INVESTIGATION OF ADSORPTION PROPERTIES OF SAWDUST

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Abstract

The present research aims the preparation of sawdust samples to be used as the effective sorbents for the removal of organic dyes. The sawdust was collected from the local saw mill at Banmaw Township, Kachin State. Two types of sorbents sample 1 (100˚C at 1 hr) and sample 2 (200˚C at 1 hr) were prepared. Physicochemical properties of sample 1 and sample 2 (moisture, pH, bulk density and specific surface area) were determined by recommended methods. Sorption studies of two sorbents (sample 1 and sample 2) were carried out spectrophotometrically. Two model dyes, malachite green as basic dye and congo red as acid 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 coloured dye were investigated. Based on the effect of contact time, the kinetics of adsorption was studied by using pseudo first order and pseudo second order kinetic model.

Keywords : Sawdust, acid dye, basic dye, congo red, malachite green

Introduction

In wood industries, economical disposal of sawdust and shavings is a problem in growing. Enormous quantities of sawdust are produced annually by sawmills. Planning and machining of lumber and other manufacture from wood leads to further residues. A planer mill produces about 600 pounds of dry residue per thousand board feet. Thus, the total amount of air-dry wood fines originating in U.S. industries alone exceeds 15 million tons a year-enough to make a (triangular cross section) pile 50 feet high, 100 feet wide, and over150 miles long(Boley and Landers, 1969).

Application of Sawdust

There are many other applications of sawdust.Among many applications, some of these are:

Fuel

These are usually made by molding fine wood particles at high temperatures and pressures without a binder, relying upon plasticization of the wood to hold the particles together (Common wealth Forest Bureau, 1967).

Fiber and wood-base board

Other uses offering possibilities of increasingly large volume consumption are fiber uses, for example, in roofing felts, building fiberboards, and paper. Particleboard provides another market for sawdust and shavings.(Dobie and Parry, 1967).

Mushroom production

Through the production of edible fungi low value wood material (sawdust, small pieces of stems) can be transformed into high value food.(John, 1969).

Environmental protection

One possibility for using sawings and sawdust for environmental protection purposes is to mix it with materials which are to be composted, e.g. manure. In the composting of sewage sludge wooden particles serve as structural material. Its main function is to help adjust the water content of the rotting mixture to an optimal value and to increase the volume and stability of the pores (Miller, 1953).

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Materials and Methods

Preparation of sample 1

The sawdustsample was air-dried, finely powdered and sieved with 80-mesh size. An accurately weighed sawdust sample (about 20g) was put into a pre-dried and cooled dish with a cover. The uncovered dish was placed in an electric oven and heated for 1 hr at 100°C. After heating, the resultant sample was cooled at room temperature and stored in a sealed bottle. This sample was denoted as sample 1.

Preparation of sample 2

The sawdustsample was air-dried, finely powdered and seived with 80-mesh size. An accurately weighed sawdust sample (about 20g) was put into a pre-dried and cooled dish with a cover. The uncovered dish was placed in an electric oven and heated for 1 hr at 200°C. After heating, the resultant sample was cooled at room temperature and stored in a sealed bottle. This sample was denoted as sample 2.

Physicochemical Properties of Sawdust Samples

Determination of free moisture

Determination of pH

Determination of bulk density

Determination of specific surface area

Sorption Studies of sawdust sample for the Colour Removal of Dye Solutions

Effect of initial concentration
Effect of contact time
Effect of dosage

Results and Discussion

Table 1 Physicochemical Properties of Sawdust Samples

No.	Parameter	Sample 1	Sample 2
1	Moisture content (%)	10	9.5
2	pH	7.14	7.02
3	Bulk density (g/cm^3)	0.395	0.400
4	Surface area(m^2/g)	20.23	27.45

Sorption Studies of sawdust sample for the Colour Removal of Dye Solutions

Adsorption Kinetics

Based upon the contact time,kineticmodels have been proposed to explain the mechanism of a solute sorption from aqueoussolution onto an adsorbent:

- Pseudo first order kinetic model.
- Pseudo second order kinetic model.

Pseudo first-order linearequation

$$log(q_e - q_t) = log\ q_e - \left(\frac{k_1}{2.303}\right) t$$

Pseudo second-order linearequation

$$t/q_t = 1/(k_2 q_e^2) + t/q_e$$

The removal of malachite greenand congo red by sample 1 and sample 2 with initial concentration 40 mgL^{-1}solution upon sorbent dose 0.1g/10 mL at 1hr contact time.The calculated results are shown in following tables and figures.

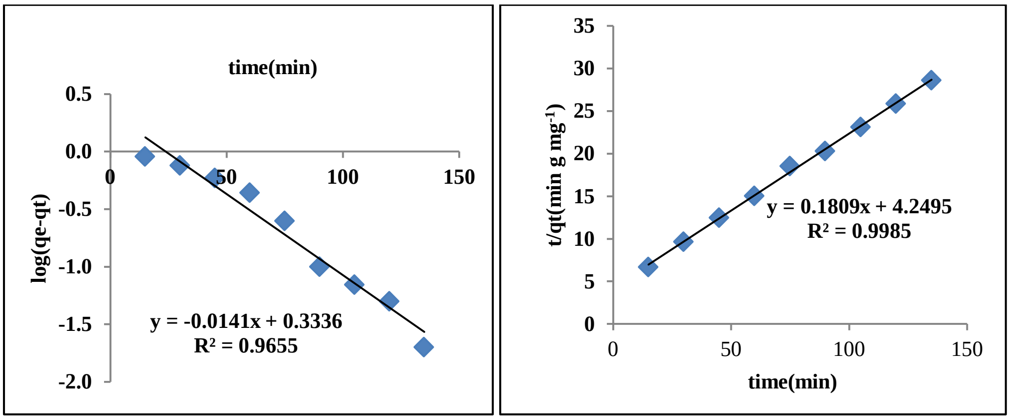
Table 2 Kinetic Study for Sorption of Malachite Green by Sample 1

Initial Concentration = 40 mgL^{-1}

Stirring rate = 150 rpm

Dose = 0.1g/10mL

Time (min)	Percent removal(%)	C_e (mgL^{-1})	q_t (mgg^{-1})	$log(q_e-q_t)$	t/q_t ($mingmg^{-1}$)
15	72.17	6.98	4.33	-0.041	3.464
30	74.58	6.32	4.48	-0.119	6.696
45	77.44	25.76	4.65	-0.229	9.677
60	80.01	25.06	4.8	-0.357	12.501
75	83.17	24.38	4.99	-0.602	15.03
90	85.74	23.68	5.14	-0.999	10.519
105	86.14	23.44	5.17	-1.155	20.309
120	86.54	23.26	5.19	-1.301	23.121
135	87.07	22.98	5.22	-1.699	25.862



(a) (b)

Figure 1 **(a)Pseudo first-order and (b)pseudo second-order kinetics plot for sorption of malachite green by sample 1**

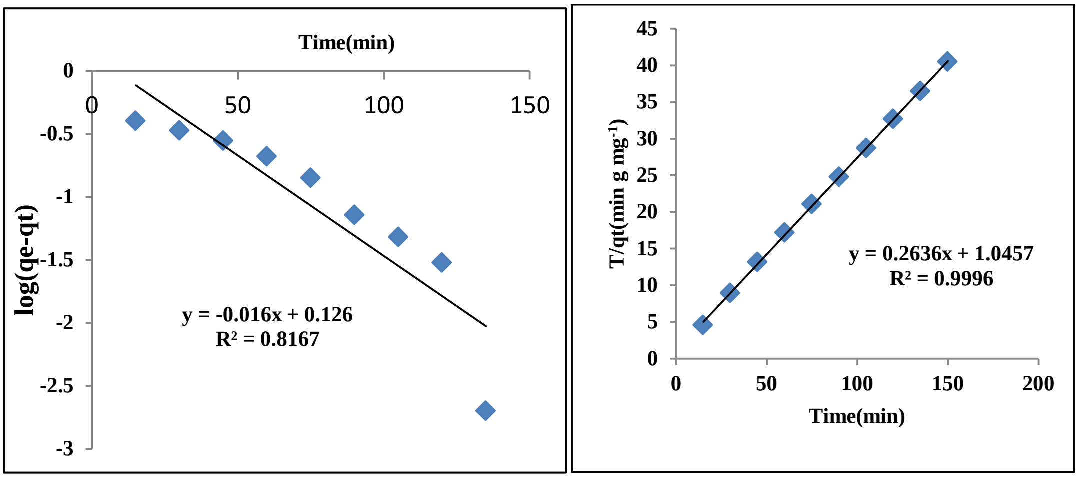
Table 3 Kinetic Study for Sorption of Congo Red by Sample 1

Initial Concentration = 40 mgL^{-1}

Stirring rate = 150 rpm

Dose = 0.1g/10mL

Time (min)	Percent Removal(%)	C_e (mgL^{-1})	q_t (mgg^{-1})	$\log(q_e\text{-}q_t)$	t/q_t ($mingmg^{-1}$)
15	55.03	26.98	3.302	-0.396	4.543
30	56.14	26.32	3.368	-0.474	8.907
45	57.06	25.76	3.424	-0.553	13.143
60	58.24	25.06	3.494	-0.678	17.172
75	59.36	24.38	3.562	-0.848	21.056
90	60.54	23.68	3.632	-1.143	24.78
105	60.94	23.44	3.656	-1.319	28.72
120	61.24	23.26	3.674	-1.523	32.662
135	61.49	22.98	3.702	-2.699	36.467



(a) (b)

Figure 2 **(a)Pseudo first-order and(b)pseudo second-order kinetics plot for sorption of congo red by sample 1**

Table 4 **Kinetic Study for Sorption of Malachite green by Sample 2**

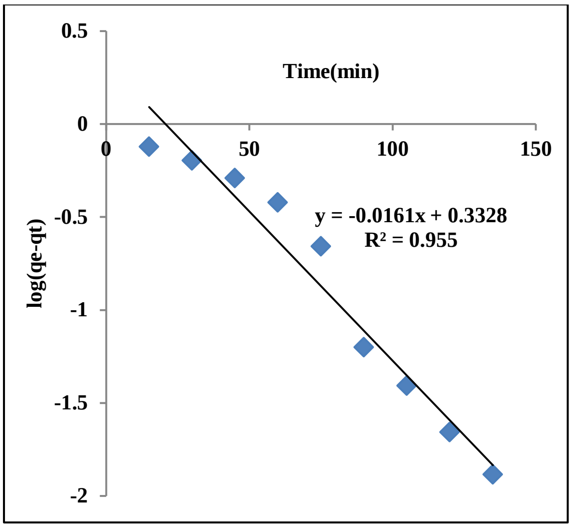
Initial Concentration = 40 mgL^{-1}

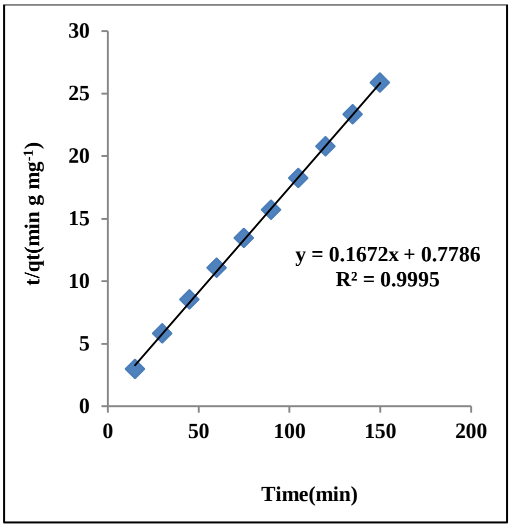
Stirring rate = 150 rpm

Dose = 0.1g/10mL

Time (min)	Percent removal(%)	C_e (mgL^{-1})	q_t (mgg^{-1})	$\log(q_e\text{-}q_t)$	t/q_t ($mingmg^{-1}$)
15	84.05	9.57	5.043	-0.122	2.974
30	86.01	8.39	5.161	-0.196	5.813
45	88.13	7.12	5.288	-0.292	8.509
60	90.33	5.8	5.42	-0.423	11.07

75	92.96	4.22	5.578	-0.658	13.446
90	95.59	2.65	5.735	-1.201	15.693
105	95.98	2.41	5.759	-1.409	18.232
120	96.27	2.24	5.776	-1.658	20.776
135	96.41	2.15	5.785	-1.886	23.336





(a) (b)

Figure 3 (a)Pseudo first-order and (b)pseudo second-order kinetics plot for sorption of malachite green by sample 2

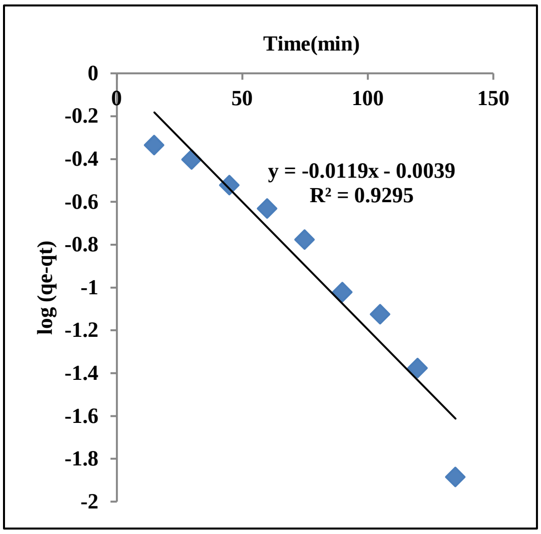
Table 5 Kinetic Study for Sorption of Congo red by Sample 2

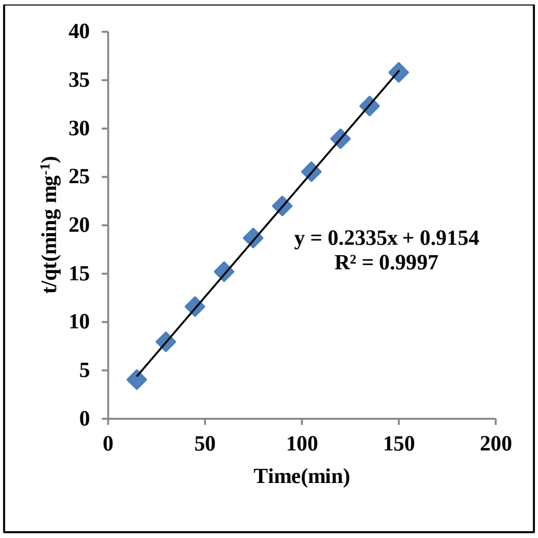
Initial Concentration = 40 mgL^{-1}

Stirring rate = 150 rpm

Dose = 0.1g/10mL

Time (min)	Percent removal(%)	C_e (mgL^{-1})	q_t (mgg^{-1})	$\log(q_e-q_t)$	t/q_t ($mingmg^{-1}$)
15	62.17	22.7	3.73	-0.335	4.021
30	63.27	22.04	3.796	-0.402	7.903
45	64.87	21.08	3.892	-0.523	11.562
60	65.97	20.42	3.958	-0.631	15.159
75	67.08	19.75	4.025	-0.777	18.634
90	68.29	19.03	4.097	-1.022	21.967
105	68.61	18.83	4.117	-1.125	25.504
120	69.17	18.5	4.15	-1.377	28.916
135	69.65	18.21	4.179	-1.886	32.304





(a) (b)

Figure 4 **(a)Pseudo first-order and (b)pseudo second-order kinetics plot for sorption of congo red by sample 2**

Table 6 **Parameters forKinetic Adsorption of malachite Green and Congo redon Sawdust Samples**

Sorbents	**Dyes**	**$q_{e,exp}$ (mg g^{-1})**	**Pseudo-first order**			**Pseudo-second order**		
			q_e (mgg^{-1})	**k_1 (min)**	**R^2**	**q_e (mg g^{-1})**	**k_2 (gmg min^{-1})**	**R^2**
Sample 1	Congo red	3.70	1.34	0.037	0.816	3.80	0.066	0.999
	Malachite green	5.24	3.15	0.032	0.965	5.55	0.007	0.998
Sample 2	Congo red	4.19	0.99	0.025	0.929	4.29	0.059	0.999
	Malachite green	5.79	2.15	0.037	0.955	5.99	0.036	0.999

Sample 1 = Sawdust (100◦C at 1 hr)

Sample 2 =Sawdust (200◦C at 1 hr)

CONCLUSION

In this research work, the sawdust was collected from the area of Banmaw Township at Kachin State. Sawdust sample 2, theeffective and low cost adsorbent for the removal of organic dye was investigated. Sawdust sample 1 was prepared by heating process of 100˚C at 1 hr and sample 2 was prepared by heating 200˚C at 1 hr.Physicochemical properties of sample 1 and sample 2 were also determined by conventional method such as moisture, pH, bulk density and specific surface area. 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. The maximum removal percent of congo red were found to be 60.54 % of sample 1 and 68.29 % of sample 2at 40 mgL^{-1} of initial dye concentration, 0.1 g/10 mL of dosageand 90 min of contact time. The maximum removal percent of malachite green by sample 1 and sample 2 were found to be 85.74 % and 95.59 % respectively under the same conditions. Then, the orders of reactions were determined by adsorption kinetics. Based upon the contact time,kineticmodels have been proposed to pseudo first order and pseudo second order model.. According to kinetic studies, the correlation factors (R^2 value) were found to be 0.999 and 0.998 in the pseudo second order model. In addition, it was found that the experimental value of q_e was nearly the same the calculated value from pseudo second order kinetics plot. Therefore the order of reactions of sawdust samples is pseudo second order reaction. Sawdust samples were effective for colour removal of dye solutions. Therefore, sawdust samples could be applied in purifying the environmentally colour polluted waste water.

Acknowledgements

We are greatly thanks to Dr Zaw Jat, Rector, Banmaw University, for their kind permission to do this research work. Deeply thanks to Dr Win Naing, Rector, Dagon University. I would like to express my sincere thanks to Professor and Head, Dr Myint Myint Sein , and Professor Dr Lwin Mu Aung, Department of Chemistry, Banmaw University for their kind advices and permitting to use research facilities in Department of Chemistry.

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