# Environment Friendly and Low-Cost Method for Removal of $NO_2$ from Aqueous Media using Paper Pulp

**S. R. Arthisree[1], G. Sowmyadevi[2], M. Sujatha[2], D. Sirisha[1]**
[1]Department of Biotechnology, PSG College of Technology, Coimbatore, TN, India.
[2]St.Anns College for Women, Mehdipatnam, Hyderabad, Telangana, 500028 India.
Corresponding author: sujatha.stanns09@gmail.com. Ph# 9866049923

## *Abstract:*

*An efficient and economic method to remove $NO_2$ from aqueous media using paper pulp has been developed. In this context, work has been carried out on analysis of $NO_2$ in laboratory and developing a control technology for its removal using news paper pulp as an adsorbent. Newspapers were collected from the scrap stalls and were used as an adsorbent. The tests are performed in terms of contact time, concentration, adsorbent dosage and temperature. FTIR spectral studies were carried out before and after adsorption of $NO_2$ aqueous solution on the paper pulp. Results revealed that $NO_2$ molecules are completely adsorbed. The developed method can also be implemented to remove $NO_2$ from air pollution.*

***Keywords:*** *Economic, Paper pulp, Adsorption, Contact time, Dosage, Aqueous solution, FTIR studies, Concentration, Air pollution*

## Introduction

Air pollution is a major concern in India. It can damage ecosystems, threaten human health, and reduce well-being. The earth's climate system is affected by air pollution. Large-scale industrialisation and urbanisation leads to the significant increase in the number of industries, vehicles and traffic flow [1]. Air pollution causes eye irritation, lung cancer, asthma, bronchitis etc. Epidemiological studies have shown that there is an important relationship between air pollution and negative health effects.

The $NO_x$ represent a family of seven compounds of nitrous oxides. Regulations are passed for $NO_x$ from all the seven compounds as it generated by androgenic activities. $NO_2$ is pollutant itself and it initiates the reactions to from ozone and acid rain [1, 2]. The Nitrogen oxides are precursors for photochemical smog, acid rain and ozone accumulation. The oxides of Nitrogen–$NO_x$, are highly corrosive and hazardous to health. Due to the environmental concerns caused by air pollution, extensive research is being done to control NOX pollution. Global weather patterns will shift and the Nitrogen dioxides trap heat in upper atmosphere due to its positive effects. It is becoming difficult to calculate nitrogen effects in climate models.

$NO_2$ abatement and control technology is relatively complex issue. This complex issue and situation has to be solved at global, national and at international levels by adapting to a

natural solution which will not bring any change in the environment [3]. Taking that unpleasant situation into the hands of the environmentalist a solution has to be framed. Various processes are investigated and proposed for controlling $SO_x$ and $NO_x$. Among these adsorption process is simple, cost effective and highly reliable process. In this context work has been carried out on analysis of $NO_2$ in laboratory by developing a control technology using paper pulp as an adsorbent [4].

## Methods and Materials

### Selection of Adsorbent:

Paper is actually a network of cellulose fibres held together by hydrogen bonds (Fig.1). Cellulose is a polymer and there is variation in the nature and number of cellulose units depending upon the type of cellulose present in the paper (Fig.2). SEM images of different papers showed the fibrous nature of celluloses [5, 6].

**Table- 1: Chemical composition of news paper pulp**

| | Cellulose | Hemi cellulose | Lignin | minerals |
|---|---|---|---|---|
| Newspaper | 32% | 21% | 26% | 21% |

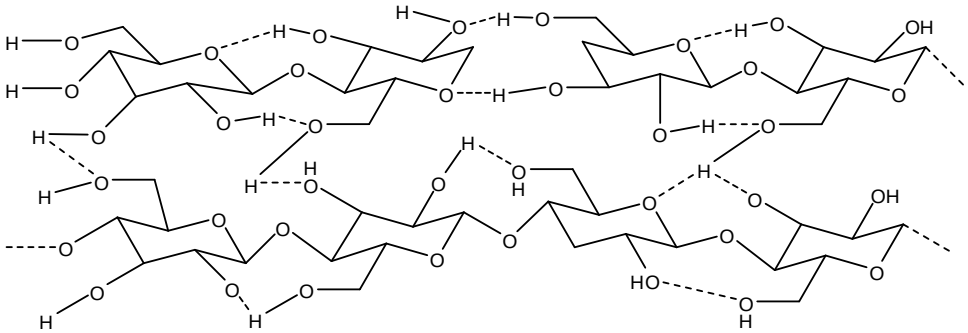

**Fig.1: Network of cellulose fibres held together by hydrogen bonds**

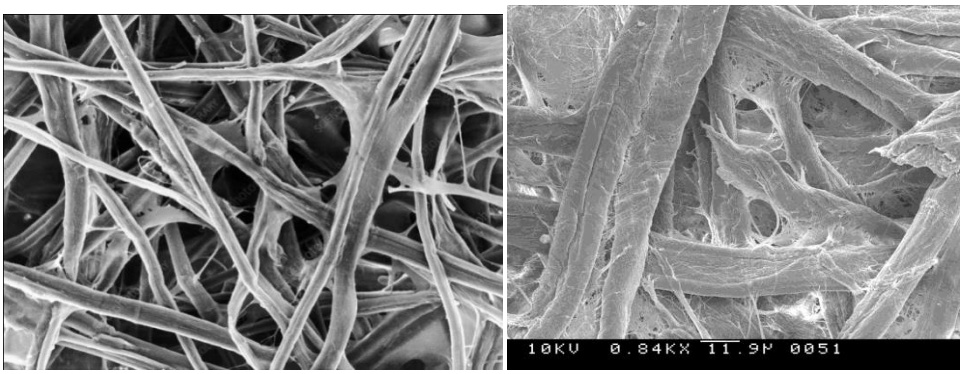


**Fig.2: SEM images of different papers showing the fibrous nature of cellulose**

Cellulose and other carbon-containing compounds present in paper pulp act as an excellent adsorbent to remove pollutants from aqueous solution Considering all of these things is rational and can be used as an adsorbent to remove $NO_2$.

### Experimental procedure:

Newspapers, waste material are collected from the scrap stalls and were used as adsorbent. These newspapers are washed with millipore water to remove grease other dust particles and

were made into the paste using mortar and pestle. The paste was dried for 15 days until they become crisp. Then this dried paste was grinded to powder by mortar and pestle and they were packed in air tight container for further use.

An aqueous solution of 100ml of $NO_2$ of various concentrations (ranging 26µg/$m^3$ – 260µg/$m^3$) is taken in 100ml Stoppard bottle and 1gram of adsorbent is added to the solution. Batch adsorption experiments are carried out at room temperatures. Optimum contact time is maintained. The UV spectrophotometer is used to determine the initial and final concentrations. NEDA reagent is used as absorbing media for analysis of $NO_x$. The experiments on the adsorption of aqueous $NO_2$ solution were studied in terms of contact time, concentration, rate and temperature [10, 11].

**Communication time result**

Adsorption tests are performed at room temperature (+ 25˚C). The contact time effect was studied for the initial concentration of 104ug / $m^3$ of $NaNO_2$ solution and the adsorbent size of 1 gram. The final filtering of $NO_2$ solution was determined at various intervals i.e. 0, 15, 20, 30, 45, 60 minutes [7 - 12].

**Effect of concentration**

The experiments were performed by varying the concentration of $NO_2$ between 26µg/$m^3$ – 260µg/$m^3$. 60minutes of contact time was maintained and 1gm of adsorbent was added [13-15].

**Effect of dosages**

The amount of adsorbent dosage will affect the adsorption capacity. Taking that factor into consideration, in the present study different amounts of adsorbents ranging from 0.1 gm - 1gm were added [16-19]. The Final concentration of the $NaNO_2$ solution is determined. The removal capacity will give direction to determine the optimum dosage.

## Results and Discussions

**Effect of contact time**

A fixed concentration 104µg/$m^3$of aqueous $NO_2$ solution is made to pass through the catalytic tube at a constant temperature and filled with 1gm of adsorbent with a surface area of 10.99sq.cms. The experiment was performed with different contact time and variation in the concentration was determined by NEDA method. The results were given in Fig.3. The volume of $NO_2$ emissions by paper pulp has been found to increase with increasing contact time. Uptake of $NO_2$ molecules by paper pulp occurs rapidly at initial stages and gets elapsed till it reaches to equilibrium. This behaviour can be attributed to the diminishing active sites of paper pulp. The optimal contact time is 45 min beyond when the removal efficiency is unsatisfactory [18, 19]. Fig.5 shows a smooth curve with no kinks showing the monolayer coating of the adsorbent.

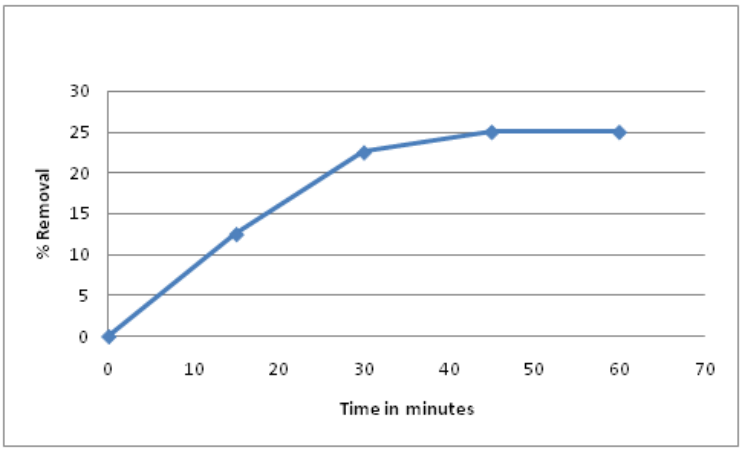


**Fig.3: Variation of Contact Time between Paper Pulp and Aq. Solution of $NO_2$**

**Effect of $NO_2$ concentration**

The experiments were performed by varying concentration of $NaNO_2$ solution at room temperature with 1gm of adsorbent. The results were given in Fig.4. Adsorption of $NO_2$ by paper pulp decreases with the increase in concentration which is observed in the Fig.4. At lower concentration the percentage removal of $NO_2$ is very high because the ratio of initial concentration of $NO_2$ to the available surface area is low and so the percentage removal is high [21-23]. At higher concentrations the availability of active sites is less so adsorption becomes less.

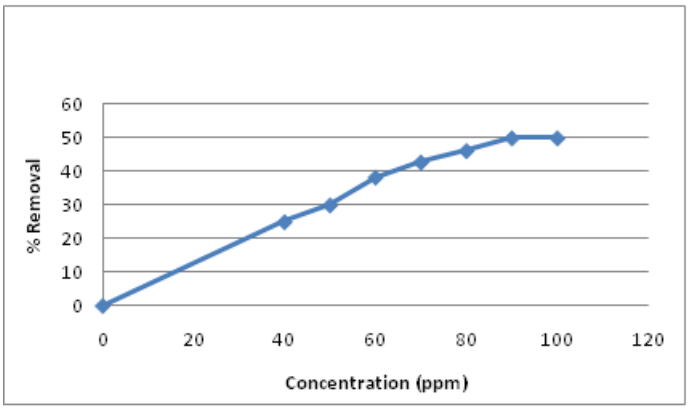


**Fig.4: Effect of initial concentration of $NO_2$ on Adsorption**

**Effect of adsorbent dosage**

$NaNO_2$ aqueous solution is passed through the various amounts of adsorbent in order to infer the dosage. A fixed concentration (40ppm) of $NaNO_2$ and contact time (45 min) was maintained at room temperature. The results were given in the Fig.5. From the figure it reflects that $NO_2$ removal increases with the increasing the amount of paper pulp due to the availability of more active sites on surface area. Beyond 6gms removal efficiency is not striking. Very slight change or no removal of $NO_2$ beyond an optimal dose may be attributed to the achievement of equilibrium between paper pulp and $NO_2$ at the operating conditions [22, 23].

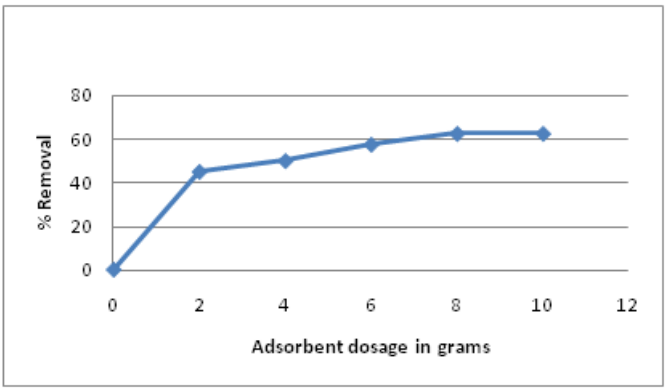


**Fig.5: Variation of paper pulp dosages**

**FTIR Analysis**

FTIR spectral studies were carried out, Figure-6, 7 represents before and after adsorption of $NO_2$ on the paper pulp. The results reveals that the prominent peaks at 2 regions after adsorption are the characteristics of –OH groups and C=O groups which proves that $NO_2$ molecules are completely adsorbed. The FTIR spectra of $NaNO_2$ showed strong peaks at 1250 $cm^{-1}$ and at 2150 $cm^{-1}$ and medium peaks at1400 $cm^{-1}$ and 1325 $cm^{-1}$.which represents Nitrate and Sodium groups Fig.6. These peaks were not observed after adsorption (Fig:7).

The mechanism of Adsorption is suggested as adsorption of $NO_2$ by paper pulp may be due to ion-dipole interactions chemical and structure of surface of paper pulp. Lignin, Cellulose, hemicelluloses functional groups are binding to those materials

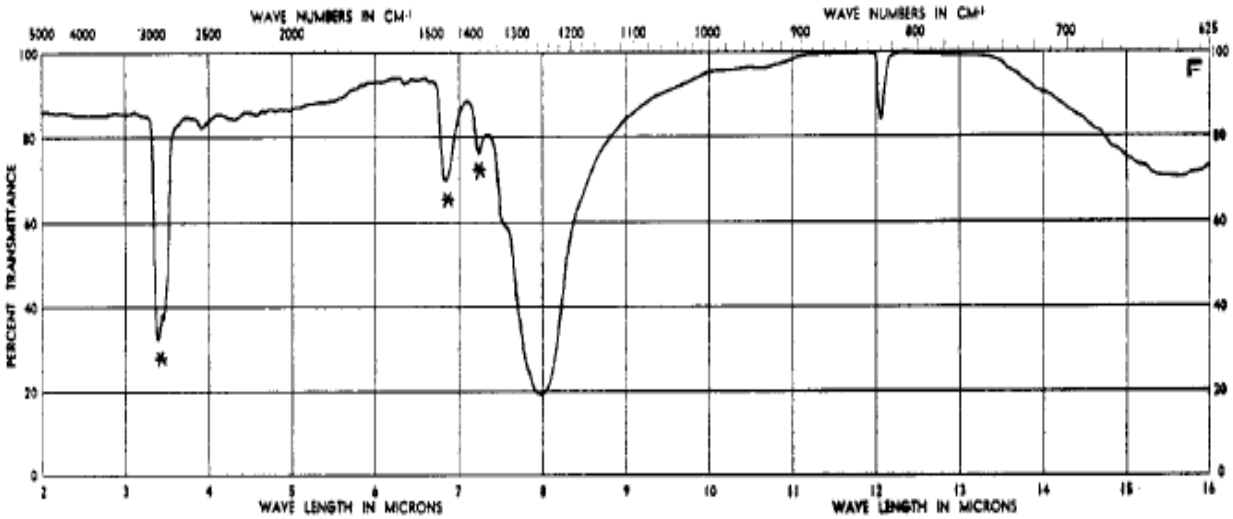


**Fig.6: FTIR spectra of $NaNO_2$ before Adsorption**

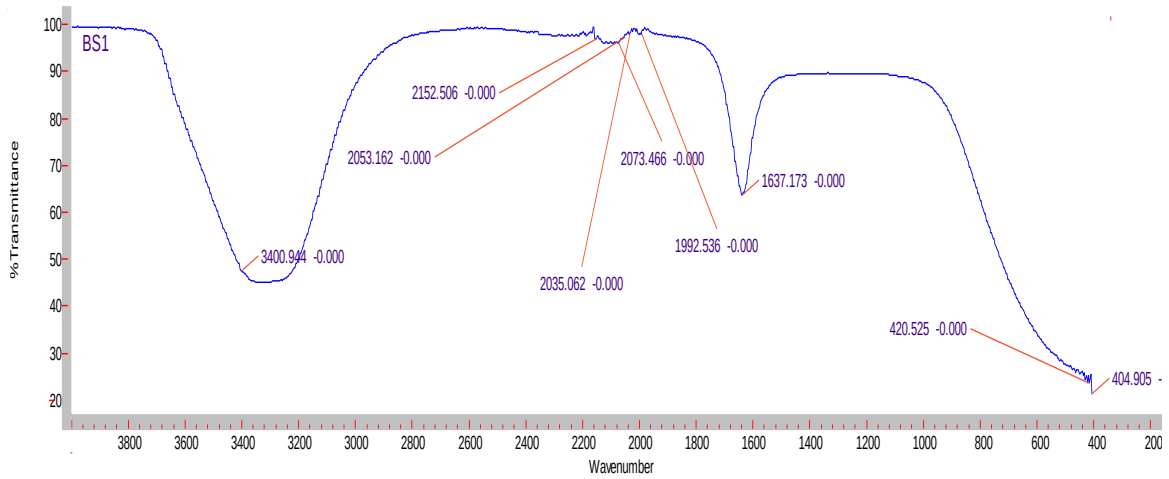


**Fig.7: FTIR spectra of $NaNO_2$ after Adsorption treatment**

**Adsorption Isotherm studies**

Studies of equilibrium on adsorption reveal the information about the capacity of the adsorbent. An adsorption isotherm is characterized by certain constant values which express the surface properties and affinity of the adsorbent and also be used to compare the adsorptive capacities of the adsorbent for different adsorbate equilibrium data can be analyzed using commonly known adsorption systems. Several mathematical models can be used to describe experimental data of adsorption isotherm. The Freundlich and Langmuir models were employed for the analysis of adsorption took place in the adsorption [19-23].

**Freundlich Adsorption isotherm**

In the Freundlich adsorption isotherm intercept (the reciprocal of slope (n)) represents the adsorption intensity and capacity the results were shown in the figure 8 The intercepts are decreasing with increase in temperature, adsorption capacity is decreasing up to certain temperature indicating lower temperature is favourable for adsorption and is becoming constant from 40-60°C indicating further increase in temperature will not influence adsorption capacity. It is slightly enhanced at higher temperature which will not influence adsorption capacity.

The adsorption intensity is also decreasing with increasing in temperature indicating lower temperature is favourable for adsorption process.

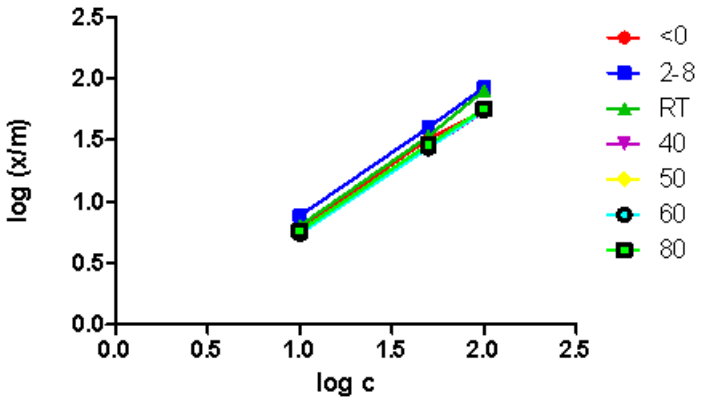


**Fig.8: Freundlich Adsorption isotherm**

**Langmuir adsorption Isotherm:** According to Langmuir adsorption isotherm the Qe/Ce versus Qe should give a linear relation (20-25). The present experiment was plotted with the same graph and shown in the fig.9. From the figure it was observed that the adsorption capacity is increasing with temperature initially as the temperature in increasing there is a deviation in the linear relation. From the figure it is concluded that adsorptive removal of $NaNO_2$ by paper pulp at 0°C, 2-8°C temp can also described by Langmuir adsorption Isotherm.

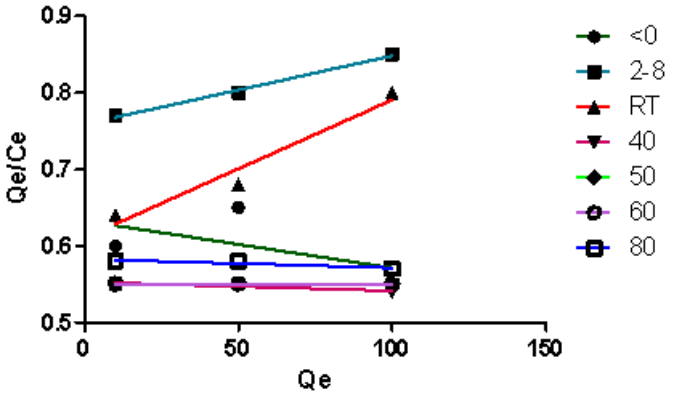


**Fig.9: Langmuir adsorption Isotherm**

## Conclusions:

- The extent of $NO_2$ removal by the paper pulp was found to increase with the increase in contact time. The optimal contact time is 45 min beyond which the removal efficiency is not appreciable.
- The percentage removal of aqueous solution of $NO_2$ increased with increase in concentrations, the maximum percentage removal of $NO_2$ is observed at the higher concentrations compared to lower concentrations.
- The transport of $NO_2$ increases with increase in paper pulp dosage (2, 4, 6, 8 and 10 grams). Percentage removal was found to increase rapidly at the beginning which declined as paper pulp dosage is increased. Optimum dosage was 25 minutes and 6gms respectively.
- The usage of waste plant materials is a vital development in sustainable environment technology. The quality of air /water can be improvised for underdeveloped countries as plant material is widely accepted and is more receptive by the environmentalists as it solves the problem of solid waste.
- Our research promotes low cost-ecofriendly technology and further work can be extended to column studies and controlling air pollution caused by $NO_x$.

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