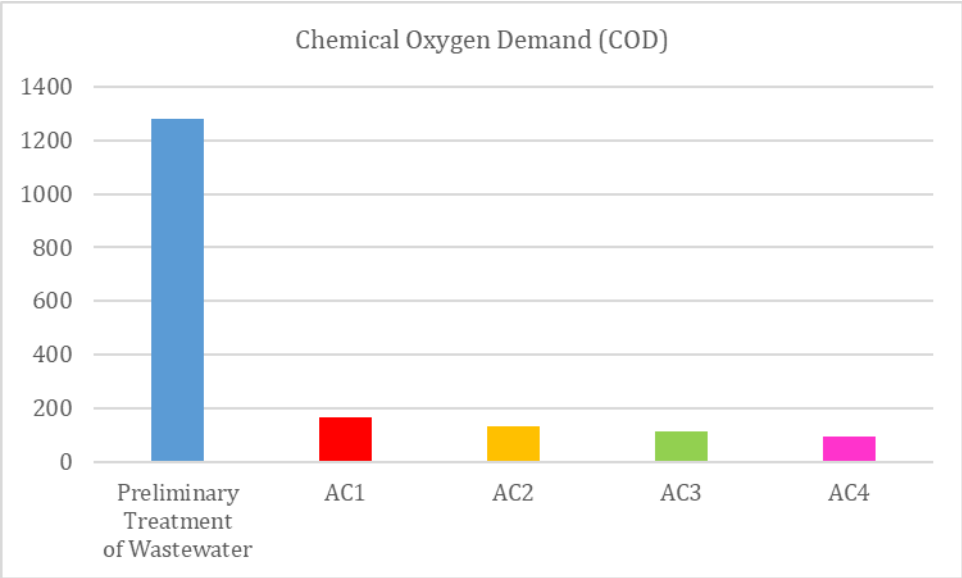


Figure 9. Value of COD Compare with Sugar Factory Wastewater and Treate Water by Using Various Absorbents

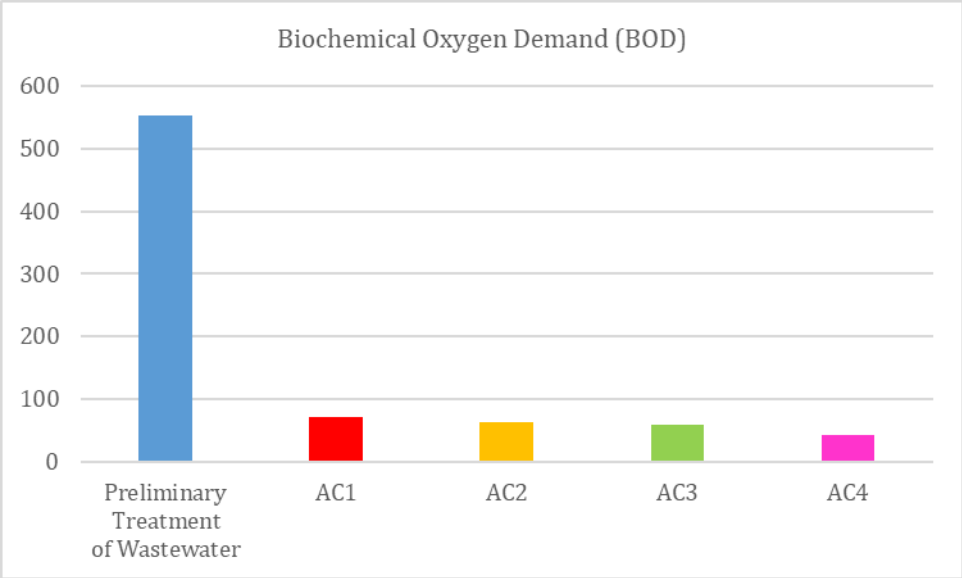


Figure 10. Value of BOD Compare with Sugar Factory Wastewater and TreatWater by Using Various Absorbents

D. Conclusion

This study presents a clear and practical investigation into using activated carbon derived from plum seed shells to remediate heavily polluted sugar factory wastewater from the Yeni area. The authors characterize the raw effluent as strongly acidic (pH 4.5) with high TSS, TDS, COD and BOD, they appropriately apply a pre-treatment pH correction with sodium hydroxide (2 mL/L) prior to adsorption. Using four activated carbon variants (AC1–AC4) at 10 g/L, the work systematically compares performance and identifies AC4 as the best-performing adsorbent, achieving substantial removals— 97.95% of TSS, 42.86 % of TDS,

94.87% of COD and 75. 2% of BOD 97.2%—demonstrating both technical effectiveness and good experimental design.

The study's findings are promising for practical wastewater management: the treated effluent met Myanmar's National Environmental Quality Guideline (NEQG) across measured parameters, indicating regulatory compliance and potential for real-world application. Framing plum seed shell activated carbon as a low-cost, sustainable adsorbent aligns well with circular-economy principles and offers relevance to civil and environmental engineering practice.

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