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Flocculation Studies of Lonchocarpus Laxiflorus Plant(Leaves, Stem Bark and Roots) for Wastewater Treatment

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Abstract
The fact that water is the most important material used by mankind defines the importance of water purification. Wastewater and industrial effluent treatment require removal of suspended solids for purification and possible re-usage. The removal can be accomplished by gravitation (very slow), by coagulation (dependent on electric charge situation) and by flocculation (not dependent on electric charges and the fastest). This work evaluates the efficiency of the leaves, stem bark and roots of *lonchocarpus laxiflorus* in removing turbidity, suspended solids from 1% w/v of kaolin suspension through coagulation-flocculation process. Flocculation capabilities of the plant were studied using UV-Visible spectrophotometer at three different wavelengths (λ=400, λ=600 and λ=800). The result generally showed that the flocculation efficiency was a function of both flocculation time allowed and the wavelength of UV-radiation used.
Keywords: Coagulation- Flocculants, Environment, *lonchocarpus laxiflorus* , waste water

1. INTRODUCTION

Effluent disposal is a major problem around the world. Growing along with the population growth, industries create environmental problems and health hazards for the population. Hence, environmental concerns and progressing depletion of raw material resources made scientists to develop materials from natural plant resources to lower the extent of pollution of the environment. The world population is increasing – while availability of potable water is decreasing. Water is essential for the survival of human beings – not to mention modern industry. Although the earth consists of 75% of water, water for drinking, sanitation, agricultural and industrial processes is not easily available. According to the United Nationals Organization Report of 2005, 1.2 billion people lack access to adequate amounts of clean water and 2.6 billion people lack proper sanitation._ this situation got worse since 2005 and necessitates recycling of municipal wastewater and industrial effluents on a massive scale (Edilson *et al*., 2013). To meet the requirements of potable, industrial and agricultural water, we have to treat the wastewater, particularly the municipal sewage sludge's and slimes and industrial effluents.

The effluents are highly undesirable and unsafe to use. Wastewater contains solid particles with a wide variety of shapes, sizes, densities and composition. Specific properties of these particles affect their behavior in liquid phases and thus the removal capabilities. Many chemical and microbiological contaminants found in wastewater are adsorbed on or incorporated in the solid particles. Thus, essential for purification and recycling of both wastewater and industrial effluents is the removal of solid particles. Environmental considerations demand to develop strong, economically viable and eco friendly replacements of conventional synthetic flocculants, based upon the renewable organic materials which are economic and degrade naturally, if ever released in the environment. One obvious advantage of using renewable materials is the minimal net effect on global warming. Other advantages include biodegradability and sustainability. Thus, flocculants based on plant materials have a great potential to be used as a safe and economic substitute of synthetic flocculants being used currently in various industries for solid–liquid separation.

1.1 METHODS OF REMOVAL OF SOLID PARTICLES SUSPENDED IN LIQUIDS

The simplest process imaginable is by gravity. Solid particles have higher densities than water. However, fine particles with diameters on the order of 10 μm will *not* settle out of suspension by gravity alone in an economically reasonable amount of time. We note that particle sizes in emulsions are still smaller, 0.05 – 5 μm, hence the removal of particles from emulsions (de emulsification) is even more difficult. The second process, still widely used, is coagulation. Destabilization of colloidal suspensions occurs by neutralizing the electric forces that keep the suspended particles separated 4. The aggregates formed in the coagulation process are small and loosely bound; their sedimentation velocities are relatively low – although higher than in gravity separation. Given the nature of the process, the results are strongly dependent on pH and its variations (Yongzhang *et al* ., 2009). Flocculation is caused by the addition of minute quantities of chemicals known as flocculants. Both inorganic and organic flocculants are in use. Among the inorganic flocculants, salts of multivalent metals like aluminum and iron are applied most often - at high concentrations (Renault *et al*.,2005). Inorganic flocculants are used in very large quantities they leave large amounts of sludge and are strongly affected by pH changes. Organic flocculants are typically polymeric in nature; by contrast to inorganic ones, they are effective already in ppm concentrations (Witold *et a*l., 2009). Both synthetic and natural water-soluble polymers are used as flocculants. In contrast to the process of coagulation, electric charge manipulation is not the dominant mechanism of action in flocculation. In fact, flocculation is possible without significant changes in the particle surface charges. As a consequence, flocculation is not strongly affected by pH in a given medium, or by pH variations. Moreover, flocculation is much more effective than coagulation since the so-called flocs are larger and more strongly bound than the aggregates obtained by coagulation. Thus, among the possible options, flocculation is the method of choice (Ghosh *et al.,* 2010).

1.1.1 Materials and Methods

1.1. 2 Plant Collection and Treatment

The roots stem bark and the leaves of *Lanchocarpus laxiflorus* plant was collected from a tree behind Modibbo Adama Federal University of Technology Yola, Nigeria. The plant was wash thoroughly under running water to remove dust and any adhering particle and then rise with distilled water. The sample was air dry for 2 weeks and the dry roots, stem bark and the leaves will be grind in analytical mill and sieve to obtain adsorbent of known particle size range. The biomass powder will be kept in an air tight bottle for further study (Igwe and Abia, 2006).

1.1.3 Characterization of plant Material

1.1.4 Fourier Transform Infrared Analysis

Infrared spectra of the plants material biosorbent was obtained using Fourier transform infrared spectrophotometer. A dry film method as describe by Gari *et al*., 2005 was adopted. 5mg of test sample is placed in a small test tube, about 5 drops of carbon tetrachloride was added and mix thoroughly to dissolve the solid. Using a pipette, several drops of the solution was put on the face of the plate and the plate is positioned properly in the spectroscopy and the spectrum was obtained at the range of 4000-400cm^{-3}.

1.1.5 Flocculation Test

A 1% w/v of kaolin aqueous suspension was used for flocculation studies in this work. 0.2g of the test samples was added. Immediately after the addition of the flocculants, all the suspension was stirred at constant speed of 75rpm for 2min then follow by a slow agitation at 25rpm for 5min. The flocs was allowed to settle down for 2min, at the end of the settling period, the transmission of supernatant liquid was measured using a UV-Vis spectrometer. Then absorbance reading at 10min interval for 90min, 2.5h, and 24h was calculated. Absorbance measurement at different wavelength (400-800) was used according to Alang *et al*., 2011 procedure.

1.1.6 Flocculation Efficiency of *Lanchocarpus Laxiflorus* Plant

The flocculation efficiency of *Lanchocarpus laxiflorus* plant was determined using a standard Jar test method describe by Alang *et al*., (2011) with Ultra-violet (UV) spectrophotometer using the range of 400-800 nm wavelengths. The absorbance measurements were used to compute for flocculation efficiency of the samples under study. The UV spectrophotometer was calibrated with distilled water (blank determination).

1.1.7 EVALUATION OF FLOCCULATION EFFICACY

When flocculant is introduced into the container, an interface is formed. Above it is the supernatant liquid while below is the suspension containing the contaminants. Under the action of the flocculating agent, that is along with the progress of the flocculation process, that interface descends, until all contaminants are settled at the bottom. Two methods of flocculation efficacy determination are in use, a so-called jar test and a settling test. In the *jar test* one adds the flocculant in solution form to the suspension.

$$\textbf{Flocculation efficiency} = \frac{A_o - A_f}{A_o} \times 100$$

Where A_o is the absorbance of the kaolin suspension and A_f is the absorbance of the clarified supernanant water. The efficiency of each sample that clarified kaolin suspension was calculated after 10min interval for 90min, 2.5h and 24h at different wavelength (400, 600 and 800). The lower the value for Absorbance, the better is the flocculant. An example of results so obtained is shown in table 1.

1.1.2Results and discussion

This peace of research was undertaken to evaluate the abilities of the root, stembark and leaves of *Lonchocarpus Laxiflorus* plant to clarify turbid water. The results showed that all the tested part possessed significant flocculation abilities and have the potential of replacing conventional flocculants as water treatment, due to their efficiency, biodegradability and low sludge produced

1.1.2.1 Infrared Analysis (FTIR) Figure1 depicts the IR spectra of *lonchocarpus laxiflorus* leaves, Figure 2 shows the IR spectra of the plant stem bark while figure 3 illustrate the IR spectra of the roots. The adsorption occurs due to the presence of functional groups comprising the adsorbent material. The infrared spectroscopy was used for determining these groups.

The absorption peaks for *lonchocarpus laxiflorus* that appear in the region of 1437- 1328 cm-1 indicates carbonyl of carboxyl acid and the larger band in the region near 3400 cm-1 is indication stretching of the hydroxyl groups (-OH) carboxyl acid. These groups serve as active sites for attachment of colloidal particles and metal ion. Figures (1-3) contain a broad peak at 1630 cm^{-1} corresponding to the absorption at Amide 1 and Amide 11(protein) groups from protein components in the natural product (Sharma *et al*.,2006).This confirms literature reports that natural plant material when mixed with water, They yield water soluble proteins due to protonation of the amine functional groups. The solution acts as a natural cationic polyelectrolyte during water treatment (Alang *et al.,* 2011). The positively charged protein components thus act like magnet attracting the predominantly negative charge particles thus leading to flocculation. The variable bands around 2930cm^{-1} in figures (1-3) were assigned to bending vibration of the –C-H- of alkyl group (Sharma *et al*., 2006).

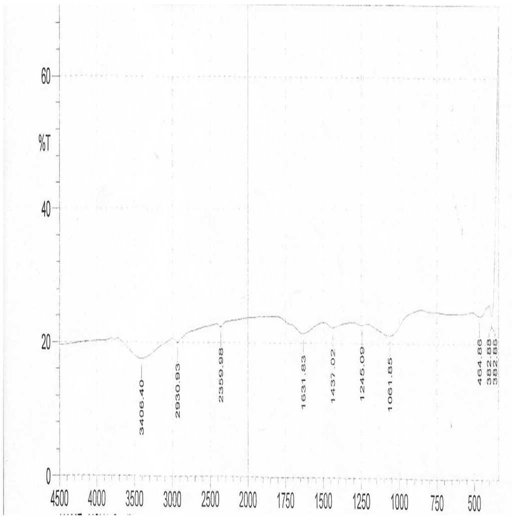

Figure: 1. FTIR Spectra of lonchocarpus laxiflorus leave

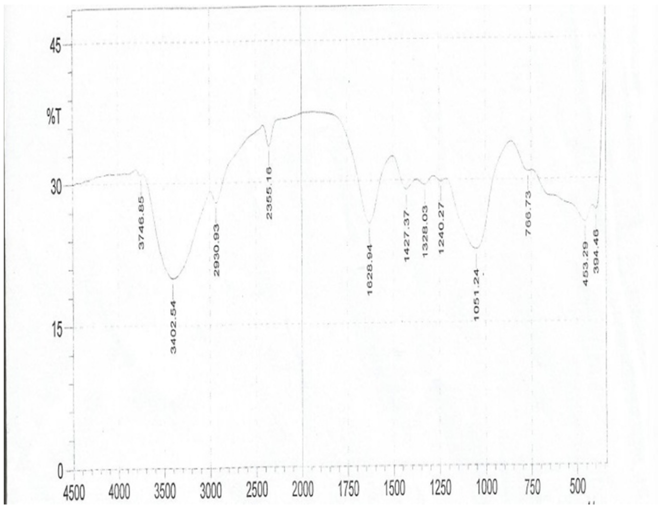

Figure 2. FTIR spectrum of *lonchocarpus laxiflorus* stembark

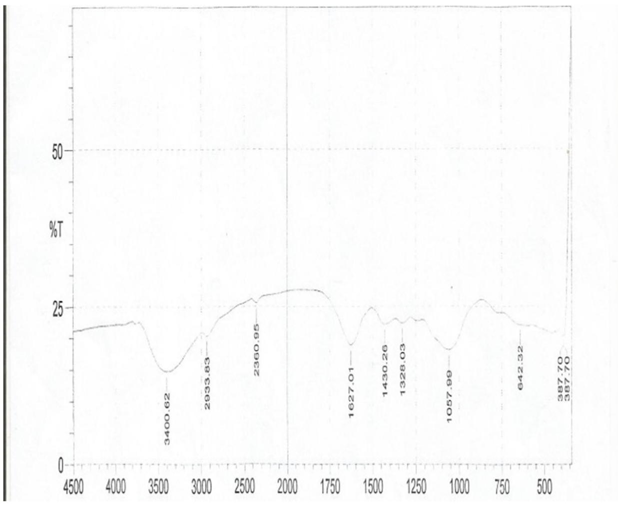

Figure 3. FTIR spectrum of *lonchocarpus laxiflorus* root

1.1.2.2 Flocculation Test

Flocculation tests were performed using 1% w/v kaolin suspension, and the effectiveness of the leaf, stem bark and the roots of *Lonchocarpus Laxiflorus* plant to be used as best flocculants is compared. The efficiency of the flocculants was tested and the results of the flocculation study are shown in Figures 4 - 6. The absorbance of the supernatant of the liquid after flocculation has been plotted against time at different wavelength.

Table1: Dependence of flocculation efficiency % with time at different wavelengths.

Time (min)	**Flocculation Efficiency %** 400nm	600nm	800nm
Leaves			
10	26.19	37.33	41.82
30	36.67	52.67	60.00
60	42.85	60.00	69.09
90	47.62	66.00	81.81
2.5h	67.61	77.33	84.54
24h	81.42	87.34	94.52
Stem bark			
10	50.00	58.00	60.00
30	57.14	68.67	69.09
60	64.28	77.33	80.00
90	71.42	84.67	86.36
2.5h	76.19	90.00	90.01
24h	91.90	96.00	98.18
Root			
10	29.52	35.33	39.09
30	40.47	46.00	57.72
60	44.76	60.00	67.09
90	51.47	72.00	77.27
2.5h	69.52	79.33	82.72
24h	79.52	84.66	90.91

Based on the above data, the flocculation efficiency of the root, stem bark and leaf were determined by spectrophotometer. The absorbance of the supernatant water of each kaolin suspension was measured with time and at different wavelengths (400nm, 600nm and 800nm). From the results of absorbance measurement obtained, the flocculation characteristics of the three samples in suspension of 1% w/v of kaolin are compared in Figure 4, 5 and 6. It is observed that, the flocculation accelerates sedimentation of kaolin suspension as well as improved final clarification of suspension these may be due to the cations in the plant biomass that accelerates sedimentation (Sharma *et al*., 2006). The time necessary for obtaining the best clarity of the supernatant in this research has found to be 24hour and the biomass materials flocculates better at longer wavelength of ultraviolet radiation (Table1).

Since cations on the flocculants bind to the kaolin particle are due to electrostatic attraction to the negative charged surface, the cations adsorbed onto the particles neutralizes their negatively surface charges leading to destabilization of the suspension. Consequently, the flocculants macromolecule is adsorbed simultaneously on several particles causing their bridging and leads to creating of heavily easily agglomerates (flocs) (Ziokawaka *et al.*, 2007).

From the results of table 1, the stem bark was seen to be the best flocculants reading a value of 90% after 2.5h of flocculation and increased to 98.18% when flocculation was extended to 24h. This agrees with literature value stipulating that solid removal is above 90% (Witold *et a*l., 2009). Figure 2 is the graphical representation of the flocculation properties of stembark. The second best flocculants in this research is the leaf which gave flocculation efficiency of 94% after 24h at 800nm. Figure 3 is the graphical representation of the flocculation properties of LL L. The above results showed that the biomass material flocculates better at longer flocculation.

1.1.2.3 Effect of Time on Flocculation Efficiency

Results from flocculation experiments carried out showed that, when time for interaction between the flocculants and impurities in the clarification water was extended, the clarification of the suspension waters goes through two stages. This is similar to the result obtained by Alang *et al*., 2010.The first step involves the formation of stable flocs through electrostatic interaction and other flocculation mechanism, while the second step has to do with the gravitational settlement of the flocs with supernatant clarification. Hence the more time allowed for the interaction of the flocculation with the suspension, the more stable flocs are formed. Also at longer time, the greater the amount of flocs settle by gravity including lighter particles and water becomes more clarified, hence flocculation efficiency increases with longer settlement times.

1.1.2.4 Effect of Wavelength on Flocculation Efficiency

Flocculation efficiency from the experimental results was found to vary with different wavelength of UV radiation used. At longer wavelength, the flocculation efficiency was higher and vice visa. Recall that Absorbance (A) = $\log I_o/I$, where I_o and I are the incidence and transmitted intensity of UV radiation respectively. When light is passed through suspension (waste water), light intensity is also passed through, at different wavelength is partly absorbed, scattered and reflected such that its transmitted intensity I is usually less than its incident light $I_{o.}$ The absorbance is then calculated from their ratios which equal their flocculation efficiency. Light makes little interaction with particles in the medium at longer wavelength which results to weak transmitted intensity that leads to low absorbance and high flocculation efficiency. On the other hand, at shorter wavelength of UV radiation in a suspension, there is greater interaction of light with the particles in the suspension resulting to greater reduction in the intensity of the transmitted light and absorbance became higher and then flocculation efficiency decreases as shown in Figures 4-6 and Table 1.Similar trend was reported by Gregory,J. (1993).

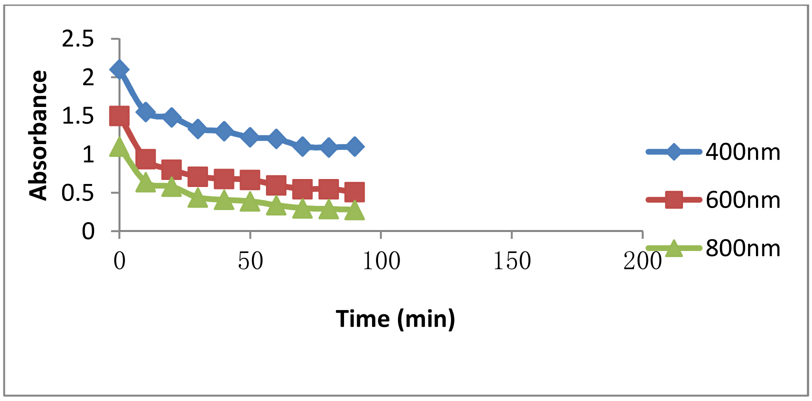

Figure: 4 Flocculation Efficiency of LLL at different wavelength

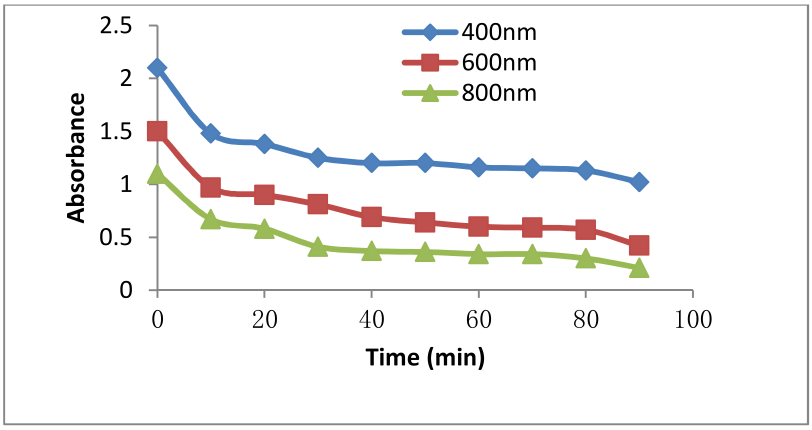

Figure 5. Flocculation Efficiency of LLSB at different wwavelength

Conclusion

The flocculation test showed that all the plant parts of the tree possessed flocculation efficiency with the stem bark as the best flocculent followed by the leaves. This plant parts are effective in the treatment of water for domestic use and also for treating environmentally harmful industrial effluents.

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