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Removal of SO_2 from Aqueous Solutions Using Chemically Altered Okra as a novel adsorbent: A Comprehensive Study

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ABSTRACT

The current work uses batch testing to study the feasibility of removing SO_2 from aqueous solutions employing okra (Abelmoschus esculentus) powder treated with HCl . The contact duration between the SO_2 solution and the adsorbent powder, the concentration of the SO_2 solution, the dosage of okra powder, and the temperature conditions were all employed to evaluate the increased adsorbent's efficacy. Contact time, adsorbent dosage, and concentration are best at 60 minutes, 1 gm, and 40 ppm, respectively. FTIR spectroscopy was utilized to examine the removal of SO_2 from aqueous solution using HCl-treated okra powder.

Keywords: *Feasibility; modified; adsorption; batch studies; concentration; efficiency; FTIR*

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INTRODUCTION

Air pollution has become a challenge to India's ability to sustain its economic growth due to the country's rapid economic expansion and ongoing rise in the use of fuels like gasoline, oil, and diesel. India is one of the nations with the highest levels of pollution and the largest population affected with diseases caused by pollution. Health expenditure, economic loss, and disease burden are common problems observed in India. The common man also has to play a vital role in controlling air pollution.[1]

The WHO has started promoting awareness programmes on the health impacts of air pollution, mitigation policies, awareness programmes, and close monitoring of air pollution have been started in the different parts of the world. In India, CPCB has specified CO, SO_2, and NO_2 as criteria pollutants. Air pollution makes the environment unfit for living organisms to breathe. Technology has assisted in the development of novel sensors that are accurate, sensitive, portable, small, and economically viable. These sensors are being used to monitor indoor and outdoor air quality.

The most cost-effective approach of reducing air pollution is adsorption technology employing inexpensive or waste materials. The current study emphasizes this method of reducing so_2 by using okra powder as adsorbent.

MATERIAL AND METHODS

Material and Methods HCl modified okra powder, Sodium metabisulphite solution.

EXPERIMENTAL TECHNIQUE ON OKRA POWDER AS ADSORBENT:

The okra vegetable is popular in India. It is a common element in the cuisine of the Telugu-speaking states of Andhra Pradesh and Telangana. Okra belongs to the Malvaceae family. Fruit in its raw state includes only a small amount of fat, 2% protein, and 90% water. [2,3]

PREPARATION OF OKRA FOR ADSORPTION:

From the Gudimalkapur vegetable market, okras (*Abelmoschus esculentus*) were procured. The okras were air dried, sun dried, and grinded with a home grinder in order to assess their efficacy in eliminating SO_2 from aqueous solutions. After being chemically altered with 0.1 N HCl and subsequently dried, it is put in dry bottles for further investigation. [4-8]

PREPARATION OF AQUEOUS SOLUTION OF SO_2 AS ADSORBATE:

A 1000 ppm sodium meta sulphate stock solution is made and kept in the refrigerator. In order to estimate the percentage removal from the stock solution standard solution, a UV spectrometer was used to analyze variations in concentration.

ADSORPTION STUDIES:

Samples were added to a 250 ml glass container comprising 100 ml of a 40ppm aqueous solution of SO_2 and 1 gram of okra powder. The bottles and glass containers were shaken and filtered. According to contact time, concentration, and okra powder amount, the investigative study is conducted, utilizing a UV spectrophotometer. The initial powder's FTIR and the residue's FTIR were both determined. All necessary factors were taken into consideration, and the standard graph was prepared using the west-gaeke technique of estimate.[9-13]

effective HCl-modified okra powder is at removing SO_2 from aqueous solutions.

$$\%\text{efficiency} = \frac{(SO_2)i - (SO_2)f}{(SO_2)i} \times 100$$

Where $(SO_2)f$ = post adsorption concentration

$(SO_2)i$ = pre adsorption concentration

RESULTS AND DISCUSSION

EFFECT OF CONTACT TIME:

In a 250 ml glass container, 100ml solution of 40 ppm concentration, and 1 gm of powdered okra were added contact time was shown in a graph as a function of the removal efficiency of SO_2 by HCl modification. It was discovered that while SO_2% removal was initially slow after modification, it gradually increased from 2.5 to 99%, indicating that adsorption time was 1 hour. Results are explained using fig 1.

EFFECT OF CONCENTRATION:

The HCl-modified okra powder was used in adsorption trials at several starting concentrations of 20, 40, 60, 80, and 100 ppm. The range of percent removal was 80, 99, 78.3, 66.2, and 70%, with 40 ppm serving as the optimal concentration for 99% removal. Outcomes are explained using fig 2.

EFFECT OF DOSAGE:

Fig 4 illustrates the dose of HCl-modified okra powder and demonstrates a range between 0.1 gm and 2.0 gm. One gm was enough to trigger a reaction after an infusion period of one hour was seen for 40 ppm. At first, the percentage elimination accelerated quickly before slowing down. . Outcomes are explained using fig 3.

FTIR ANALYSIS OF HCl TREATED OKRA POWDER BEFORE & AFTER ADSORPTION:

Using a Shimadzu Fourier transform infrared spectrophotometer , information about the structure and functional groups of HCl-treated okra powder was obtained before and after adsorption. It is represented from fig 4 and 5.

CHARACTERISATION OF FUNCTIONAL GROUPS OF HCl MODIFIED OKRA:

The band between 3724 and 3824 cm^{-1} may be caused by an increase in the intensity of the Carboxyl OH group or by the stretching of adsorbed water molecules, according to the FTIR technique, which can be used to determine the activity of surface functional groups on biologically and chemically active HCl treated fruit powder. Similar measurements of 2936.80 to 2928.31 cm^{-1} show a slight variation, smoothed peaks of 2876.83 to 2761.02 cm^{-1}, and variations of 2366.36 to 2367.81 cm^{-1} before and after adsorption, respectively. Additionally, measurements of 2319.20 cm^{-1}, 2273.44 cm^{-1}, 2087.56 cm^{-1}, 1917.41 cm^{-1}, 1837 cm^{-1}, and 1825.90 cm^{-1} before adsorption were not made. Peaks 1752.98 to 1751.31 cm^{-1} before and after adsorption show that there is no change from 1400 to 1600 cm^{-1} and that some peaks have been diminished and not noticed due to changes in the c-o and co-functional groups.

There is an increase in intensity between 1314.19 and 1321.17 cm^{-1}, 1296.88 and 1249.88 cm^{-1}, and vibrations are not observed between 1245.39 and 1151.02 cm^{-1} or between 1080.96 cm^{-1} and 1065.23 cm^{-1}. Other similar observations include 710.63 to 639.14 cm^{-1}, which was not observed, and 497.58 to 500 cm^{-1}, which is observed.

PROPOSED MECHANISM OF ADSORPTION OF SO_2 MOLECULES BY HCl MODIFIED OKRA:

HCl enhanced the activity of the okra as adsorbent, which led to COOH coordination. This may be because protein, lignin, and cellulose contain organic acid groups due to the presence of amine and amide groups, as shown by FTIR studies. The proposed research has successfully outlined the interaction mechanism between the SO_2 molecules and the polymer structural behavior of plant material. The work has shed light on the possibilities of cleaning up various pollutants by using biological materials.

Effect of temperature on adsorption and adsorption isotherms:

Samples were placed in a 250 ml glass container, and 1 gram of okra powder was added to 100 ml of a 40ppm aqueous SO_2 solution. The glass containers were kept at 20,40,60,80 degrees centigrade. The glass containers were shaken and filtered. A UV spectrophotometer is used to conduct the investigational study.

The adsorption isotherms help in studying the adsorption phenomena by varying temperature. The adsorption isotherm is plotted between log qe (or x/m) and log ce (Freundlich isotherm) and ce/qe vs ce (Langmuir isotherm) and ce vs qe(Temkin isotherm).

Temkin isotherm:

Temkin isotherm is attained by plotting a graph between qe and ce. R^2 (correlation coefficient) is ranging between 0.7149 - 0.9551 which indicates that lower temperature is favorable. Temkin adsorption isotherm is followed at lower temperature and K values decreased with increase in temperature and there is no variation in the intercept values and it is ranging from 10.3 to 14.4.

Langmuir adsorption isotherm:

R^2 values reduce with the increase in temperature. It is ranging between 0.8384 - 0.9653. The adsorption potential reduced with increase in temperature but there is no much variation in the values. The adsorption intensity is almost constant indicating that temperature is not having much effect on adsorption phenomena.[14]

Langmuir adsorption isotherm:

R^2 values, which range from 0.6588 to 0.7436, are low. Because of the extremely low slope and intensity, the Langmuir adsorption isotherm was unable to satisfactorily explain the adsorption processes which are explained in Fig 6, 7, 8, and 9.

After the SO_2 molecules were adsorbed, a significant amount of variation was seen in the spectra, as illustrated in the images. The peaks in Fig.5 1230 cm^{-1}, 1130 cm cm^{-1}, 1464 cm^{-1}, and 1610 cm^{-1} correspond to changes in the vibrations of the C-O and COO functional groups, which indicate chelation. These changes may be related to the existence of lignin, cellulose, and protein functional groups in the treated samples, which were useful in adsorption.

Adsorption kinetics model:

Pseudo-first order, second order, and Elovich models as well as interparticle diffusion models are used for analyzing kinetic behavior.[15]

It adheres to the interparticle diffusion paradigm and pseudo first order kinetics and it does not follow pseudo second order kinetics represented in graphs that are given in fig 10,11,12,13.

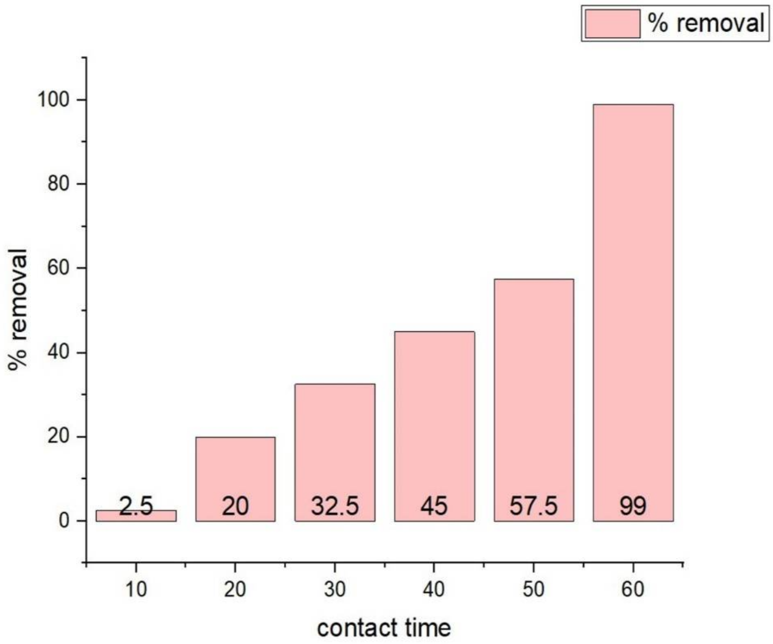

Fig 1: Contact time Vs Percent removal

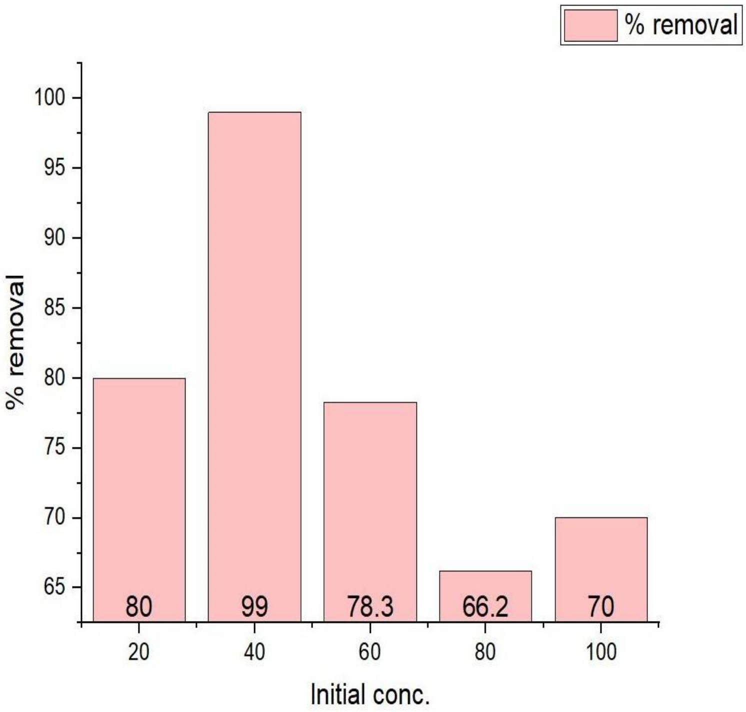

Fig 2: Initial Concentration Vs Percent removal

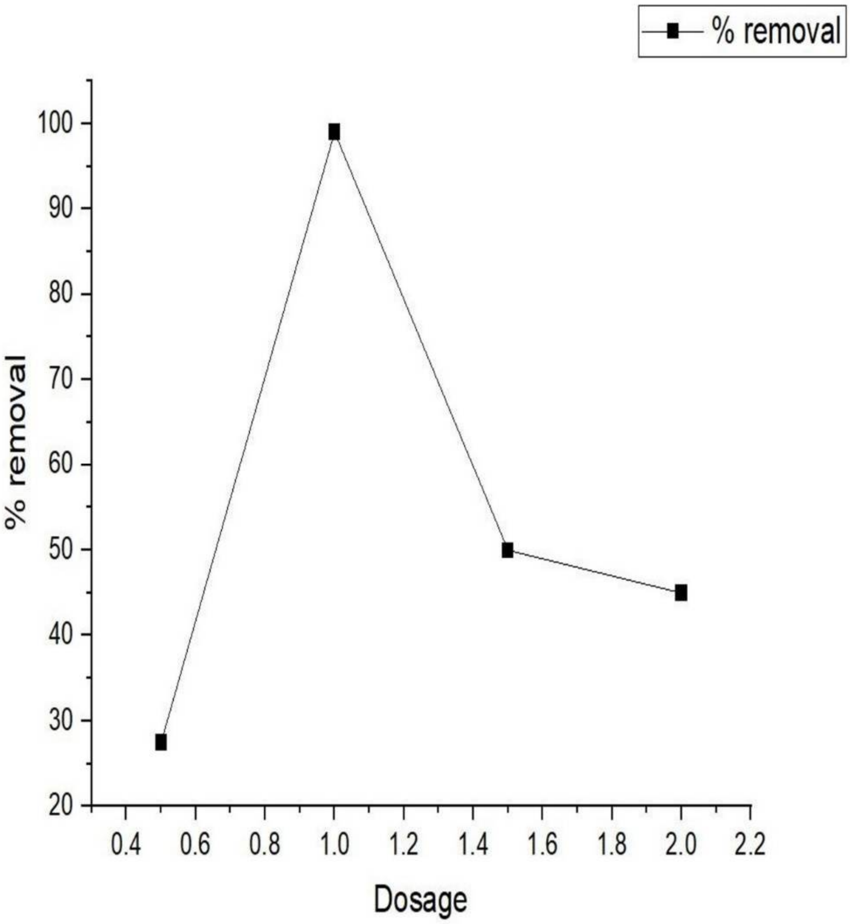

Fig 3: Contact time Vs Dosage

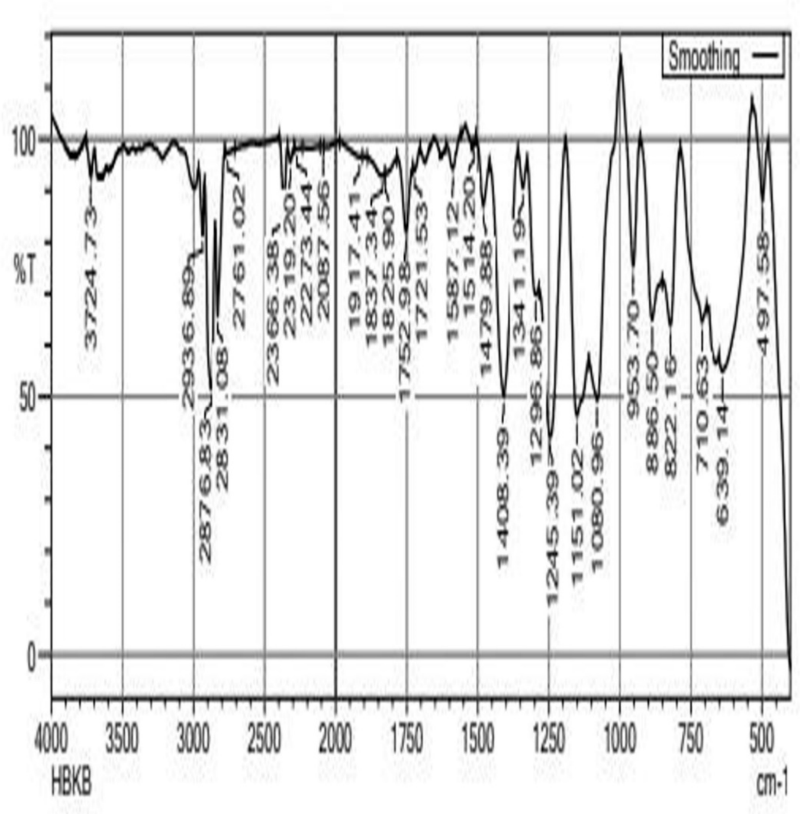

Fig 4: IR Before adsorption

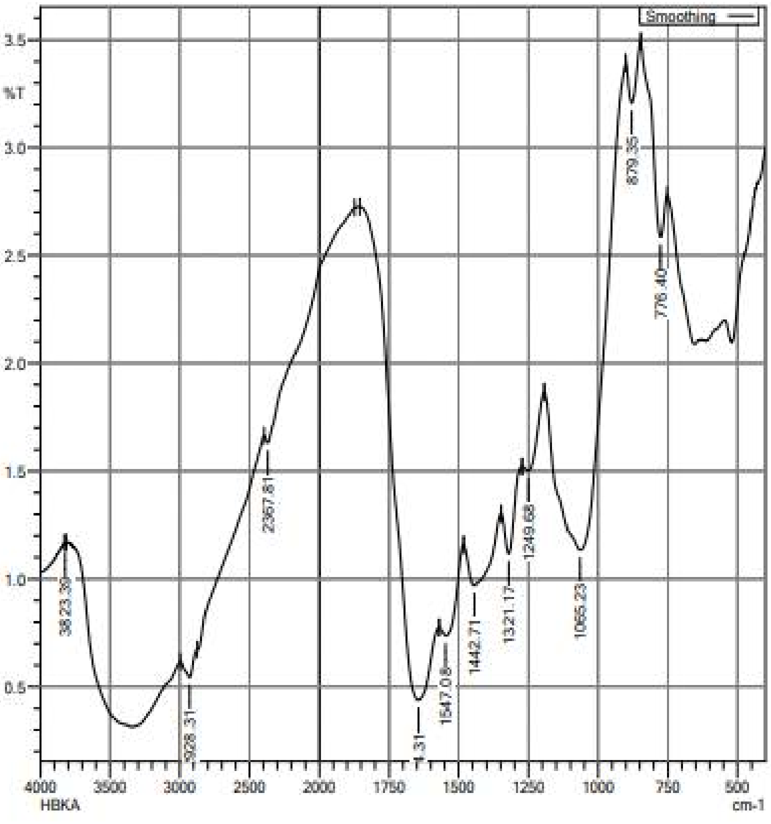

Fig 5: IR After adsorption

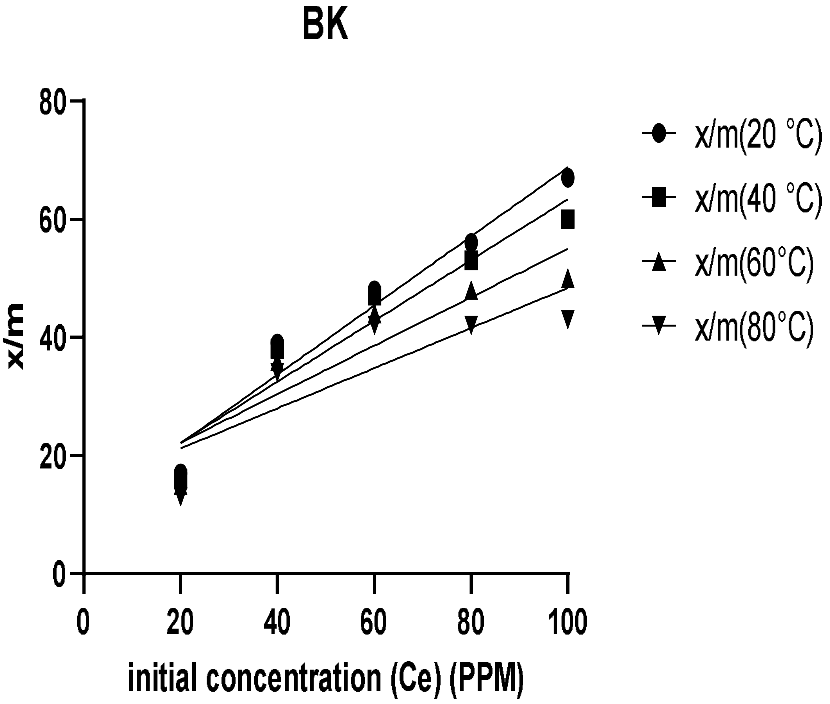

Fig 6: Qe v/s Ce

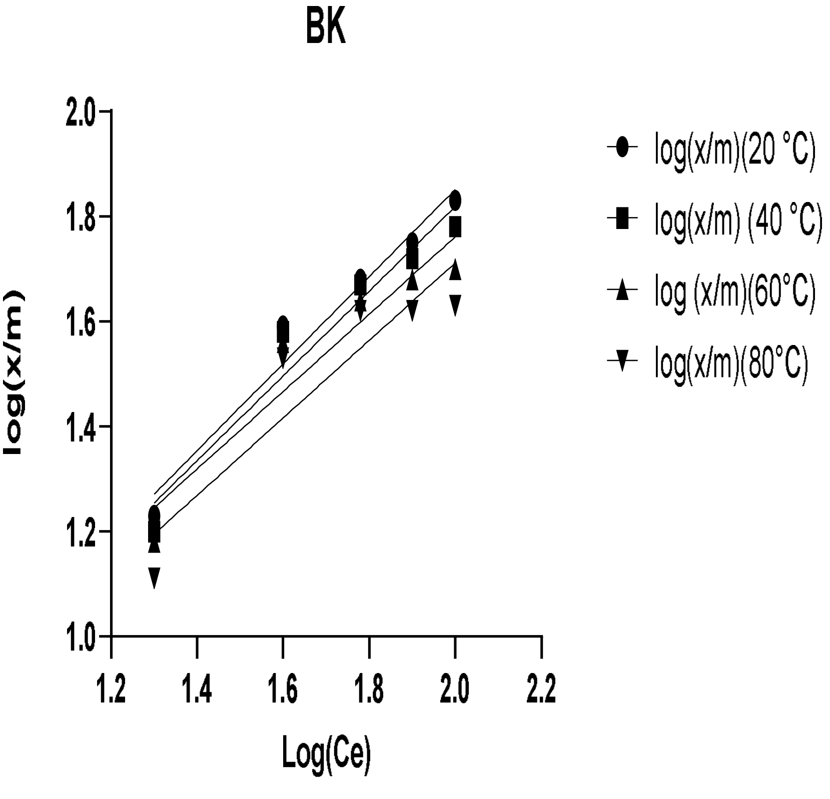

Fig 7: log Qe v/s log Ce

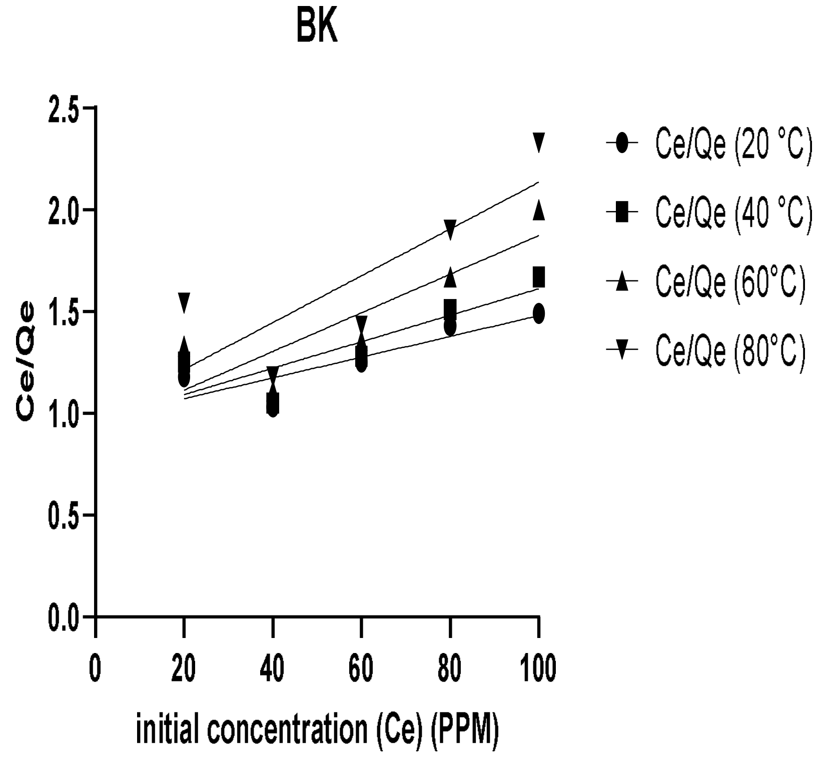

Fig 8: Ce/Qe v/s Ce

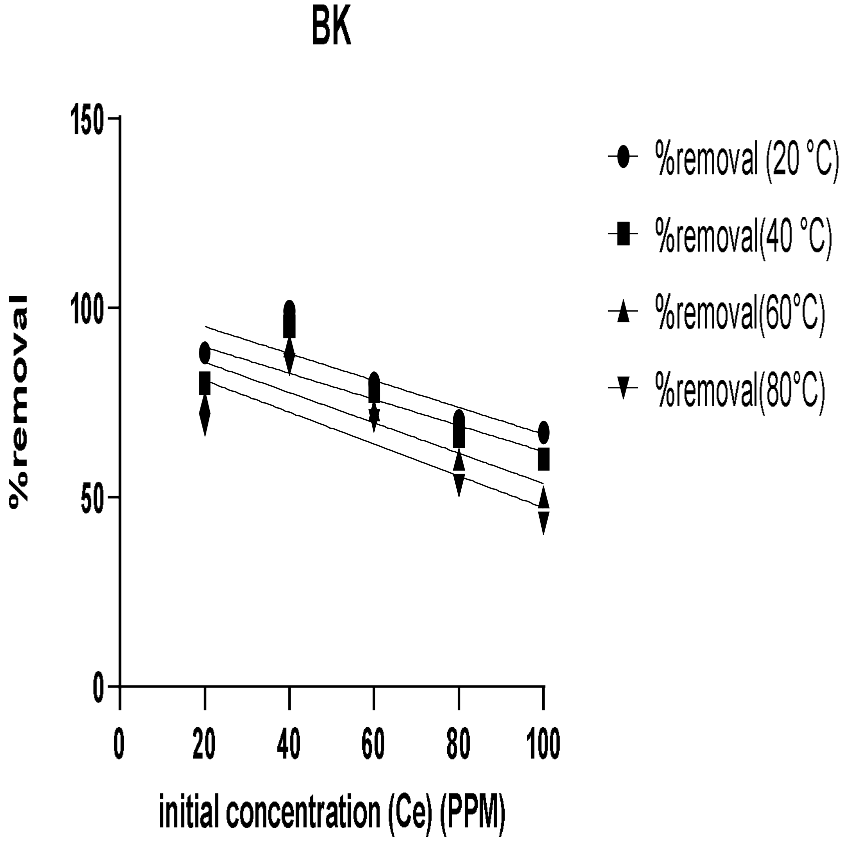

Fig 9: %removal v/s Ce

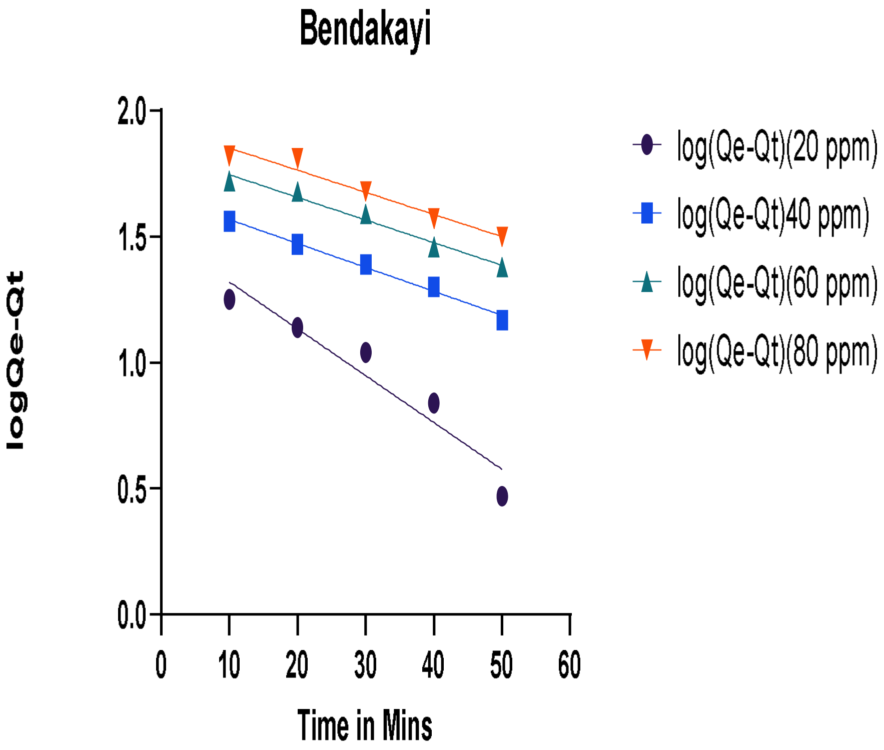

Fig 10: Log Qe-Qt v/s T

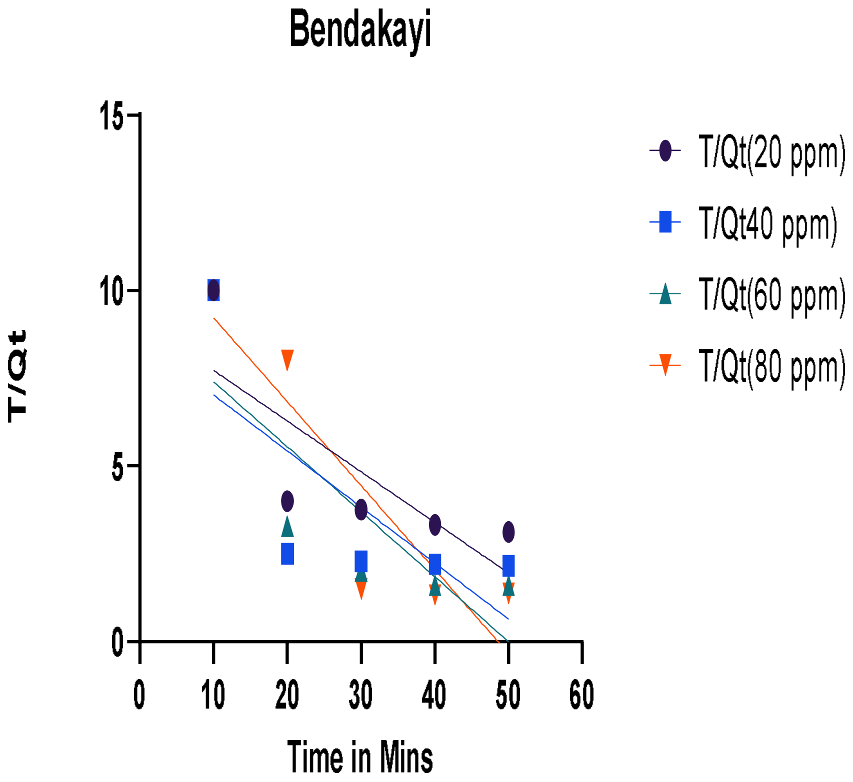

Fig 11: T/Qt v/s T

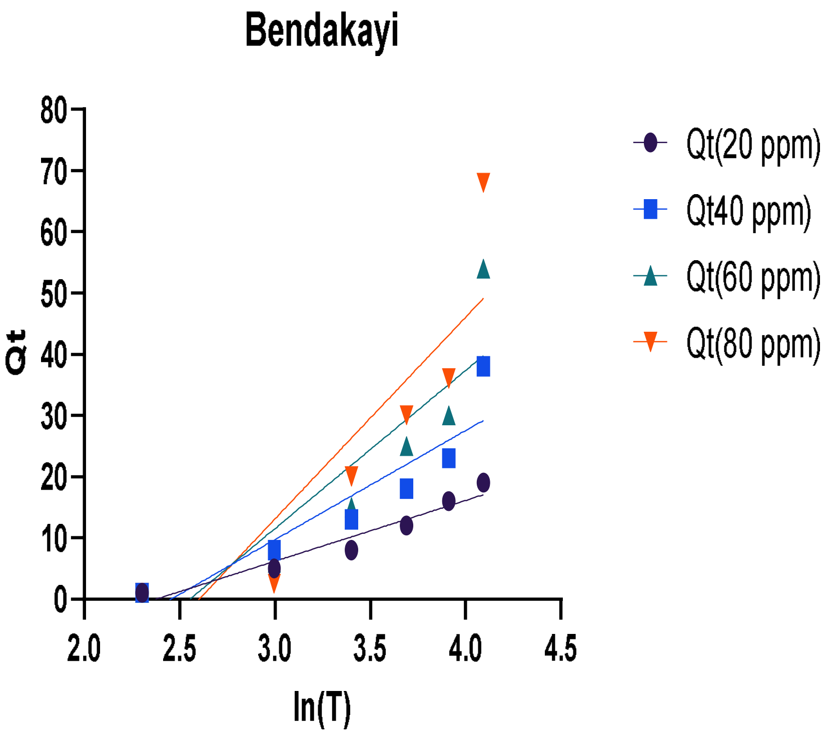

Fig12: Qt v/s ln(T)

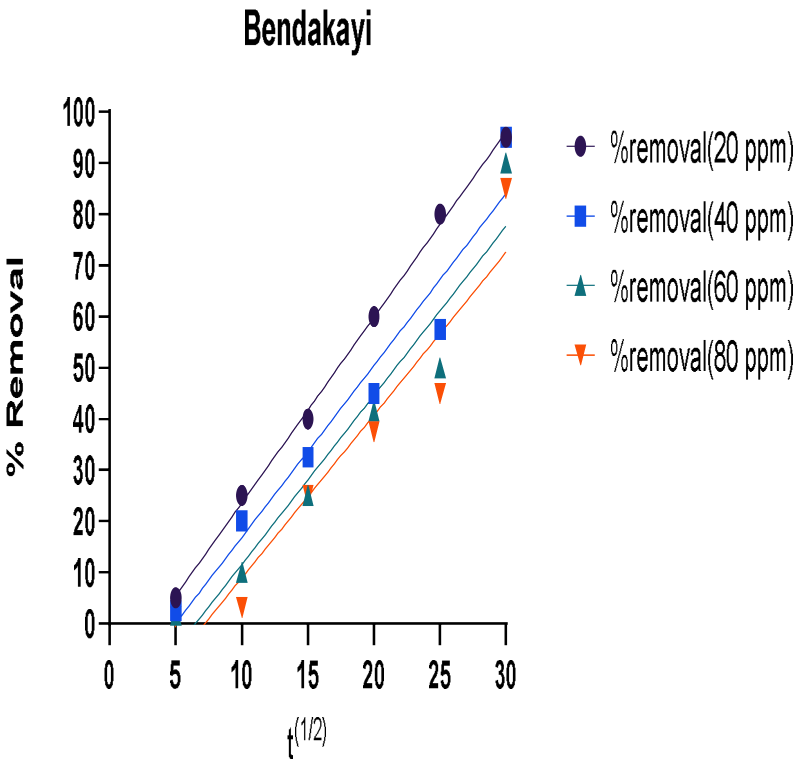

Fig 13: % removal v/s t$^{(1/2)}$

CONCLUSION

- Bio-waste materials have played a significant part in the bio-sorption process. FTIR studies revealed that cellulose molecules were involved in the ion-exchange or complexation of SO_2 molecules. These adsorbents can be employed successfully as an eco-friendly and cost-effective material for remediation and more selective adsorption.
- The ability of modified okra powder to remove SO_2 grew with the duration of contact, with 60 minutes being the ideal. As the concentration rose the amount of SO_2 removal decreased, with 40 ppm marking the highest fraction.
- A higher percentage of SO_2 removal was achieved with a 1-gram adsorbent dosage.
- It shows that lower temperatures are more advantageous for the adsorption process and correlates with the Temkin adsorption isotherm.
- It uses the interparticle diffusion model and pseudo first order kinetics instead of pseudo second order kinetics.

REFERENCES

1. Sharma, D., & Mauzerall, D. (2022). Analysis of air pollution data in India between 2015 and 2019. *Aerosol and Air Quality Research*, *22*(2), 210204.
2. Makur, M. M., Duraisamy, R., & Birhanu, T. (2019). Clarifying capacity of eco-friendly nano CaO and okra (*Abelmoschus Esculentus*) extract on the processing of sugarcane juice: a Review. *International Research Journal of Science and Technology*, *1*(1), 21-30.
3. Benchasri, S. (2012). Okra (*Abelmoschus esculentus* (L.) Moench) as a valuable vegetable of the world. *Field & Vegetable Crops Research/Ratarstvo i povrtarstvo*, *49*(1).
4. Lee, L. Y., Chin, D. Z. B., Lee, X. J., Chemmangattuvalappil, N., & Gan, S. (2015). Evaluation of Abelmoschus esculentus (lady's finger) seed as a novel biosorbent for the removal of Acid Blue 113 dye from aqueous solutions. *Process Safety and Environmental Protection*, *94*, 329-338.
5. Chen, Y., Zhang, B. C., Sun, Y. H., Zhang, J. G., Sun, H. J., & Wei, Z. J. (2015). Physicochemical properties and adsorption of cholesterol by okra (Abelmoschus esculentus) powder. *Food & Function*, *6*(12), 3728-3736.
6. Hashem, M. A. (2007). Adsorption of lead ions from aqueous solution by okra wastes. *International Journal of Physical Sciences*, *2*(7), 178-184.
7. Rahman, M. M., Maniruzzaman, M., Islam, M. R., & Rahman, M. S. (2018). Synthesis of nano-cellulose from okra fibre and FTIR as well as morphological studies on it. *American Journal of Polymer Science and Technology*, *4*(2), 42-52.
8. Ofori, J., Tortoe, C., & Agbenorhevi, J. K. (2020). Physicochemical and functional properties of dried okra (Abelmoschus esculentus L.) seed flour. *Food Science & Nutrition*, *8*(8), 4291-4296.
9. Reiszner, K. D., & West, P. W. (1973). Collection and determination of sulfur dioxide incorporating permeation and West-Gaeke procedure. *Environmental science & technology*, *7*(6), 526-532.
10. Lua, A. C., & Guo, J. (2001). Adsorption of sulfur dioxide on activated carbon from oil-palm waste. *Journal of Environmental Engineering*, *127*(10), 895-901.
11. Samet, C., & Valiyaveettil, S. (2018). Fruit and vegetable peels as efficient renewable adsorbents for removal of pollutants from water: a research experience for general chemistry students. *Journal of Chemical Education*, *95*(8), 1354-1358.
12. Sabri, A. A., & Hashim, Y. A. (2020). Application of treated Iraqi rice husk as adsorbent for phosphate removal from aqueous solution. *Engineering and Technology Journal*, *38*(11A), 1602-1617.
13. Chen, Y., Zhang, B. C., Sun, Y. H., Zhang, J. G., Sun, H. J., & Wei, Z. J. (2015). Physicochemical properties and adsorption of cholesterol by okra (Abelmoschus esculentus) powder. *Food & Function*, *6*(12), 3728-3736.
14. Ayawei, N., Ebelegi, A. N., & Wankasi, D. (2017). Modelling and interpretation of adsorption isotherms. *Journal of chemistry*, *2017*(1), 3039817.
15. Gogoi, M., Konwar, K., Bhuyan, N., Borah, R. C., Kalita, A. C., Nath, H. P., & Saikia, N. (2018). Assessments of pyrolysis kinetics and mechanisms of biomass residues using thermogravimetry. *Bioresource Technology Reports*, *4*, 40-49.