e-ISSN :2798-2114
Terakreditasi Peringkat 5
Keputusan Direktur Jenderal Pendidikan Tinggi, Riset, Dan Teknologi Kementerian Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesia Nomor 152/E/Kpt/2023 Tentang Peringkat Akreditasi Jurnal Ilmiah Periode II Tahun 2023
Direktur Jenderal Pendidikan Tinggi, Riset, Dan Teknologi

Baselang, Vol. 4. No. 2

http://ojs.umb-bungo.ac.id/index.php/JAS/index

BASELANG
Jurnal Ilmu Pertanian, Peternakan, Perikanan dan Lingkungan
e-journal.faperta.universitasmuarabungo.ac.id

Kajian Penggunaan Karbon Aktif Kulit Singkong Untuk Meningkatkan Kinerja Proses Koagulasi Dan Flokulasi Dalam Pengolahan Air

Study On The Use Of Cassava Peel Activated Carbon To Improve The Performance Of Coagulation And Flocculation Process In Water Treatment

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Article Info

Keywords : Adsorption, Bioadsorbent; Cassava peel activated carbon; Clean water treatment; Water treatment efficiency

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ABSTRACT

Based on statistical measures of food consumption in 2022, the annual quantity of cassava waste amounts to 578 tons. Beyond its usage as animal feed, cassava skin has further potential as an active carbon source for absorbing heavy metals. This is because cassava skin contains carbon (59.31%), cellulose (13.75%), and lignin (9.14%), which may serve as precursors in the production of activated carbon. The objective of this work is to identify the optimal use of cassava skin waste. This study used a laboratory-based approach, beginning with the production of activated carbon from cassava peel and then applying it to synthetic materials on a laboratory scale. A cassava peel activated carbon produced using an H3PO4 activator has been determined to satisfy the requirements specified in the SNI 06-3730-1995 standard. The activated carbon has a water content of 0.65%, an ash content of 0.85%, a pure carbon content of 98.72%, and an iodine absorption capacity of 809 mg/g. Based on the findings of this experiment, it can be inferred that including a processing unit prior to the aforementioned stage, such as flash mixing and sedimentation, is necessary to optimize the efficiency of activated carbon technology. Based on the test result, 2.5 gr of activated carbon added to 700 ml of sample was continued with the addition of PAC 30 mg/l. Able to reduce turbidity level with a removal efficiency of up to 89.9%, iron of 43%, and ammonia at 17% these results are better than the use of PAC without activated carbon. The adsorption isotherm model represents the adsorption of iron and ammonia is Freundlich while turbidity is Langmuir.

Keywords: Adsorption, Bioadsorbent, Cassava peel activated carbon, Clean water treatment, Water treatment efficiency

INTODUCTION

Based on statistical measures of food consumption in 2022, the annual quantity of cassava waste amounts to 578 tons. Beyond its use as animal feed, cassava peel has further potential as an active carbon source for absorbing heavy metals. This is because cassava peel contains carbon (59.31%), cellulose (13.75%), and lignin (9.14%), which may serve as precursors in the production of activated carbon. Furthermore, cassava peel is rich in protein, non-reducing cellulose, high crude fiber, and HCN (cynic acid), which function as a potent adhesive in binding heavy metals. Consequently, cassava peel has the potential to be used as a bio-absorbent.[1].

According to Cintia, iron (Fe) levels in water can be reduced using the adsorption method[2]. Utilising activated carbon as a bio-absorbent in a batch system may result in an ammonia reduction of 86.05% - 88.07%. A variety of carbon-containing materials, including bones, softwood, husks, maize cobs, coconut shells, coconut husks, sugar cane pulp, sawdust, and cassava skin, can be used to produce activated carbon. The underlying concept of the adsorption process is that a certain amount of gas will be absorbed by the substance acting as an absorbent. An inherent benefit of this approach is its cost-effectiveness, absence of hazardous consequences, and efficacy in eliminating organic substances from the water.

The water quality of most rivers In Indonesia is compromised by the presence of both solid and liquid garbage. In 2020, the Directorate of Water Pollution Control classified roughly 59% of river water quality in Indonesia as severely contaminated. The primary factor contributing to the decline in river water quality is pollution, originating from concentrated waste generated by industrial company operations, animal farm activities, hotels, and hospitals.[3]. Furthermore, non-permanent sources of pollution, such as agricultural, plantation, and household trash, also make a substantial contribution to the deterioration of river water quality.

Given the intricate nature of pollution origins and the severity of river contamination, it is essential to conduct water quality tests to ensure the integrity of the water intended for community use. Analysis of water quality test parameters may be approached from three perspectives: physical, chemical, and biological. To guarantee compliance with the prescribed criteria, it is necessary to use suitable water technology to optimize the quality of the water for usage. The use of PAC as a coagulant in water management is primarily employed for the purpose of water purification, elimination of dissolved compounds such as heavy metals, and hydrolysis of organic compounds.

Prior studies investigated the use of cassava skin waste as an adsorbent with the purpose of decreasing the Fe content in synthetic samples containing 10-40 mg/l (ppm).[4] Therefore far, no study has been conducted that explicitly investigates the use of cassava skin waste as an adsorbent for the purpose of lowering ammonia levels in artificial samples obtained from river water.

Based on the aforementioned context, researchers are interested in doing study on the issues pertaining to iron levels, ammonia, and turbidity present in river water. Utilising cassava peel as an absorbent to enhance PAC function may bolster the quality of clean water by eliminating iron, ammonia, and turbidity levels in water for sanitary applications..

RESEARCH METHOD

Overall, the approach used in this research is preceded by the identification of the issue and a review of existing literature. Following the production and activation of the adsorbent from cassava skin, an artificial solution containing iron and ammonia was prepared using river water. Subsequently, experiments were conducted to decrease the concentrations of iron and ammonia in the artificial solution. These tests were analysed and evaluated using literary research. Given the facts and findings of the debate, it is possible to derive conclusions and recommendations that will be beneficial for future study.

The approach used in this study is a quantitative approach with an experimental method carried out on a laboratory scale. The purpose of this experiment is to determine the ability of cassava peel activated with H3PO4 in removing iron (Fe2+), ammonia (NH3) and turbidity levels in water. The research process is visualized in detail in the form of a diagram in Figure 1 below.

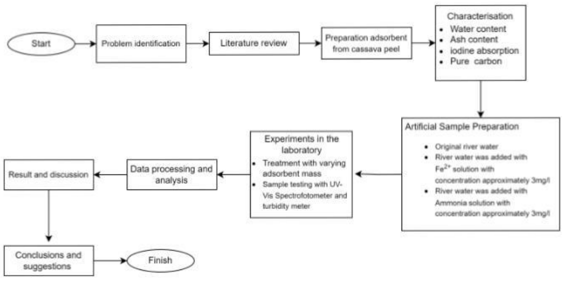


Figure 1. *Research Framework*

1. Time and Location

The experiment was conducted at the President University Laboratory facility in Cikarang, Bekasi Regency, on a laboratory scale. The experiment was conducted from February to June 2024.

2. Tools and Materials

The equipment used in this study included a 1 liter beaker, volumetric pipette, UV-VIS spectrophotometer, measuring flask, analytical balance, furnace, oven, 100 mesh screen, jar test, and turbidity meter. The materials needed in this research consist of cassava peel waste as raw material for making adsorbents, $H3PO4$ (phosphoric acid), $Fe (NH4)2(SO4)2.6H2O$ (Ferrous Ammonium Sulfate), $NH4Cl$ (Ammonium Chloride) grade PA (Pro-Analysis) and distilled water.

3. Method of Collecting Data

The present study employs both primary and secondary data sources. An analysis of secondary data was conducted to determine the appropriate therapy for this study. Data was collected first using experimental techniques conducted in laboratory settings

Primary Data

Primary data refers to data that is directly acquired or gathered in the field. In this study, the specific primary data used is derived from test results conducted in the laboratory. This experiment was conducted at the laboratory of President University to evaluate the ability of adsorbents derived from cassava peel to absorb reducing iron and ammonia. The turbidity value was adjusted to meet the threshold specified in PERMENKES No.02 of 2023. The testing of samples was conducted in triplicate.

Secondary Data

The acquired secondary data was used to substantiate the investigation of the impact of the activator employed and the duration of contact.

4. Data Analysis

For the purpose of determining the efficacy of activated carbon derived from cassava peel in adsorbing iron and ammonia from synthetic samples, removal efficiency was evaluated. A formula is used here.:

$$\text{Removal Effectiveness } (\%) = \frac{C_0 - C_e}{C_0} \times 100$$

Information:
C_0: Initial concentration
C_t: Concentration after adsorption

The analysis of the paired T-test was carried out with the help of Microsoft Excel. Through the use of this statistical test, the objective is to determine whether or not the independent variable has a substantial impact on the dependent variable.

For the purpose of determining the influence of active carbon mass from cassava peel on the adsorption of turbidity, ammonia, and iron from fake samples, the removal efficiency was computed. A formula is used here:

a. $H0: \mu 1 - \mu 2 = 0$ The addition of activated carbon derived from cassava peel as an adsorbent did not have a significant influence on the reduction of iron, ammonia, and turbidity in the water sample.
b. $HA: \mu 1 - \mu 2 < 0$ As an adsorbent, the incorporation of activated carbon derived from cassava skin has a substantial influence on the reduction of iron, ammonia, and turbidity in water samples.

If:
a. P-value < 0.05 then H0 is rejected (Significant)
b. P-value > 0.05 then H0 is accepted (Not significant)

The analysis of the paired T-test was carried out with the help of Microsoft Excel. Through the use of this statistical test, the objective is to determine whether or not the independent variable has a substantial impact on the dependent variable.

5. Research Procedurs

a. Stages of Making Adsorbent from Cassava Skin

(1) Adsorbent Pre-Treatment. The cassava peel trash is collected from the residual output of small-scale industrial enterprises or commercial dealers. First, the gathered cassava skin is thoroughly cleansed to remove dirt and dust, and then separated from the epidermis by washing. Cassava skin is mostly composed of the cortical layer. Following the cleaning of impurities, the cassava skin is subjected to a 2-day drying process in direct sunlight in order to decrease its moisture content. Shrinkage of dried cassava skin is induced by solar heat, leading to the evaporation of water content and consequent reduction in weight and volume. To eliminate the residual moisture in the cassava skin, the subsequent procedure involves subjecting the cassava skin to a baking process in the oven at a temperature of 105oC for a duration of 3 hours.[11]. Following that, the cassava skin was allowed to cool to ambient temperature in order to achieve weight stability before to being weighed. Presented below is Figure 2 illustrating the procedure of dehydrating cassava skin.

(2) Carbonation. As the cassava peel moves on to the next phase, which is the manufacture of charcoal or carbonation, the pyrolysis method is used. A chemical digestion of organic molecules is known as pyrolysis. This process involves heating the material with very little or no oxygen or other chemicals present. The substance goes through a process of undergoing a breakdown of its chemical structure, which results in the transformation into a gas known as carbonation. Carbonation is the residue that is left over after intense pyrolysis.. [12]. Carbonation is the process of breaking down hemicellulose, cellulose, and lignin into pure carbon residue. The carbonation temperature used in the study was 600°C for a duration of 60 minutes[13]. The following is Figure 3 Carbonation process.

(3) Activation. The carbonated cassava peel adsorbent was then removed and left at room temperature. The adsorbent was ground using a mortar and sieved with a 100-mesh sieve[7]. It is important to note that the surface area of the adsorbent is one of the factors that affects the ability of activated carbon to absorb substances. The absorption capacity of adsorbent particles increases in proportion to the size of the particles themselves.

b. Adsorbent Characterization

(1) Water content (SNI 06-3730-1995). Knowing the water content in activated carbon aims to determine the hygroscopic properties of activated carbon because carbon generally has an affinity for water.[10]. According to SNI 06-3730-1995[14]. To determine the water content of the adsorbent, 2 gr of activated carbon is first placed in the oven at a temperature of 115oC for 3 hours. And cooled in a desiccator for 15 minutes before weighing it with the calculation formula which can be seen in Equation 1.

Water Content (%) $=\frac{a-b}{a} \times 100\%$

(2) Ash content (SNI 06-3730-1995). Ash content measurement is performed with the purpose of determining the amount of residual metal oxides that are present in activated carbon and that include minerals that were not lost during the carbonation process..[15]. The lower the ash content in activated carbon, the better it is and it affects the quality of activated carbon as a heavy metal adsorbent[16]. One gramme of the sample must be ashed in a furnace at a temperature of 800 degrees Celsius for a period of two hours in order to determine the amount of ash that is present in the adsorbent. Before being weighed, it was allowed to cool in a

desiccator. The results of the ash content test were calculated using the formula, which can be found in Equation 2.

$$\text{Ash Content (\%)} = \frac{b-c}{b-a} \times 100\%$$

(3) Pure carbon (SNI 06-3730-1995). Testing on pure carbon aims to determine the remaining pure carbon that is still bound after the carbonation and activation processes have taken place. To obtain the percentage of pure carbon, it is obtained from subtracting the portion of carbon lost during heating using a furnace at a temperature of 950oC. To get the active carbon content, shown at Equation 3.

$$\text{Pure Carbon (\%)} = 100 - (a + b)$$

(4) Iodine absorption capacity (SNI 06-3730-1995). An indication of the surface area that activated carbon has is the amount of iodine that it is able to absorb. On the other hand, the capacity of activated carbon to adsorb adsorbate increases in proportion to the amount of iodine that is absorbed. [17]. To obtain iodine levels, 0.5 grams of activated carbon sample were used, and the sample was heated at 110oC for 1 hour. Add 50 ml of 0.1 N iodine solution and shake for 15 minutes. After that, leave it until the active carbon settles, then pipette 10 ml of the supernatant and titrate directly with 0.1 N sodium thio sulfate (Na2S2O3). If the color of the solution becomes yellow, add 1% starch as an indicator and continue titrating until the blue color of the solution disappears. The calculation formula, which can be seen in Equation 4.

$$\text{Iodine absorption capacity} = \frac{\frac{V \times N}{0,1} \times 12.69 \times Fp}{W}$$

c. Quality of Activated Carbon

Following the activation procedure, the subsequent stage involves evaluating the characterisation of activated carbon in accordance with SNI 06-3730-1995. This takes the form of determining the water content, dust, pure carbon, and iodine absorption capacity of the activated carbon materials. According to the findings of the results of the active carbon characterisation test, which were based on SNI 06-3730-1995, the activated carbon derived from cassava peel is in compliance with the norms.

***Table 1**. Characteristics of activated carbon from cassava peel[14]*

No	Parameter	Standard	Results
1	Water (%)	Max 15	0.65
2	Ash (%)	Max 10	0.85
3	Part lost at 950^{o}C (%)	Max 25	0.42
4	Pure activated carbon (%)	Min 65	98.72
5	Iodine absorption capacity (mg/g)	Min 750	809

From the findings of the tests, it was determined that the water content that was acquired was 0.65%, with a maximum percentage of 15%. One of the goals of determining the hygroscopic qualities of a carbon material is to ascertain the amount of water that is contained inside activated carbon. Due to the fact that the pores of activated carbon, which are supposed to be employed for adsorbing contaminants, are filled with water, a high water content might limit the adsorption capability of the material. [8].

Testing the ash content of activated carbon aims to determine the metal oxide content remaining in the activated carbon after the carbonation process [16]. This demonstrates that the ash content included in the adsorbent is in accordance with the standard, as the results of the ash content test revealed that the ash content contained in the sample of activated carbon was 0.85%. Pores may get clogged and the effective surface area of activated carbon can be reduced when there is a high ash concentration. [18].

The ash content and the amount of carbon that is lost when heated to 950 degrees Celsius are both decreased during the pure carbon characterisation testing step. Therefore, the outcomes that are achieved are as follows. The quantity of carbon that is bonded to active carbon may be determined by the amount of pure carbon that is present in active carbon. The proportion of pure carbon was found to be 98.72%, according to the findings of the tests. The ability of activated charcoal to absorb contaminants is directly proportional to the amount of pure carbon that is present in the adsorbent media. [17].

Utilising iodine absorption tests, one may determine whether or not activated carbon is capable of absorbing contaminants. As the iodine absorption capacity of activated carbon increases, the effectiveness of the material in adsorbing pollutants also increases. A total of 809 mg/g of iodine has been absorbed by the substance. The capacity to absorb iodine has been shown to be satisfactory; nevertheless, in order to fulfil these prerequisites, the iodine absorption capacity must be at least 750 mg/g.

d. Criteria of water samples

The production of an artificial iron solution is accomplished by incorporating contaminants from the stock solution into a sample of wastewater from a river..

(1) Making Water Samples for Iron Analysis
   (a) Preparation of Iron Stock Solution. Preparation of iron stock solution (Fe2+) by dissolving 1,404 grams of Ferrous Ammonium Sulfate compound Fe(NH4)2(SO4)2.6H2O with 1000 ml of distilled water to obtain a concentration of 200 mg/l of Fe shown in Appendix B [19].
   (b) Making Water Samples for Iron Analysis. Preparation of an iron solution with a concentration of 3 mg/l is carried out by diluting the stock solution using the following Equation 5.

$$V1M1 = V2M2$$

(2) Making Water Samples for Ammonia Analysis
   (a) Preparation of Ammonia Stock Solution. Preparation of ammonia(NH3) stock solution by dissolving 3,819 grams of ammonium chloride NH4Cl which has been dried at a temperature of 100oC with 1000 ml of distilled water to obtain a concentration of 1000 mg N/L[20].
   (b) Making Water Samples for Ammonia Analysis. Through the use of Equation 5, the process of diluting the stock solution in order to produce an ammonia solution with a concentration of 3 mg/l is carried out. In order to achieve the desired level of homogeneity in the stock solution, 2.1 milliliters of ammonia stock solution were pipetted into a beaker that contained 700 milliliters of river water sample and swirled with a stirrer until the mixture was completely uniform. Following that, a UV-VIS spectrophotometer and a turbidity meter were used in order to determine the quantities of ammonia that were present in the fabricated samples.

d. Adsorbent absorption testing of iron and ammonia levels in samples

Artificial samples of Fe and Ammonia with a concentration of approximately 3 mg/l were prepared each in a 1000 ml beaker. The adsorbent was added to a glass containing 700 ml of artificial solution sample, with variations in the adsorbent mass of 0.5 gr, 1 gr, 1.5 gr, 2 gr, and 2.5 gr. The adsorbent is stirred using a stirrer to mix well with the sample, then left for 60 minutes[4], which is the contact time between the adsorbent and the sample. Next, 500 ml of supernatant from the sample was added with 30 mg/l PAC[5], and fast mixing using a test jar at a speed of 100 rpm for 3 minutes. Followed by slow mixing at 40 rpm for 10 minutes[21]. And then left for half an hour, till the floc has settled down. Next, a UV-VIS spectrophotometer will be used in order to take measurements of the sample.

RESULT AND DISCUSSION

Application of Activated Carbon to Water Samples

On the basis of the impact of changes in adsorbent mass, tests were carried out to determine whether or not activated carbon could be able to minimize the amount of pollutants that are present in water..

a. Flow of the first experiment

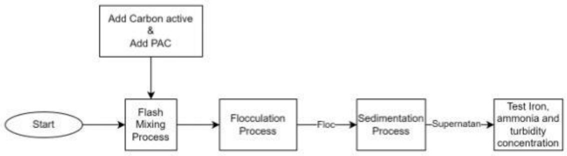


Figure 2. Flow Proces First Experiment Plan [9]

The experiment was carried out by adding PAC to a glass that had been combined with activated carbon. The objective of the experiment was to determine whether or not the active carbon powder residue might clump together with other particles and create a floc. Nevertheless, the first experiment that was carried out did not provide satisfactory results.

Figure 3. Water Condition with First Experiment Plan

Additionally, the addition of a processing unit to the water processing unit system in the form of an active carbon contactor tank is a method that may be used to implement the utilization of activated carbon for the purpose of reducing pollutants in water. [22]

b. Flow of the second experiment

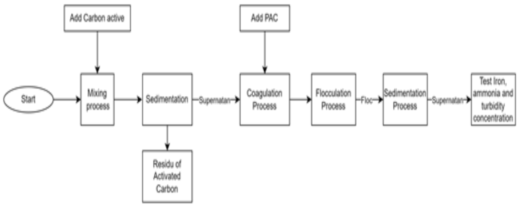


Figure 4. Flow Process Second Experiment Plan

c. Effect of adsorbent mass to reduce pollutants in a water sample

Then the test results were obtained with the average figures from tests as stated in the following table.

Table 2. The Ability of Adsorbents to Reduce Pollutans in Water Sample

Polutan	Adsorbent Mass (gr)	Contact Time (minute)	Initial concentration (mg/l)	Final concentration (mg/l)	Removal Efficiency (%)
Iron	0	60	3.58	3.20	12%
	0.5			3.08	16%
	1			2.70	26%
	1.5			2.52	31%
	2			2.28	37%
	2.5			2.06	43%
Ammonia	0	60	4.70	4.63	1.3%
	0.5			4.61	1.8%
	1			4.57	2.6%
	1.5			4.53	3.6%
	2			4.50	4.1%
	2.5			3.90	17%
Turbidity	0	60	37	6.36	82.8%
	0.5			5.90	84%
	1			4.89	86.7%
	1.5			4.80	87%
	2			4.18	88.7%
	2.5			3.78	89.8%

The findings of experiments that were conducted to determine the influence of adsorbent mass in decreasing iron pollutants in comparison to the use of PAC without activated carbon revealed that the removal efficiency attained was improved when the mass of the adsorbent was increased. The results of the tests, on the other hand, demonstrated that the capacity of activated carbon did not reach the criterion for iron content in water as specified by PERMENKES No. 2 of 2023, which is 0.2 mg/l.

The picture that follows demonstrates that the most effective method for removing iron from water samples is to use 2.5 grams of activated carbon. This method is capable of removing 45 percent of the iron that is present in all of the water samples.

Conclusion

Activated carbon produced from cassava peel using an H3PO4 activator has been determined to satisfy the requirements specified in the SNI 06-3730-1995 standard. It has a water content of 0.65%, an ash content of 0.85%, a pure carbon content of 98.72%, and an iodine absorption capacity of 809 mg/g. Based on the findings of this experiment, it can be inferred that including a processing unit prior to the aforementioned stage, such as flash mixing and sedimentation, is necessary to optimize the efficiency of activated carbon. Using the test result, 2.5 grams of activated carbon were added to 700 milliliters of the sample, followed by the addition of 30 milligrammes of PAC per litre. Enabled to decrease turbidity levels with a removal effectiveness of up to 89.9%, iron removal of 43%, and ammonia reduction of 17%, these results surpass those achieved with PAC alone. An adsorption isotherm model characterizes the adsorption of iron and ammonia as Freundlich, while turbidity is represented as Langmuir.

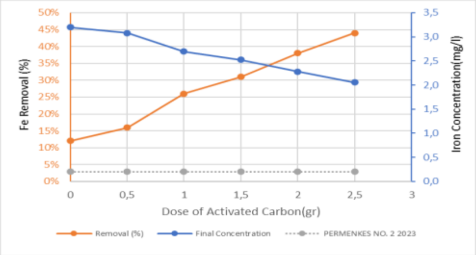


***Figure* 5**. *Relationship Curve of Activated Carbon Dose With Iron Reduction*

The graph that follows illustrates the effectiveness of utilizing activated carbon derived from cassava peel to remove ammonia. The optimal amount of activated carbon to use is 2.5 grams, and the beginning concentration of the water sample is 4.70 mg/l.

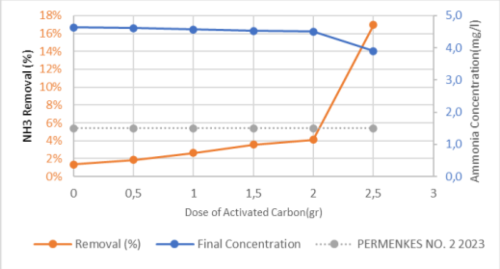


***Figure* 6**. *Relationship Curve of Activated Carbon Dose With Ammonia Reduction*

From the test results, it is known that the ability of active carbon to reduce organic pollutants in the form of ammonia in water is not as good as the ability of active carbon to reduce the iron metal content in water. The removal of ammonia in the water sample is only 17% .

High turbidity will encourage bacterial growth and increase the need for chlorine use[23]. In accordance with PERMENKES No. 02 of 2023, the maximum amount of turbidity that may be tolerated in water that is considered clean is three NTU. The following findings were obtained from the tests that were conducted on the use of activated carbon for the purpose of reducing turbidity in water:

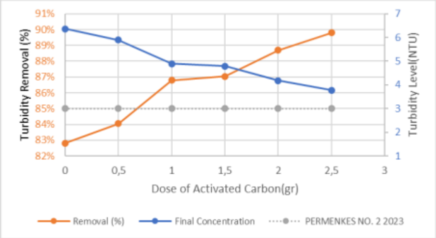


***Figure* 7**. *Relationship Curve of Activated Carbon Dose With Turbidity Reduction*

The test findings suggest that utilizing activated carbon plus PAC to remove turbidity in water produces better results than using alone PAC. The capacity of activated carbon to remove turbidity in water is determined by the mass of the adsorbent, with larger mass resulting in a higher percentage of removal efficiency. 2.5 grams of activated carbon may clear water with a removal effectiveness of roughly 89.8%, compared to the usage of PAC alone, which yields a removal efficiency of 82.8%.

Ishoterm Adsorption

The kind of isotherm may help to determine the mechanism of pollutant adsorption in the air. The interaction of contaminants and adsorbents is classified as physisorption or chemisorption. The author intends to investigate the sort of isotherm that occurs in pollutant adsorption in water samples using activated carbon adsorbents derived from cassava peels. Isotherm adsorption (Langmuir and Freundlich) was used to describe the equilibrium adsorption properties.[24].

a. Freundlich

The Freundlich adsorption isotherm equation is a commonly used empirical equation for representing the adsorption isotherm of chemical adsorption systems in the liquid phase. The Freundlich equation is widely used to characterize the adsorption isotherms of different contaminants on different adsorbent mediums.[25]. The Freundlich isotherm is invalid if the concentration of the material to be adsorbed is very high. The limitation of this equation is that it does not forecast the maximum adsorption value. [26]. Mathematically, the Freundlich isotherm equation can be written as follows[24]:

$$qe = K_f C_e^{1/n}$$

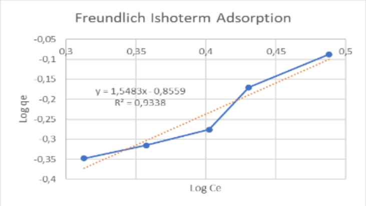


Figure 8. *Ishoterm adsorption model for Iron*

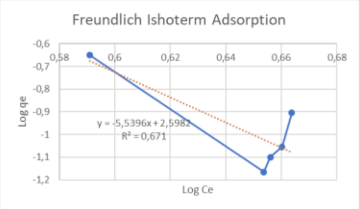


Figure 9. *Ishoterm adsorption model for Ammonia*

The Freundlich isotherm graph in Figure 11 with a linear equation y=1.5483x-0.8559 dan R^2=0.9338 in the iron adsorption process. The adsorption capacity value was obtained [27] 0.22 milligrammes per glass. Figure 12 displays the Freundlich Isotherm Graph for the ammonia absorption process, which is described by a linear equation. Coefficient y = -5.5396x + 2.5982 and R^2 = 0.671. The measured adsorption capability is 44 mg/g. The Freundlich isotherm type is the predominant isotherm observed during the adsorption process of iron and ammonia. Values of R^2, which represents the anticipated proportion of the total variance, approaching 1 suggest that the regression model is more precise. [28]. Indications suggest that the adsorption of iron and ammonia ions onto the activated carbon surface takes place in the structure of many layers. [29]. Utilising 2.5 grammes of activated carbon for 60 minutes results in an adsorption capacity of 0.44 mg/g iron and 0.22 mg/g ammonia.

b. Langmuir

Adsorption by Langmuir exclusion The isotherm equation is extensively utilized to precisely characterize the equilibrium conditions in liquid phase adsorption. An advantage of employeding the Langmuir equation is its manifestation as Henry's law at extremely low concentrations and as a saturation capacity at exceedingly high equilibrium concentrations. [25]. Represents the Langmuir's isotherm[24]:

$$qe = \frac{q_{max} K_L C_e}{1 + K_L C_e}$$

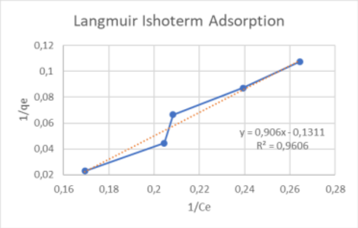


Figure 10. *Ishoterm adsorption model for Turbidity*

Figure 13 displays the Langmuir Isotherm Graph for the adsorption process of turbidity, represented by a linear equation.Coefficient of y=0.906x-0.1311 and R^2=0.9606 It is established that the adsorption capacity is 9.3 mg/g. This implies that when 2.5 grammes of activated carbon are used and the contact period is 60 minutes, the maximum adsorption achieved is 9.3 mg/g. The Langmuir isotherm type is the predominant trend observed in the turbidity adsorption process. The observed phenomenon indicates that the adsorption process is of a chemical nature, resulting in the formation of a monolayer layer.[29].

Analysis Statistic Result

The present study used statistical tests to assess the importance of the independent variable on the dependent variable. The purpose of using the paired t-test (Two samples assuming equal variances) between participants is to assess the comparison of the treatment's effect on the final concentrations of the parameters large, ammonia, and turbidity in this experiment. In the paired t-test, if the significance value of the t test exceeds 0.05, the null hypothesis is accepted and the alternative hypothesis is rejected. This is because it is established that there is no statistically significant relationship between the independent variable and the dependent variable. Conversely, if the significance value of the t test is less than 0.05, the null hypothesis will be rejected and the alternative hypothesis will be accepted due to the presence of a relationship between the independent quantity and the dependent variable. The statistical tests conducted indicated that the usage of activated carbon with the lowest mass yielded significant outcomes in the reduction of iron, ammonia, and turbidity contaminants in the selected water sample.

Table 3. *Statistical Test Results*

Parameter	T-stat	T-Critical	P-Value	Significant/ not
Iron	25.4	2.91	0.0015	Significant
Ammonia	26.3	2.91	0.0014	Significant
Turbidity	46	2.91	0.0004	Significant

Design Recommendation

The author proposes an alternative design for the contactor tank processing unit, namely a flash mixing tank. This tank is designed to achieve homogenization of active carbon and water. It also integrates a sedimentation tank that serves the dual purpose of settling and providing contact time for the active carbon to efficiently adsorb contaminants in the water.

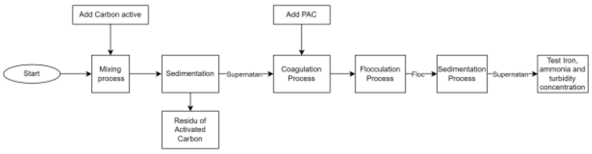


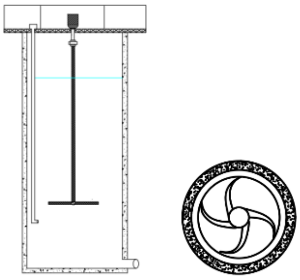
Figure 11*. Focus Design From This Proces*

The design suggestion mostly concerns the mixing process and sedimentation in this particular step. The agitation and sedimentation processes in water treatment are essential steps to guarantee the maximization of adsorption by activated carbon. The stirring procedure involves agitating activated carbon with water to achieve uniform dispersion. Following agitation, the sedimentation process is initiated, during which the uniformly distributed activated carbon will interact with contaminants in the water, leading to an optimal adsorption process. Furthermore, the activated carbon that has absorbed the contaminants will precipitate to the container's bottom. The objective of this settling is to prevent the residual activated carbon from being transferred to the subsequent phase of the process, therefore ensuring that the water that advances to the next stage of purification has been adequately treated.

Table 4. *Result Calculation Of Flash Mixing Basin*

Criteria	Unit	Requirement	Value
Design Flow Rate	m^3/d		1000
Rapid mixing Detention Time	s		180
Velocity gradient	s^{-1}	600-1000	600
Volume	m^3		2.1
Diameter of Tank	m		1.1
Water depth	m		2.2
Water depth below the impeller	m		1.57
Height Tank	m		1.6
Type of Impeller			
Impeller Diameter	m		0.5
D/T		0.14 – 0.5	0.5
H/D		2-4	4
H/T		0.28 - 2	2
B/D		0.7 – 1.6	1.5
Power Number		5.7	5.7
Power	rpm		99

The induction of higher turbulence by the radial flow impeller renders it more suitable for flash mixing. [30]. The process of flash mixing facilitates the swift and uniform blending of activated carbon with water within a limited timeframe, therefore improving the interaction between the activated carbon and contaminants to achieve the most effective adsorption. The agitation in the tank operates in a manner like to a propeller, producing a precise volumetric rate, which is a critical factor of the mixing process's quality. [31].



(a) (b)

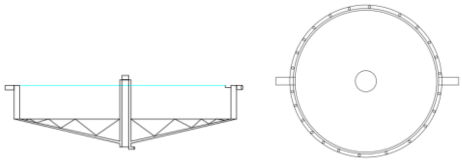
Figure 12. *Design of Flash Mixing Unit (a) Side view (b) Bottom view*

The use of sedimentation as a contact time unit in water treatment is justified due to its ability to create ideal circumstances for the adsorption process of activated carbon. This enables a longer and more efficient interaction between activated carbon and contaminants, in contrast to the turbulent character of flash mixing tanks.

Table 5. *Result Calculation Of Sedimentation Basin*

Criteria	Unit	Requirement	Value
Design Flow Rate	m^3/d		1000
Weir loading	m^3/mh	2.5	2.5
Surface loading	$m^3/m^2.h$	1.3 – 1.9	1.9
Depth (Exclude Free Board)	m	3	3
Water depth below the impeller	m	3 – 5	3
V	m^3		66
Detention time	hours		2
Diameter	m		5
Width Gutter	m		0.3
r_1	cm		30
t in gutter	second		30
V gutter	m^3		0.3
Depth of Gutter	m		0.07
L peripheral	m		17

Circular sedimentation tanks are specifically engineered to provide a uniform distribution of flow from the centre towards the outside boundary, hence establishing a radial flow pattern. The adopted design facilitates enhanced particle settling efficiency by eliminating the presence of dead zones commonly observed in rectangular tanks. The uniform flow distribution optimizes the sedimentation process, thereby enhancing the overall quality of the treated water. [32]. The sedimentation process facilitates the physical isolation of activated carbon containing bonded contaminants from the water, so preventing the transfer of activated carbon particles to subsequent processes, so potential reduction in treatment effectiveness. Furthermore, sedimentation decreases the amount of energy required and enhances the available processing capacity.



(a) (b)

Figure 13. *Design of Sedimentation Unit (a) Side View (b) Top View*

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