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A Study to Investigate the Potential of Mimosa Pudica (Sensitive Plant) Leaves in The Detoxification of Laundry Waste Water.

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Abstract
This study aimed to purify laundry wastewater using the leaves of the Sensitive Plant (Mimosa Pudica). The purification process primarily targets the reduction of pathogen content in the wastewater. The physiochemical properties of both the effluent and the plant leaves were determined, as well as the effects of the leaves on the properties of the wastewater. Significant differences were observed in the concentration of the parameters analyzed in the discharged laundry wastewater compared to national and international standards. It was noted that the predominant functional groups in the sensitive plant leaves are O-H stretching, N-H stretching, C=C Stretching, and C-O deformation. Reductions in pathogens, BOD and COD were observed, indicating that the sensitive plant leaves have a potential application for laundry effluent detoxification.

Keywords: Laundry, waste water, Mimosa, Detoxification

1.1 Introduction

The reuse of treated wastewater is a sustainable water resource with numerous possible applications [1]. Besides producing reusable water, wastewater treatment is crucial for health and environmental protection by reducing waste and producing natural fertilizer, energy, and other products [2]. The wastewater often has high loads of organic nutrients primarily originating from carbonaceous and nitrogen-containing compounds. Furthermore, the effluent may contain suspended and dissolved solids, microbes, and variable pH levels. The effluent's high salinity (Na+, Cl-, SO_4^{2-}) is another important aspect of this industrial wastewater [3]. Wastewater can be characterized by its chemical and physical properties [4]. Key pollutant parameters include chemical parameters such as pH; biochemical oxygen demand (BOD); the COD, ammoniac nitrogen (NH3-N), nitrate nitrogen (NO3-_N), and phosphorus (P); while physical parameters, include temperature, odor, color, and solid contents [5]. The pollutants in wastewater can cause eutrophication or oxygen depletion. Consistent oxygen depletion in these waters could deprive aquatic life of the oxygen it requires, leading to the anaerobic decomposition of organic matter. This process results in the breakdown of proteins and other nitrogenous compounds, releasing potentially hazardous substances to the ecosystem, such as hydrogen sulphide, methane, amines, diamines, and occasionally ammonia. These substances are toxic to aquatic life in low concentrations and can also lead to the development of unpleasant odors and unsightly scenes [6]. Odors in the other hand play a significant role in public perception and acceptance of any wastewater treatment plant [7]. Although relatively harmless, they can affect the general public by inducing stress, nausea or sickness [8]. Biological treatment uses microorganisms to remove organic solids and nutrients from wastewater, and it is generally considered to be more cost-effective and environmentally friendly [9]. Biological treatment involves the use of a biological reactor that contains wastewater rich in biodegradable organics and nutrients [10]. Here, microorganisms utilize organic matter for life-sustaining processes and as a food source to produce cell growth and reproduction; the nutrients available in the wastewater enhance the growth of microorganisms and allow the biological treatment to be effective

[11]. The assimilatory pathway occurs when microorganisms utilize nitrate to produce ammonia, which is then used as a nitrogen source to generate biomass [12]. Laundry wastewater is a type of grey water that contains soap, suspended solids, oil, perfumes, and other high concentrations of chemicals [13]. They cover several sectors including, for example, hospitality, hospitals, and pre-marketed textiles and contains over 20000 $mg \cdot L^{-1}$ COD and commonly has basic pH and high levels of turbidity, suspended solids, phosphorous compounds and allergenic fragrance compounds, among others [14].

The wastewater produced from laundry industry after biological treatment has a high potential to be reused in agriculture since the main constituents are organic and nutrient substances capable of promoting plant growth. Therefore, this wastewater, could be a valuable resource for agriculture, such as liquid fertilizer production, etc. However, potential utilization of these wastewater has been limited due to its toxicity.

The cost of water and wastewater treatment has increased due to the rise in population and industrial activities. The use of chemicals in the treatment of pathogens in wastewater has also increased. Most of these chemicals are either synthesized from cheap raw materials or are obtained from compounds containing heteroatoms, which are toxic to the environment. This has prompted the search for natural compounds, like plant leaves, for the treatment of pathogens in wastewater. This research therefore focused on the investigation of the potential of Mimosa pudica (also called sensitive plant, sleepy plant, action plant, touch-me-not, shame plant) [15] which its leaves fold inward and droop when touched or shaken, and re-open a few minutes later [16] for the treatment of pathogens in laundry waste water.

2.1 Materials and Method

The materials used in this study included locally sourced laundry waste from the Diamond Hostel of the Enugu University of Science and Technology Agbani and Pudica Munica (Sensitive plant) leaves obtained from Amalla in Udenu LGA of Enugu State Nigeria. Other items included distilled water, $MnSO_4$ alkaline Sodium Azide, concentrated H_2SO_4, Sodium thiosulphate (Na2S2O3), freshly prepared starch, potassium dichromate solution ($2Cr_2O_2$), phenolphthalein and ferrous ammonium sulphate. Equipment used included a UV spectrophotometer, oven, muffle furnace, test tube, water can, filter paper, measuring cylinder, beaker, burette, pipettes, wash bottle, 500ml conical flask, shaker, water bath.

2.3 Experimental procedures

The fresh leaves of Mimosa pudica were collected, washed, and sun-dried for four days before being ground into a powdered form. The ground leaves were stored in a container from where samples were collected for analysis [17] The functional groups and the mineral oxides present were determined with Fourier transform infra-red (FTIR) and X-ray Florescence (XRF) spectroscopy respectively.

2.4 Physicochemical and biological characterization of the Laundry Wastewater.

The quantity of pathogens was determined using the method of direct plate count [18]. The nutrients alga was weighed into a conical flask and dissolved in water according to the manufacturer's direction. The dissolved nutrients alga was sterilized in an autoclave at 121°C for 15 minutes and was poured aseptically into different sterilized petri dishes and allowed to gel. A serial dilution was then made by setting 5 test tubes containing 9ml of distilled water each. 1ml of the sample was added into the first test tube and then from it to others, thereafter the sample with the least concentration was used. A sterile wire loop was used to inoculate 0.1ml of the sample into the petri dishes and then stroked. It was incubated for 24 hours at 37°C and the cells were then counted. pH was determined using lovibond instruments and electronic meters. Temperature was determined with a Mercury-in-glass thermometer. Electrical conductivity was determined with a Mettler Toledo MC 2006 conductivity meter. Turbidity levels were measured in Nephelometric units (NTU) using a HACH 2100A turbidity meter. A transmission spectrometer was used to determine sulphate. Chloride was determined by titrating samples with silver nitrate. Nitrate was determined by titrimetric method. 1ml of sodium arsenic was added to the sample, shaken thoroughly, 5ml was separated from the mixture in a test tube and 10ml of bruane sulphate added, then 10 ml of conc. Sulphuric acid was added and the remaining solution mixed and allowed to develop for about 1hr; the absorbance was then read with the aid of UV Spectrophotometric 20. Biochemical Oxygen Demand was determined by conventional methods according to [19] Association of Official Analytical Chemists (AOAC) 2002. In the determination of Chemical Oxygen Demand, potassium dichromate was used in the test and oxygen used in oxidizing the water was determined.

3. Results and Discussion

3.1 The Physicochemical characteristics of the laundry waste water.

The characteristics of the laundry waste water sample are shown in Table 1. It is clear from the table that the BOD, COD and SS are in higher values than the general limits prescribed by the national (NESREA) and international standards (WHO).

Table 1: The characteristics of laundry waste water and some national and international standard.

Parameters	Wastewater Discharge	National Discharge Standard (NESREA) [20]	International Discharge Standard (WHO) [21]
Temperature ^{0}C	34	40	40
Ph	7.8	6-9	6-9
COD mg O_2/L	1230	60-90	60
BOD mgO_2/L	930	30-50	80
SS mg/l	480	25	15
TDS mg/l	875	500	500
Pathogens MPN/100mL	12000	400	NIL
Turbidity NTU	11	1-5	7
Chloride ppm	150	250	250
Nitrate ppm	320	45	10
Sulphate ppm	180	200	200
Oil and grease mg/L	12	10	10

3.2. Characteristics of the Sensitive plant leaves
3.2.1 Fourier Transform Infrared Spectroscopy Results.

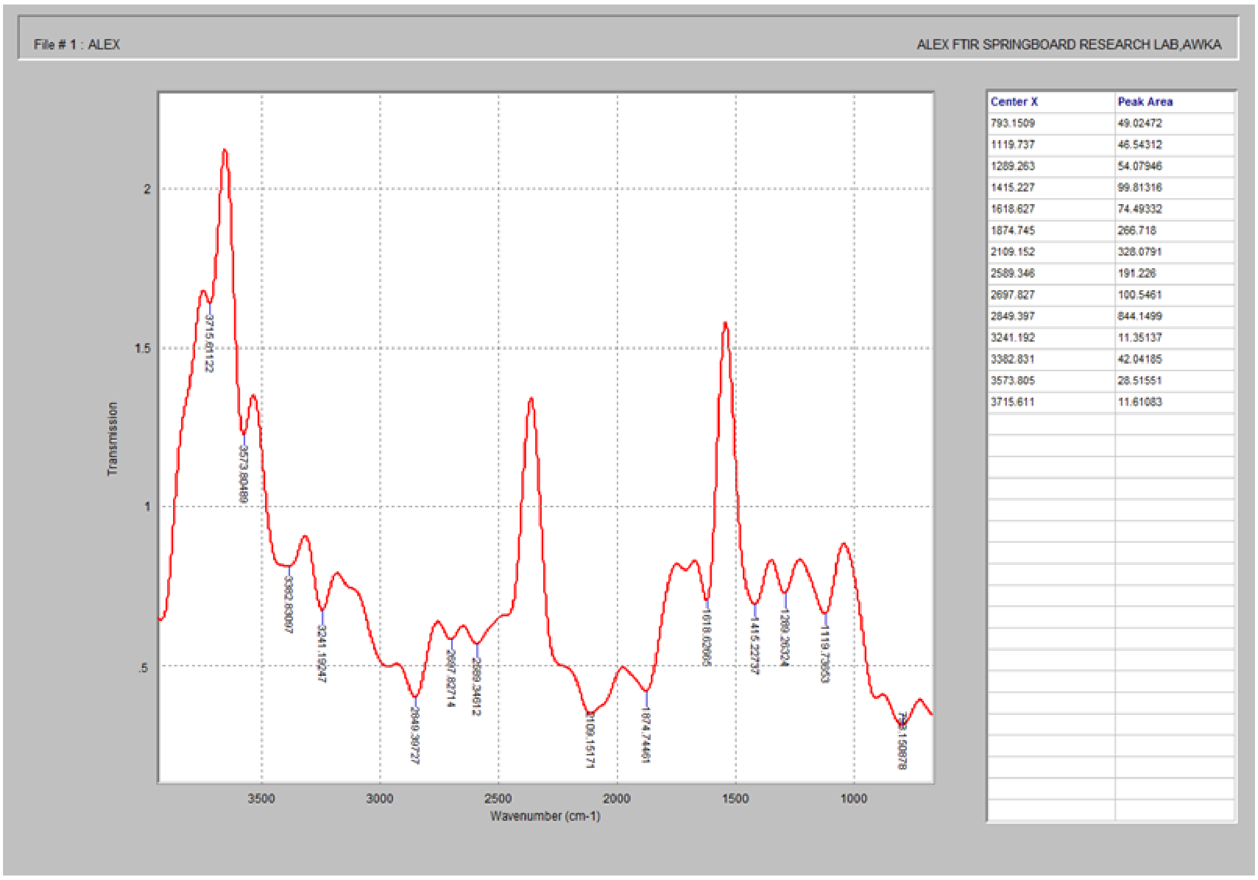

Fig .1: FTIR analysis of sensitive plant leaves.

Fourier Transformed Infrared (FTIR) technique is an important tool used to identify the characteristic functional groups and organic compounds inherent in any given sample. Results of FTIR spectra of the analyzed sample are recorded in Fig 1. From the figure, the peak values around 1119.737cm^{-1} and 1286.263cm^{-1} were assigned to C0 stretching vibration of ether compound respectively. The absorbance around 1415.227cm^{-1} was assigned to C=C stretching vibration of ethane compound. The medium band around 1618.627cm^{-1} was assigned to N-H stretching vibration of 1^0 amine compound whereas the around 1874.627cm^{-1} was due to C0 stretching vibration of cyclic ester compound. The wavelength around 2109.152cm^{-1} was assigned to C00 stretching vibration of carboxylic acid. The absorbance around 2589.346cm^{-1} was assigned to CN stretching vibration of nitrile compound. The weak bands around 2697.827cm^{-1} and 2849.397cm^{-1} were assigned to C-H stretching vibration of methylene compounds respectively. The strong bands around 3241.1 92cm^{-1}, 3382.831cm^{-1}, 3573.805cm^{-1} and 3715.61 lcm^{-1} were assigned to 0H stretching vibration of 1^0, 2^0 and 3^0 alcoholic compounds respectively.

3.2.2 Determination of the mineral composition
X-ray fluorescence (XRF) is a scientific technique that is used to measure the percentage of elemental and metal oxides present in a given sample. A spectrum of the analyzed plant sample is recorded in table 2. From the table

of results, the most predominant metal oxides present in the analyzed plant samples were recorded as K_20 34.789%, Ca0 29.149%, $S0_3$ 6.998%, $Si0_2$ 6.016%, P_20_5 5.876% and F_20_3 4.463%. The results imply that the above predominant metal oxides serve as potent constituents in paint quality. Furthermore, out of 26 spectrum of metal oxides identified and recorded, 7 spectrums were observed to contain the predominant metal oxides with a total concentration of 87.291% whereas 19 spectrums record l2.709%.

Table 2: XRF Analysis of sensitive plant leaves.

S/N	Components	% Concentration
1	SIO_2	0.016
2	V_2O_5	0.046
3	Cr_2O_3	0.052
4	Mn0	0.241
5	Fe_2O_3	4.463
6	CO_3O_4	0.041
7	Ni0	.017
8	CUO	0.387
9	Nb_2O_3	0.048
10	$M00_3$	0.021
11	$W0_3$	0.039
12	P_20_5	5.876
13	$S0_3$	6.998
14	Ca0	29.149
15	Mg0	0.00
16	K_20	34.789
17	Ba0	0.00
18	Al_20_3	7.902
19	Ta_20_5	0.00
20	$TI0_2$	0.718
21	Zn0	0.128
22	Ag_20	0.032
23	Cl	2.117
24	$Zr0_2$	0.014
25	$Sn0_2$	0.702
26	Rb_20	0.105

3.3. Treatment of the Laundry waste water with the sensitive plant

Table 3: Effect of time on the physicochemical properties of the laundry waste water.

Time (day)	SAMPLE	pH	BOD (mg/L)	COD (mg/L)	Pathogen Content (CFU/ml)
0	Laundry waste water	7.91	930	1230	$12.2x10^3$
	Laundry Effluent + Sensitive plant Leaves	7.73	930	1230	$12.2x10^3$
1.	Laundry waste water	7.61	910	1200	$10.1x10^3$
	Laundry waste water + Sensitive plant Leaves	7.31	720	1120	$6.0x10^3$
2.	Laundry waste water	7.56	905	1011	$6.2x10^3$
	Laundry waste water + sensitive plant Leaves	7.47	520	925	$2.2x10^3$
3.	Laundry waste water	7.45	880	984	$2.45x10^3$
	Laundry waste water + Sensitive plant Leaves	7.33.	325	620	$1.12\ x10^3$
4.	Laundry waste water	7.39	810	920	$2.25x10^3$
	Laundry waste water + Sensitive plant Leaves	7.21	280	410	$4.10x10^2$
5.	Laundry waste water	7.33	728	880	$2.1x10^2$
	Laundry waste water + Sensitive plant Leaves	7.14	152	268	$4,4x10^1$
6.	Laundry waste water	7.32	722	870	2x102
	Laundry waste water + Sensitive plant Leaves	7.07	111	182	$3x10^1$

Table 3 represents the effect of time on the physicochemical properties of the samples. There was reduction of the Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and the pathogen content as the time increases. The pH has an undulating pattern as it increases and reduces with time. This may be as a result of microbial activities at a given time.

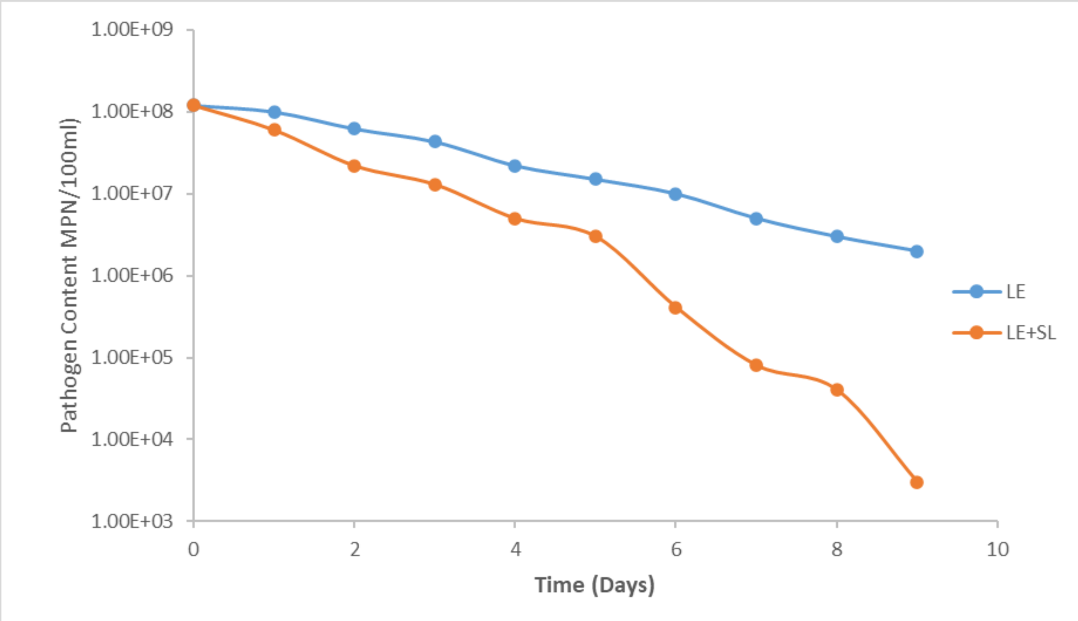

Fig 2: Effect of time on the Pathogen content of the laundry waste water.

Figure 2 shows the plot of Pathogen content against time. The reduction of the pathogen content with time is in exponential form. The coefficient of determination, R^2, is close to unity 1, indicating that the reduction of the pathogen content with time obeyed exponential equation. The rate of pathogen reduction content is higher in laundry effluent with sensitive leaves, compared to that of laundry effluent alone. There was drastic reduction in Pathogen, BOD and COD from 12.2×10^3MPN/100ml to 1x10MPN/100ml, 930mg/L to 110 mg/L, and 1230 mg/L to 182 mg/L respectively, indicating that there was a great effect and therefore sensitive leaves can be used to reduce the level of pathogens in the waste water. This means that when more time is given there would be more reduction of pathogens.

4.0 Conclusion

The physiochemical analysis of the laundry waste water reveals that its parameters are much higher than the national and international discharge standard of waste water. The FTIR analysis of the sensitive plant leaves shows that it contains alcohols and phenolic compounds mainly, which are the main constituents of antibiotics. The sensitive plant reduced the pathogen content, COD, BOD of the waste water thus making it fall within the national and international standards of waste water discharge.

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