Adsorption Study for Removal of Methyl Red and Malachite Green by Teak Leaves Powder

Lwin Mu Aung,[1] Aye Phyu Zin,[2] Ni Ni Pe[3]

ABSTRACT

The present research work is on the preparation of Teak leaves to be used as the effective sorbent for the removal of organic dyes. Two types of sorbents sample 1 (at 100°C for 2 hr) and sample 2 (at 200°C for 2 hr) were prepared. The elemental content of teak leave powder was determined by EDXRF analysis. The adsorption properties of two sorbents (sample 1 and sample 2) were carried out spectrophotometrically. Two model dyes, methyl red as acid dye and malachite green as basic dye, were used in sorption experiments. The effects of sorption parameters (concentration of dye solution, contact time and sorbent dose) of each sorbent upon the removal of specified colored dye were investigated. Based on significant sorption parameters, the sorption capacities of sorbents for the removal of methyl red and malachite green were observed that sample 2 greater than that of sample 1.

Keywords : *adsorption, dye, sorbent, spectrophotometrically, teak*

INTRODUCTION

Pure water is colourless, but water in nature often coloured by foreign substances. Colour contributed by dissolved solid that remains after removal of suspended matter is known as true colour. Highly coloured water is unsuitable for laundry, dying, paper production dairy products and other industrial uses. Thus the colour in water affects its marketability for both domestic and industrial use. Dyes are widely used in industries such as textiles, leather, paper, plastics, etc. to colour their final products. The textile industries are the greatest generators of liquid effluent, due to high quantity of water used in the dyeing processes (de Souza *et al*; 2007). Dye removal from wastewater effluent is a major environmental problem because of the difficulty in treating such streams by conventional physical, chemical, physico-chemical and biological treatment methods. Many physical and chemical treatment methods including adsorption, coagulation, precipitation filtration, electro-dialysis, membrane separation and oxidation have been used for the treatment of dye containing effluents (Chiou and Li, 2002). Adsorption process is one of the most effective and economically feasible methods for the removal of dyes from aqueous solutions.

Most dyes are inert and non-toxic at the concentration discharged into the receiving water; however, they impart undesirable colours to the water uses. The release of these colored wastewaters in the ecosystem is a dramatic source of esthetic pollution, of eutrophication and of perturbations in the aquatic life (Manel*et al*., 2007). Color is a characteristic of wastewater, and can easily be detected. Elimination of color from dye bearing wastewater is one of the major environmental problems, because of difficulties in treating such wastewaters by conventional methods, as most of the dyes are stable to heat and oxidizing agents. Color pollution may cause potential toxicity and turbidity problems, thus contributing significantly to the pollution of aquatic ecosystems (Adowei *et al*., 2012). Recently, use of naturally occurring low cost and harmless material for removing of trace contaminants from colored wastewater has attracted extensive attention (Noroozi *et al*., 2004). Raw materials, which are either abundant or wastes from other industrial and agricultural operations, can be used as bio-sorbents. In this research, teak leaf was used as bio-sorbent for the removal of dyes.

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MATERIALS AND METHODS

Sample Collection and Preparation

The Teak leaves were collected from the University Campus, Banmaw Township at Kachin State. The teak leaves were air-dried, finely powdered and sieved with 80-mesh sized sifter. An accurately weighed sample (20g) was put into a predried and cooled dish with a cover. The uncovered dish was placed in an electric oven and heated for 2 hr at 100°C for sample 1 and 200°C for sample 2. After heating, the resultant samples were cooled at room temperature and stored in a sealed bottle.

EDXRF analysis

The elements in the Teak leaves sample powder were determined by EDXRF 8000 spectrometer, Shimadzu, made in Japan at the Department of Chemistry, West Yangon University.

Sorption Studies of Teak Leaves Sample for the Colour Removal of Dye Solutions

Effect of initial concentration

After removing dyes solutions, two samples (sample 1 and sample 2) were determined by varying the initial concentration from 20 $mgL^{-1}$to 140 mgL^{-1}(methyl red and malachite green) under the same conditions (0.1g/10mL dosage, 60 min contact time at room temperature). The equilibrium concentration was determined spectrophotometrically at its corresponding λ_{max} 410 nm for methyl red and 617 nm for malachite green respectively.

Effect of contact time

Batch adsorption experiments were conducted by putting 0.1 g of Teak leaves samples (sample 1 and sample 2) into 10 mL of 60 mgL^{-1}dye solution (for methyl red and malachite green) in a 150 mL conical flask, and shaking at room temperature. After every 15 min intervals, the samples were taken and the sorbents were removed by centrifugation. The equilibrium concentration was determined spectrophotometrically at the corresponding λ_{max} 410 nm for methyl red and 617 nm for malachite green respectively.

Effect of dosage

The colour removal of methyl red and malachite green (initial concentration 60 mgL^{-1}) for sample 1and sample 2 in 10 mL dye solution were also determined by varying the adsorbent dosage from 0.02 g to 0.14g under the same conditions (60 min contact time at room temperature). The equilibrium concentration was also determined spectrophotometrically at its corresponding λ_{max} 410 nm for methyl red and 617 nm for malachite green respectively.

The percent removal for dye solution was calculated by the following equation.

$$\text{Percent removal (\%)} = \frac{C_o - C_e}{C_o} \times 100$$

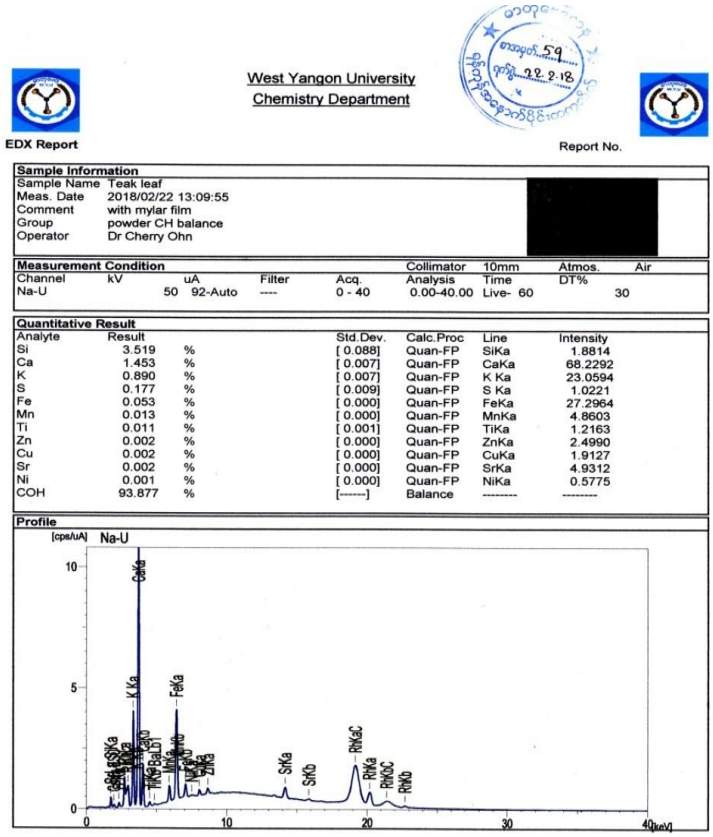
Where, C_o = initial concentration of dye solution

C_e = equilibrium concentration of dye solution

RESULTS AND DISCUSSION

EDXRF Analysis

The elemental content of the Teak leaves sample powder before thermal activation was determined by energy disperses X-ray fluorescence (EDXRF) method. The EDXRF spectrum was represented in Figure 1. From the experimental data, Si, Ca, and K were observed as the major constituents. The highest amount of Si was found in this sample. In addition, other elements such as S, Fe, Mn, Ti, Zn, Cu, Sr, and Ni as the minor elements were also observed.



West Yangon University
Chemistry Department

EDX Report

Report No.

Sample Information

Sample Name	Teak leaf
Meas. Date	2018/02/22 13:09:55
Comment	with mylar film
Group	powder CH balance
Operator	Dr Cherry Ohn

Measurement Condition

Channel	kV	uA	Filter	Acq.	Collimator	10mm	Atmos.	Air
Na-U	50	92-Auto	----	0 - 40	Analysis 0.00-40.00	Time Live- 60	DT%	30

Quantitative Result

Analyte	Result		Std.Dev.	Calc.Proc	Line	Intensity
Si	3.519	%	[0.088]	Quan-FP	SiKa	1.8814
Ca	1.453	%	[0.007]	Quan-FP	CaKa	68.2292
K	0.890	%	[0.007]	Quan-FP	K Ka	23.0594
S	0.177	%	[0.009]	Quan-FP	S Ka	1.0221
Fe	0.053	%	[0.000]	Quan-FP	FeKa	27.2964
Mn	0.013	%	[0.000]	Quan-FP	MnKa	4.8603
Ti	0.011	%	[0.001]	Quan-FP	TiKa	1.2163
Zn	0.002	%	[0.000]	Quan-FP	ZnKa	2.4990
Cu	0.002	%	[0.000]	Quan-FP	CuKa	1.9127
Sr	0.002	%	[0.000]	Quan-FP	SrKa	4.9312
Ni	0.001	%	[0.000]	Quan-FP	NiKa	0.5775
COH	93.877	%	[------]	Balance	--------	--------

Profile

Figure 1 EDXRF spectrum of Teak leaves powder

Colour Removal of Methyl Red and Malachite Green by Two Types of Sorbents

Effect of initial concentration

Table 1, 2 and Figure 2(a) and (b) showed the percent removal of methyl red and malachite green by a constant amount of sorbents sample 1 and sample 2 with initial concentration in the range from 20 mgL^{-1} to 140 mgL^{-1} of dye solution. It can be seen that the percent removal of methyl red and malachite green decreases with increases in initial concentration. For two dyes solutions, sample 2 was greater removal capacity than that of sample 1.

Table 1 Effect of Initial Concentration of Dye Solution on the Sorption of Methyl Red by Sample 1and Sample 2

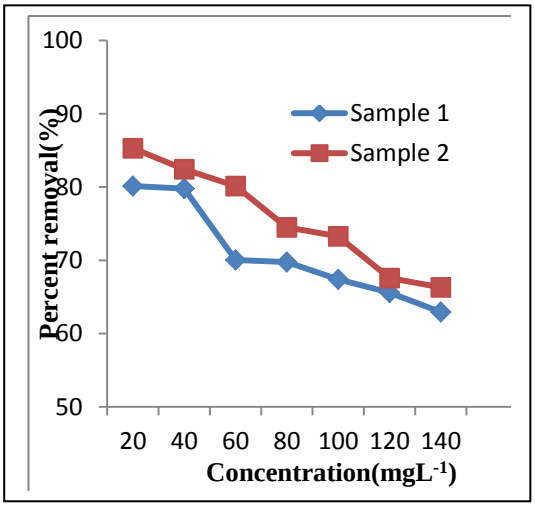
No	Dose (g)	C_0 (mgL^{-1})	Sample 1		Sample 2	
			C_e (mgL^{-1})	Percent removal (%)	C_e (mgL^{-1})	Percent removal (%)
1	0.1	20	3.971	80.145	2.943	85.285
2	0.1	40	8.086	79.785	7.029	82.428
3	0.1	60	17.971	70.048	11.914	80.143
4	0.1	80	24.200	69.750	20.400	74.500
5	0.1	100	32.600	67.400	26.714	73.286
6	0.1	120	41.286	65.595	38.914	67.572
7	0.1	140	51.886	62.939	47.171	66.306

Table 2 Effect of Initial Concentration of Dye Solution on the Sorption of Malachite Green by Sample 1and Sample 2

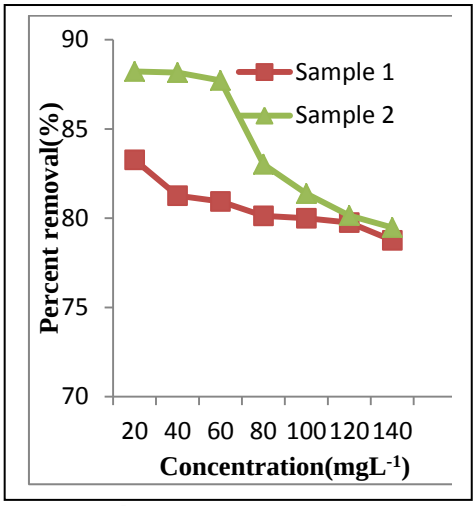
No	Dose (g)	C_0 (mgL^{-1})	Sample 1		Sample 2	
			C_e (mgL^{-1})	Percent removal (%)	C_e (mgL^{-1})	Percent removal (%)
1	0.1	20	3.345	83.275	2.356	88.220
2	0.1	40	7.494	81.265	4.736	88.160
3	0.1	60	11.437	80.938	7.368	87.720
4	0.1	80	15.897	80.129	13.586	83.018
5	0.1	100	20.000	80.000	18.621	81.379
6	0.1	120	24.299	79.751	23.816	80.153
7	0.1	140	29.736	78.760	28.736	79.474

Effect of contact time

The effect of contact time on the removal of methyl red and malachite green (initial concentration 60 mgL^{-1}) by sample 1and sample 2 were shown in Table 3, 4 and in Figure 3(a), (b). It can be seen that if the contact time of sample 1 and sample 2 with two dyes solution increased, the percent removal also increased. In addition, the percent removal for sample 1 and sample 2 increased contact time from 15 min to 90 min. The percent removal of methyl red was found to be 84.000% for sample 1 and 88.618% for sample 2 after 90 min. The percent removal of malachite green was observed at 86.572% for sample 1 and 93.085% for sample 2 after 90 min. Therefore the sample 2 was higher percent removal than that of sample 1 for two dyes solutions



(a)



(b)

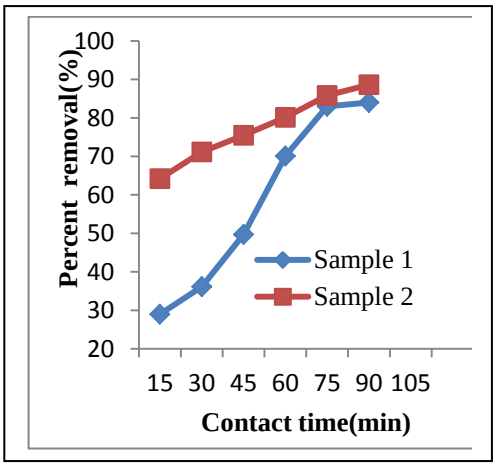
Figure 2 **Effect of initial concentration on the sorption of (a) methyl red by sample 1 and sample 2(b) malachite green by sample 1 and sample 2**

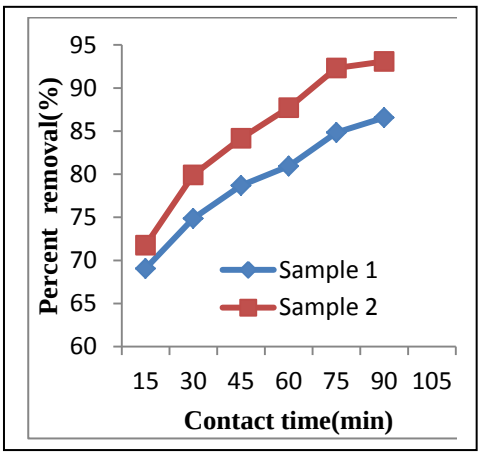
Table 3 **Effect of Contact Time on the Sorption of Methyl Red by Sample 1 and Sample 2**

No	Contact Time	Sample 1		Sample 2	
	(min)	C_e(mgL^{-1})	Percent removal (%)	C_e(mgL^{-1})	Percent removal (%)
1	15	42.629	28.952	21.486	64.190
2	30	38.314	36.143	17.314	71.143
3	45	30.200	49.667	14.714	75.477
4	60	17.971	70.048	11.914	80.143
5	75	10.200	83.000	8.514	85.810
6	90	9.600	84.000	6.829	88.618

Table 4 **Effect of Contact Time on the Sorption of Malachite Green by Sample 1 and Sample 2**

No	Contact Time	Sample 1		Sample 2	
	(min)	C_e(mgL^{-1})	Percent removal (%)	C_e(mgL^{-1})	Percent removal (%)
1	15	18.563	69.062	16.943	71.762
2	30	15.080	74.867	12.046	79.923
3	45	12.782	78.697	9.494	84.177
4	60	11.437	80.938	7.368	87.720
5	75	9.092	84.847	4.609	92.318
6	90	8.057	86.572	4.149	93.085





(a) **(b)**

Figure 3 **Effect of contact time on the sorption of (a) methyl red by sample 1 and sample 2(b) malachite green by sample 1 and sample 2**

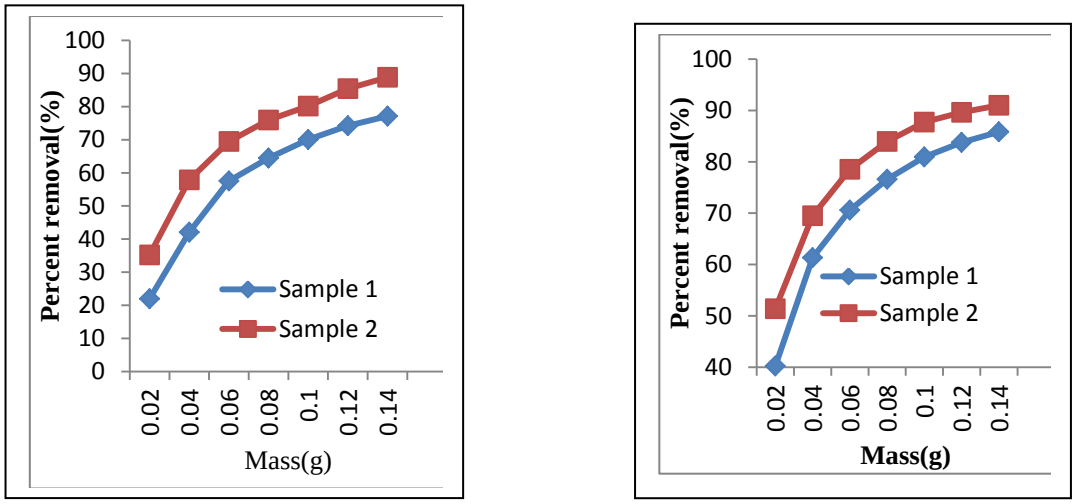
Effect of sorbent dose

Table 5 **Effect of Dosage on the Sorption of Methyl Red by Sample 1 and Sample 2**

No	Dose(g)	Sample 1		Sample 2	
		$C_e(mgL^{-1})$	Percent removal (%)	$C_e(mgL^{-1})$	Percent removal (%)
1	0.02	46.829	21.952	38.886	35.190
2	0.04	34.743	42.095	25.286	57.857
3	0.06	25.486	57.523	18.314	69.477
4	0.08	21.343	64.428	14.429	75.952
5	0.10	17.971	70.048	11.914	80.143
6	0.12	15.486	74.190	8.743	85.428
7	0.14	13.743	77.095	0.686	88.851

Table 6 **Effect of Dosage on the Sorption of Malachite Green by Sample 1 and Sample 2**

No	Dose(g)	Sample 1		Sample 2	
		$C_e(mgL^{-1})$	Percent removal (%)	$C_e(mgL^{-1})$	Percent removal (%)
1	0.02	35.850	40.250	29.161	51.398
2	0.04	23.207	61.322	18.299	69.502
3	0.06	17.644	70.593	12.885	78.525
4	0.08	14.034	76.610	9.621	83.965
5	0.10	11.437	80.938	7.368	87.720
6	0.12	9.736	83.773	6.218	89.637
7	0.14	8.494	85.843	5.390	91.017



(a) **(b)**

Figure 4 Effect of doage on the sorption of (a) methyl red by sample 1 and sample 2(b) malachite green by sample 1 and sample 2

Table 5 and 6 showed the removal of methyl red and malachite green from a constant initial concentration of 60 mgL^{-1} by the amount of sorbents sample 1and sample 2 in the range from 0.02 g to 0.14 g in 10mL of two dyes solutions. Figure 4(a) and (b) showed the corresponding data in terms of percent removal with respect to sorbent dose. It can be seen that as the removal percent of two dyes solution increases with an increase in sorbent dosage. For the sorbent of 0.14 g in 10 mL dye solution, the percent removal of methyl red dye was77.095 % for sample 1 and 88.851 % for sample 2, the percent removal of malachite green dye was 85.843% for sample 1 and 91.017% for sample 2 respectively.

CONCLUSION

In this research work, the Teak leaves were collected from the Banmaw University campus, Banmaw Township at Kachin State. Thermal activations of sample 1and sample 2 were prepared by heating process at 100˚C for 2 hr and at 200˚C for 2 hr. The elemental content of teak leave powder was determined by EDXRF analysis. Si was found to be the highest amount in this sample.

The effects of sorption parameters (concentration of dye solution, contact time and sorbent dose) of each sorbent upon the removal of specified coloured dye were investigated by spectroscopic method. For concentration parameter, the decreases in percent removal for methyl red and malachite green on sample 1 and sample 2 were observed with increases in concentration. For dosage method, the amounts of used adsorbents were 0.02 g, 0.04 g, 0.06 g, 0.08 g, 0.10g, 0.12g and 0.14 g respectively. It was found that the percent removal of methyl red and malachite green on sample 1 and sample 2 were increased with the increased in adsorbent dosage. For contact time method, the percent removal for methyl red and malachite green on sample 1 and sample 2 were steadily increased with increasing contact time. In addition the amount of percent removal for Sample 2 was greater than that of sample 1 for sorption parameters (concentration of dye solution, contact time and sorbent dose). Therefore it can be concluded that sample 2 was more effective for the removal of organic dye in waste water.

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