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Adsorption of Aqueous solution of NO_2 by Neem Bark Dust

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Abstract: The present study deals with the adsorption of aqueous solution of NO_2 by neem bark dust. The adsorption experiments were conducted with respect to contact time, neem bark dust dosages, concentration and temperature. It was found that percentage removal increased with increase in contact time and with increase in adsorbent dosage. It follows first order kinetics. The amount of NO_2 gas adsorbed is more at lower concentration than at higher concentrations.

Keywords: Aqueous solution of NO_2 ,Neem Bark Dust, Adsorption.

Introduction

NOx is a generic term for the mono-nitrogen oxides NO and NO_2 (nitric oxide and nitrogen dioxide). They are produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures. In areas of high motor vehicle traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere as air pollution can be significant. NOx gasses are formed everywhere where there is combustion – like in an engine. NOx react to form smog and acid rain. NOx are also central to the formation of tropospheric ozone. Oxides of nitrogen react with volatile organic compounds (VOCs) in the presence of sunlight to form ozone. Ozone is a reactive and corrosive gas that contributes to many respiratory problems. NOx emissions themselves can damage respiratory systems and lower resistance to respiratory infection (2, 4, 6,10).

Neem bark dust is a waste material collected from the Timber industry. Neem bark dust is a bio adsorbent and it consists of lignin and cellulose and many hydroxyl groups such as lumins or phenolic compounds. The composition of Neem bark dust is given by Cellulose – 36.5% and Lignin – 49.5%. The ligno-cellulosic components present in the Neem bark dust are responsible for complete adsorption observed in the present study. Neem bark dust is a cheap material and the adsorption capacity of the Neem bark dust is high compared to other adsorbents, hence, it can be used as an effective adsorbent for removal of NO_2. (1, 3, 5, 7, 8,9)

Methods And Materials

Selection of Adsorbent

The present work, examines the possibility of using a well-known physicochemical method like adsorption for the removal of NO2 from air. The initial screening studies have been carried by introducing a known amount of adsorbent into the aqueous solution of NO2. It was found that neem bark dust has large capacity to adsorb NO2. For the present studies adsorption techniques are selected because NO2 gas is incombustible and it is present in very low concentrations. The experiments are carried with respect to to contact time, with respect to initial concentration of NO2 and with respect to neem bark dust dosages.

Effect of Contact Time

Contact time plays an important role in designing a system. The initial (before adsorption) and final (after adsorption) concentration is determined at regular intervals of time i.e. 5, 10,15,30,45 and 60 minutes. The results are given in TABLE 1 and FIG 1.

Effect of Initial NO2 Concentration

Different concentrations of NO2 were studied, which consists of a fixed amount of adsorbent. The experiments are carried out with constant contact time and the contact time is fixed depending upon contact time experiments. The results are given in TABLE 2 and FIG 2.

Effect of neem bark dust Dosages

Definite concentration of NO2 is studied with different amounts of adsorbent dosages i.e. 0.2 gms, 0.4gms, 0.6gms, 0.8gms respectively. The experiments are carried out with constant contact time of 45 minutes.

From the table 1, it is evident that the %removal increases with increase in contact time. The optimum time for the removal of NO_2 is 45 minutes. The percentage removal of NO_2 increases with the increase in contact time and it follows a smooth curve which indicates that the process is of first order (11).

Results And Discussions

Table 1: Variation Of Contact Time Between Neem Bark Dust And No2

Amount of Adsorbent: 1gm
Volume: 100ml
Concentration: 40 ppm

S.NO	Contact time (min)	Initial concentration(ppm)	Final concentration(ppm)	Gas adsorbed	%Removal
1.	0	40	40	-	-
2.	5	40	40	-	-
3.	10	40	35	5	12.5
4.	15	40	27	13	32.5
5.	30	40	25	15	37.5
6.	45	40	3	37	92.5
7.	60	40	3	37	92.5

Fig 1: Effect Of Contact Time Between Neem Bark Dust And No2

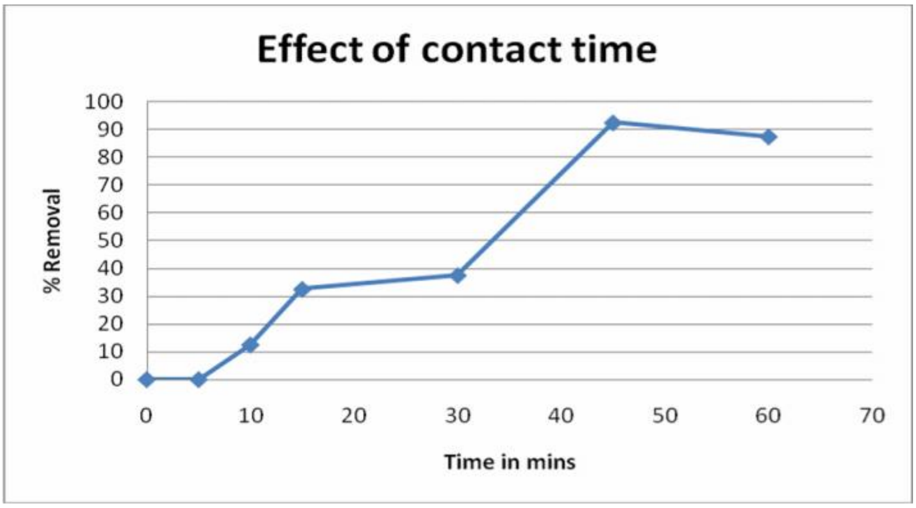
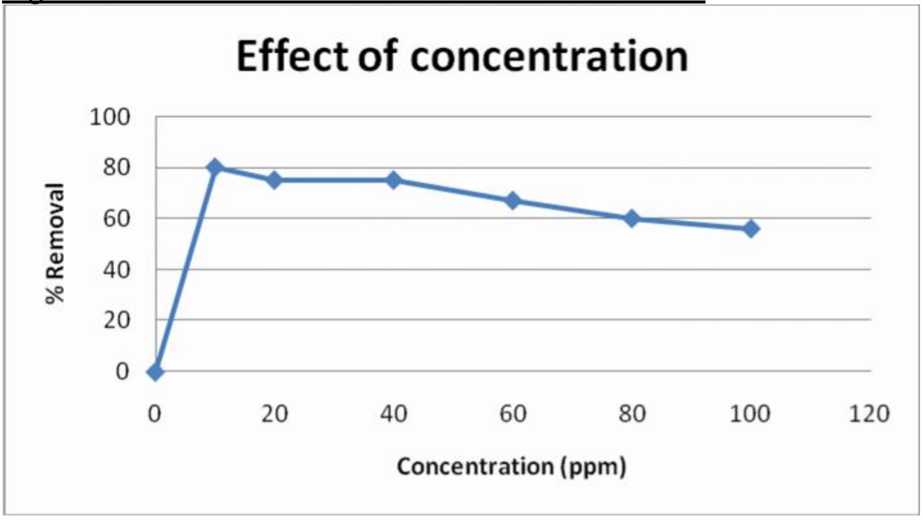


Table 2: Variation Of No2 Concentration On Neem Bark Dust
Amount of adsorbent: 1 gm
Volume: 100 ml
Contact time: 45 mins

S.NO	Initial Conc. (ppm)	Final Conc. (ppm)	Amount Adsorbed	% Removal
1	10	2	8	80
2	20	5	15	75
3	40	10	30	75
4	60	20	40	67
5	80	32	48	60
6	100	42	56	56

Fig 2: Effect Of No2 Concentration On Neem Bark Dust



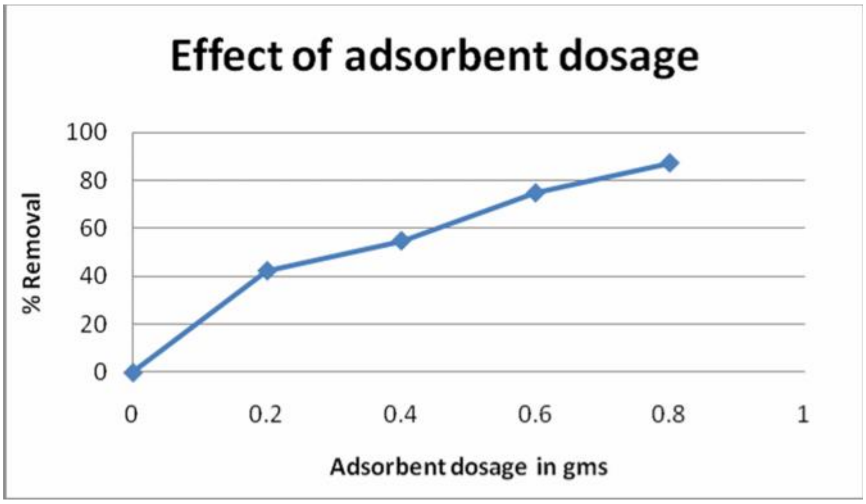
From the table 2, it is clear that the % removal decreases with increase in concentration. The number of gas molecules will be low at low concentrations and at the higher concentrations the number of gas molecules is more and so adsorption is less (11).

Table 3: Variation Of Adsorbent Dosage
Concentration: 40 ppm
Volume: 100 ml
Contact time: 45 mins

S.NO	Amount of neem bark dust introduced (gms)	Initial Conc. (ppm)	Final Conc. (ppm)	Absolute Amount of aqs. NO_2	% Removal
1	0.2	40	23	17	42.5
2	0.4	40	18	22	55
3	0.6	40	10	30	75
4	0.8	40	5	35	87.5
5	1	40	5	35	87.5

From the table, it is clear that the % removal increases with increase in adsorbent dosage. Greater the number of adsorbent sites, greater is the percentage of adsorption (11).

Fig 3: Effect Of Adsorbent Dosage



Effect of temperature

Initial concentration (10 ppm)

S.No	Temperature (^{O} C)	Initial conc. (Ce) (ppm)	Final conc. (ppm)	x/m	Log x/m	Qe/Ce	Log (x/m / Ce)	Log c
01	<0	10	6	4	0.602	0.40	-0.39	1
02	2-8	10	3.5	6.5	0.812	0.65	-0.18	1
03	RT	10	1.5	8.5	0.929	0.85	-0.07	1
04	40	10	1.2	8.8	0.944	0.88	-0.05	1
05	50	10	1.5	8.5	0.929	0.85	-0.07	1
06	60	10	0.5	9.5	0.977	0.95	-0.02	1
07	80	10	0.5	9.5	0.977	0.95	-0.02	1

Initial concentration (50 ppm)

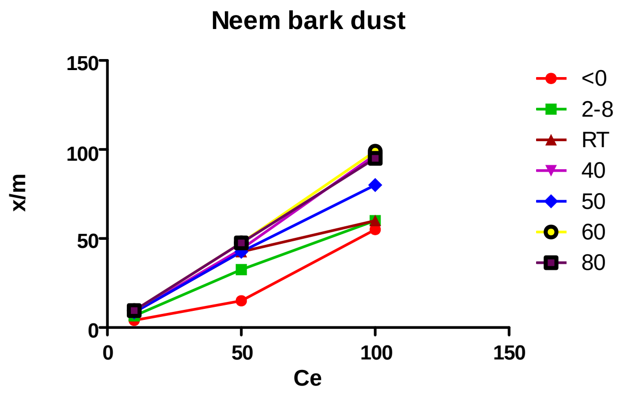
S.No	Temperature (^{O} C)	Initial conc. (Ce)(ppm)	Final conc. (ppm)	x/m	Log x/m	Qe/Ce	Log (x/m / Ce)	Log c
01	<0	50	35	15	1.176	0.30	-0.52	1.698
02	2-8	50	17.5	32.5	1.511	0.65	-0.18	1.698
03	RT	50	7.5	42.5	1.628	0.85	-0.07	1.698
04	40	50	6	44	1.643	0.88	-0.05	1.698
05	50	50	7.5	42.5	1.628	0.85	-0.07	1.698
06	60	50	2.5	47.5	1.676	0.95	-0.02	1.698
07	80	50	2.5	47.5	1.676	0.95	-0.02	1.698

Initial concentration (100 ppm)

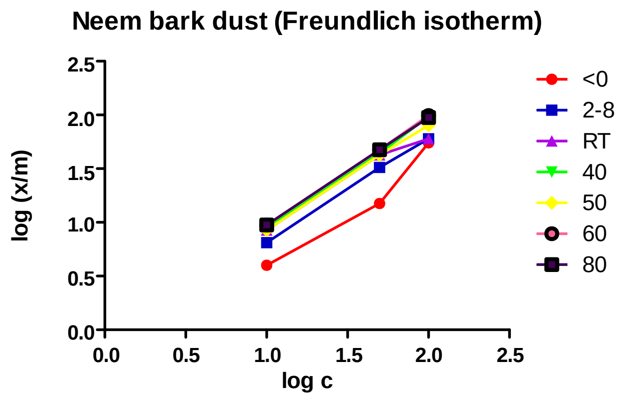
S.No	Temperature (^{O} C)	Initial conc. (Ce) (ppm)	Final conc. (ppm)	x/m	Log x/m	Qe/Ce	Log (x/m / Ce)	Log c
01	<0	100	45	55	1.740	0.55	-0.25	2
02	2-8	100	40	60	1.778	0.60	-0.22	2
03	RT	100	40	60	1.778	0.60	-0.22	2
04	40	100	3	97	1.986	0.97	-0.01	2
05	50	100	20	80	1.903	0.80	-0.09	2
06	60	100	1	99	1.995	0.99	-0.004	2
07	80	100	5	95	1.977	0.95	-0.02	2

Slope and Intercept

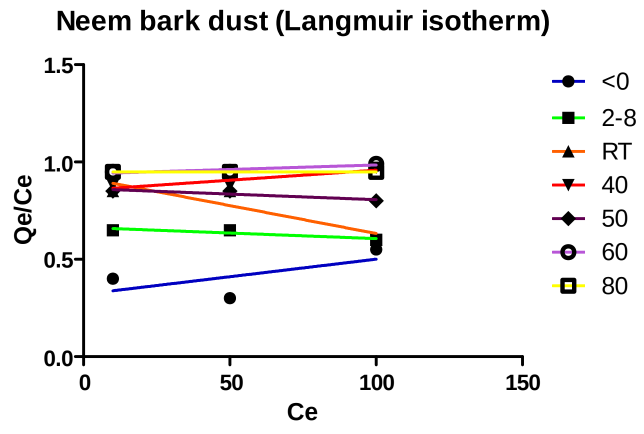
	<0	2-8	RT	40	50	60	80
Slope (Freundlich)	0.7	1	1	1	1	1	1
Intercept (Freundlich)	-0.1	0	0	0	0	0	0
Slope (Langmuir)	0.006	-0.0001	-0.006	0.006	0	0	0
Intercept (Langmuir)	0.25	0.6	0.85	0.85	0.85	0.95	0.95



Relationship between x/m and Ce



Freundlich isotherm



Langmuir isotherm

The amount of the gas adsorbed by the given amount of adsorbent depends on the temperature as well as pressure and concentration of the gas. To explain the effect of temperature on adsorption the Freundlich adsorption isotherms are plotted. The freundlich adsorption isotherms are given by

$x/m = K\ c^{1/n}$

$\log x/m = \log K + 1/n \log c$

The intercept gives the value of log K and the slope is equal to 1/n. From the intercept and slope values , it is observed that the value of 1/n increases initially and then decreases. This indicates that the lower temperatures are favourable. At the higher temperature there is no change in slope and intercept values. The adsorption capacity decreases with increase in temperature. The process is exothermic in nature. Initial rise in the temperature is favourable for activation but once it is activated, higher temperature does not favour the adsorption process.

The equilibrium data for the removal of NO_2 by different adsorbents at all temperatures were fitted in the rearranged Langmuir isotherm.

$Ce/qe = 1/q_0 b + Ce/q_0$

Where Ce is the equilibrium concentration and qe is the amount adsorbed at equilibrium. q_0 and b are related to adsorption capacity and equilibrium constants respectively. The linear plots indicate that monolayer coverage of adsorbate at the outer surface of the sorbent. The parameters q0 and b have been calculated from the slope and intercept of the plots. From the plots for various adsorbents, it is evident that the adsorption capacity and intensity of adsorption are enhanced upto certain optimum temperature. The chemical reactivity between NO_2 and adsorbent is not observed instead the porosity of adsorbents are the reason for adsorption. As the porosity does not change with temperature, intensity and capacity of the adsorption will not increase with temperature and it is almost a constant indicating the physical adsorption.

Conclusions

Neem bark dust has a capacity to adsorb NO_2. The percentage removal of NO_2 molecules increased with the decrease in concentration, with the increase in adsorbent dosages and with the increase in contact time. This study provides an economic solution for cleaning up environmental pollutant NOx and it is recommended to use this adsorbent in industries.

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