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A Pontential Agriculture Waste Material as Coagulant Aid: Cassava Peel

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Abstract. All A large amount of cassava peel waste is generated annually by small and medium scale industries. This has led to a new policy of complete utilization of raw materials so that there will be little or no residue left that could pose pollution problems. Conversion of these by-products into a material that poses an ability to remove toxic pollutant would increase the market value and ultimately benefits the producers. This study investigated the characteristics of cassava peel as a coagulant aid material and optimization process using the cassava peel was explored through coagulation and flocculation. This research had highlighted that the Cassava peels contain sugars in the form of polysaccharides such as starch and holocellulose. The FTIR results revealed that amino acids containing abundant of carboxyl, hydroxyl and amino groups which has significant capabilities in removing pollutants. Whereas analysis by XRF spectrometry indicated that the CP samples contain Fe_2O_3 and Al_2O_3 which might contribute to its coagulation ability. The optimum condition allowed Cassava peel and alum removed high turbidity up to 90. This natural coagulant from cassava peel is found to be an alternative coagulant aid to reduce the usage of chemical coagulants

1. Introduction

Principle of water treatment brings raw water up to drinking water quality. Water treatment process for surface water supplies include the basic water treatment processes namely, screening, mixing, coagulation & flocculaation, sedimentation, filteration and chlorination. Coagulant used to be applied in coagulation & flocculation process to remove priority pollutant that is solid. Alum is the most favorable coagulant used in various water treatment plant in Malaysia due to its low cost [1].

Despite the superiority of chemical coagulants in treating turbid water, knowledge is still lacking in terms of green chemistry. Several studies had published the detrimental effects of chemical coagulants on human health [2]. Epedemiological studies and clinical observations have suggested at least 70% of positive correlations between the presence of aluminium in drinking water and Alzheimer's disease [2]. Therefore, there is a high demand to find an alternative coagulant which is preferably from natural, renewable sources and safe for human health. Several studies have been done on natural coagulants produced or extracted from plants, animals, or microorganisms [3][4]. Inorganic coagulants such as alum in combination with lime have been conventionally used for removal of turbidity from surface waters. The sludge formed from such treatment poses disposal problems because of its aluminium content and tend to accumulate in the environment and also because of large volume. Therefore, it is desirable that other cost effective and more environmentally acceptable alternative coagulants be developed to supplement if not replace alum, ferric salts and synthetic polymers. In this context, natural coagulants present viable alternatives for developing countries.

Natural macromolecular coagulants are promising and have attracted the attention of many researchers because of their abundant source, low price, multi-purposeness and biodegradation. Okra, Rice, Moringa olifera and chitosan are natural compounds which have been used in turbidity removal [5]. In this study Cassava peel is among non-exploited waste to be selected as a coagulant aid. Cassava with high protein and carbohydrate is among the criteria to be selected as coagulant aid.

2. Experimental Work

2.1 Raw Water

Samples of raw water were collected from raw water inlet at Sembrong water treatment plant, Sembrong, Johor, Malaysia.

2.2 Preparation of Cassava Pee l Starch (CPS) as coagulant aid

The cassava peel (CP) used in this study was obtained from small medium industries around Parit Raja, Johor, Malaysia. The peels were cleaned using tap water before rinse with distilled water. After that, periderm layer was scrapped off from the whole peel using a fruit scraper. The peel then chopped into approximately 1 cm length and pulverized. Subsequently, the pulp was suspended in 10 times of its volume of distilled water and stirred for 2 minutes. The suspension was then filtered using doubled fold muslin cloth. The filtrate was allowed to stand for 2 hours for sedimentation before the top liquid was decanted and discarded. The sediment was collected and oven dried at 60°C for 24 hours to remove the moisture content. Dried CPS was kept in air tight plastic container for further use [2].

2.3 Characterization of Cassava Peel

SEM-EDX- This analysis was conducted to determine the surface morphology of the CP samples. A scanning electron microscope (SEM) equipped with energy dispersive X-ray spectrometer (EDX).
Fourier Transform Infrared (FTIR) spectroscopy**-** was done to identify surface functional group of native CP samples and performed using Perkin Elmer Spectrum 100 [2]. The adsorption bands were recorded at characteristics wave numbers between 600cm^{-1} and 4,000 cm^{-1}[6]
XRF- Native cassava peel were subjected to X-Ray Fluoresence analysis to determine elemental composition of the samples using Bruker AXS S4 Pioneer XRF spectrometer [7]

2.4 Coagulation and Flocculation Test

Three set of JAR test were carried out. Optimization was investigated in the effect of coagulant dosage: alum (5, 10, 15, 20, 25, 30 mg/L), CP (100, 200, 300, 400, 500, 600mg/L), alum + CP(100%:0%, 70%:30%, 50%:50%,30%:70%,0%:100%). The pH and settling time were kept constant at 7 and 60min.

2.5 Preparation of CPS and Alum Stock Solution

Stock solution of 1000mg/L for CPS was prepared by adding 1g of CPS powder into 1L of distilled water. The suspension was stirred for 1 hour in order to ensure the powder mix uniform of the particles.
Alum solution was prepared by dissolving 10 g Aluminium Sulphate ($Al(SO_4)_3.18H_2O$) in 1L of distilled water. This stock solution was used to prepare alum solution of varying concentration for coagulation test.

3. Results and Discussions

3.1 (a) Characterization of Cassava Peel

Figure 1 shows that the Cassava Peel surface feature is non-porous and heterogeneous characteristics. Similar observations were reported by other studies on SEM analysis on other fruit waste [8]. Smooth and globular in shape of bound starch granules were observed to mostly cover overall surface of the cassava peel.

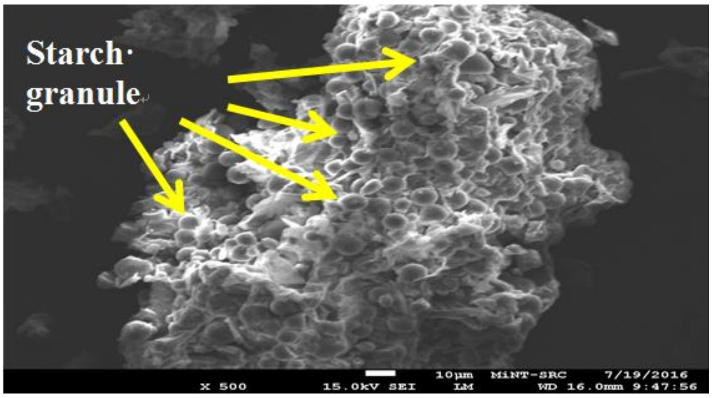

Figure. 1. FE-SEM micrograph of native Cassava Peel

Various chemical groups and bonds in accordance with the respective wavenumbers (cm^{-1}) were shown as peaks in the FTIR spectra In Figure 2, the broad band observed between 3500 – 3200 cm^{-1} was assigned to O-H groups of free hydroxyl groups and bonded O-H group in polymeric compounds such as alcohols, phenols and carboxylic acids presented in pectin, cellulose and lignin on the CP. The peak at wavenumber between 3000 – 2850 cm^{-1} may indicate the stretch of symmetric or asymmetric CH, CH_2, of aliphatic acids [9]

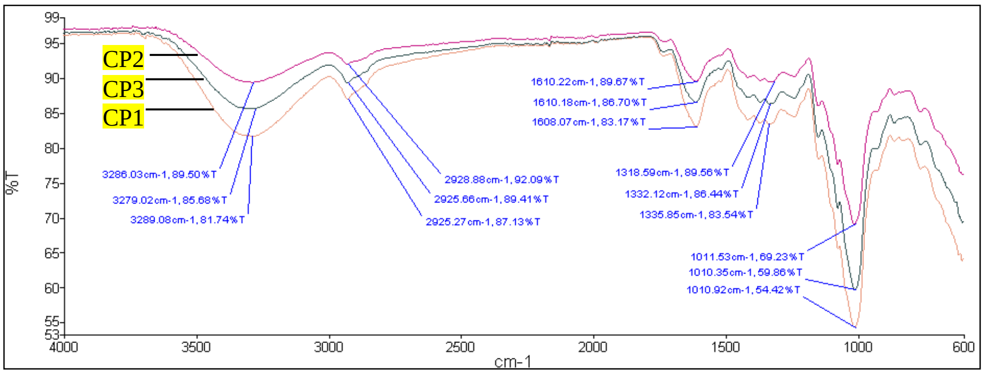

Figure. 2. FTIR spectra of CP1, CP2 and CP3 of native Cassava Peel

Furthermore, the characteristic peak appeared between 1750 – 1680 cm^{-1} are demonstrating the stretching vibration of C=O bond of carboxyl groups. Whereas the peaks observed between `1375 – 1300 cm^{-1} may reflect the stretching vibration of ionic carboxylic groups of pectin. While the deep peaks between 1300 – 1000 cm^{-1} indicate the C-O stretching of –COOH [8].

XRF analysis results are presented in Table 1. The elements present in the CP that gave it the coagulant properties are Al_2O_3 and Fe_2O_3. Both elements are expected to give the CP the ability to aid the coagulation process via precipitation of the particles in the raw water.

Table 1. Elemental composition of native cassava peel

Formula	Weight (%)
	CPS
C	0.10
O	5.83
CaO	3.48
Fe_2O_3	0.41
SiO_2	0.40
SO_3	0.94

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Al_2O_3	0.26
P_2O_5	0.42
LOI	88.16

3.1(b) Characterization of floc

Figure 3 shows that the alum floc in the form of shaped pieces with veined and no regular shape was detected. The SEM image of floc is in a granular shape (smooth and globular in shape of bound starch granules) by using cassava peel starch (CPS) (Figure 4). Figure 5 shows pieces of floc for alum + CPS. There are also formations of shining particle that indicate on metals adsorbed onto the floc [10].

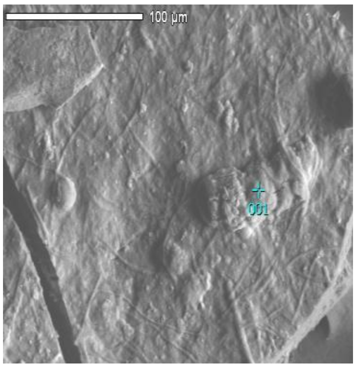

Fig. 3. Alum Floc

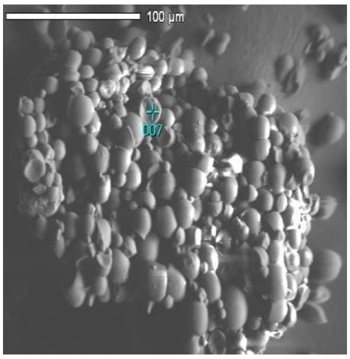

Fig. 4. CPS floc

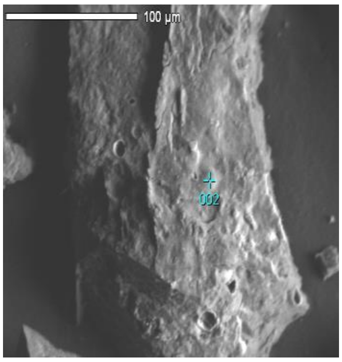

Fig. 5. Alum + CPS floc

(Figure 3,4 and 5: Floc after coagulation flocculation process)

3.2Effect of Dosage

Figure 6 shows turbidity removal increase up to 86.04% with increasing of alum dosage. The percentage of chemical oxygen demand (COD) removal was increased from 23.08% to 52.31% with the addition of alum dosage. Alum is high in charge density and it is dissolved in the suspension [6] with the mechanism on charge neutralization [10].

Figure 7 shows the effect of CP dosage. The percentage of turbidity removal was decreasing from 39.61% up to the lowest 23.64% with additional CP dosage. Natural coagulant is used as a coagulant aid to bridge the coagulated particles when aluminium or iron salt has been used as a primary coagulant in water and wastewater treatment [3].

Figure 8 shows the effect of aluminium sulphate + cassava peel starch dosage. The turbidity reduce from 78.05% to 32.20% at ratio 30 : 70 to 0 : 100.

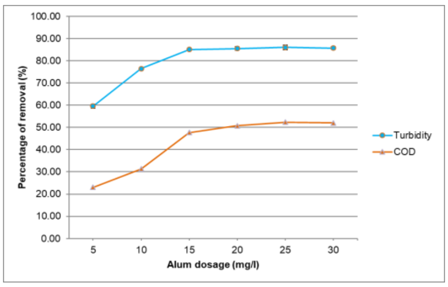

Fig. 6. Effect of Alum Dosage

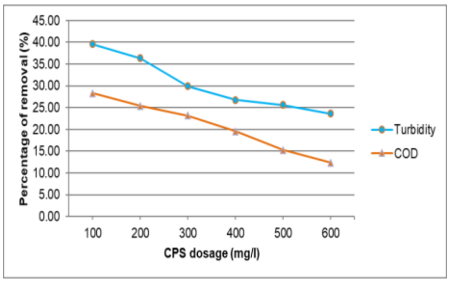

Fig. 7. Effect of CPS Dosage

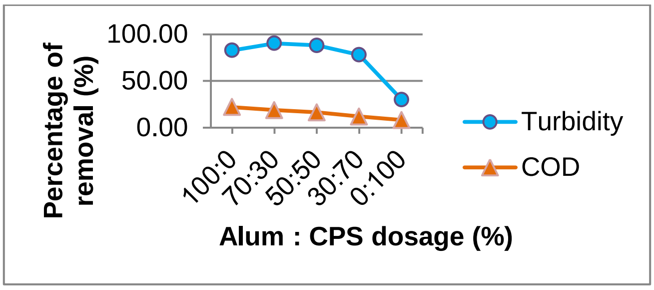

Fig. 8. Effect of Alum + CPS Dosage

4.Conclusions

This results from this study revealed that Cassava peel has the characteristic to be coagulant aid in removing turbidity and chemical oxygen demand.

5.Acknowledgement

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6. References

[1] J.D Theodoro, (2013). Coagulants and Natural Polymers:Perspectives for the Treatment of Water. Plastic and Polymer Technology (PAPT) Volume 2 Issue 3.

[2] N. Zayadi, N. Othman., R. Hamdan, (2016). A potential waste to be selected as media for metal and nutrient removal, IOP Conference Series : Material Science and Engineering, 136 (1) 012051

[3] S.Y. Choy (2014). Utilization of plant-based natural coagulants as future alternatives towards sustainable water clarification. Journal of Environmental Science 2 6, 2178 - 2189.

[4] Zayadi, N and Othman, N.(2013). Characterization and optimization of heavymetals biosorption by fish scale. Advanced Material Research. 795: 260-265

[5] J. Zhang, (2006). A preliminary study on cactus as coagulant in water treatment. Else, Process Biochemistry 41, 730–733.

[6] S. Zhao. (2013). Influence of a new coagulant aid-Enteromorpha extract on coagulation performance and floc characteristics of aluminum sulfate coagulant in kaolin–humic acid solution treatment, Colloids and Surfaces A: Physicochem. Eng. Aspects 417, 161– 169.

[7] Saritha, K. S. (2012). Evaluation of Chitin as Natural Coagulant in Water Treatment. Journal of Advanced Laboratory Research in Biology, 109-114.

[8] N.Othman, S.Y Kueh, M-F-H Azizul Rahman, R, Hamdan,R. Watermelon rind: a potential adsorbent for zinc removal, Applied mechanics and material, 680, 146-149 (2014)

[9] N. Othman, S. Mohd-Asharuddin, *Cucumis melo* rind as biosorbent to remove Fe(II) and Mn(II) from synthetic groundwater solution, Advanced Materials Research, **795**, 266-271, (2013).

[10] M.J. Fakir (2012). Starch and flour extraction and nutrient composition of tuber in seven. J. Bangladesh Agril. Univ. 10(2), 217-222.