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DECOLOURIZATION OF DYES FROM WASTEWATER USING ZnO NANO PARTICLES BY ADSORPTION.

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Abstract:

Water is an inevitable part of our day-to-day life for almost all the living and non-living forms present on this globe. The usable/potable water resources are shrinking with every passing day even though the earth constitutes of 71% of water. The major problems due to which the water gets contaminated is presence of dyes as part of effluents. This particular study focuses about using the advanced technique which uses using ZnO nano particle (Nps) as adsorbent for removal of methylene blue (MB) from the wastewater. The ZnO nano particles are synthesized in the laboratory using simple precipitation method. The prepared nano particles will be used in the adsorption process which is the treatment method of wastewater. The ZnO nano particles prepared are characterized by scanning electron microscopy (SEM) and its analysis is carried out along with its structural morphology. The UV-Vis spectrophotometer is used to check UV-vis spectroscopic method is used for the analysis of methylene blue dye of MB dyes present at different mg/L of the wastewater. The application of these NPs are tested at various concentrations of dyes. The adsorption mechanism is studied with varying parameters of contact time, dye concentration and adsorbent dosage. The treated water possesses characteristics within the safe disposable limits and can be either disposed to any stream of water or used for any raw water intake.

Index Terms **– Methylene blue, adsorption, dye removal, adsorbent, effluent.**

1. Introduction

The dyes are commonly present in the effluents of many industries namely leather, textiles, paints and printing inks. Physical, biological, chemical and mixed wastewater treatment systems provide more opportunity to reuse water over and again. On the other hand, nano technology can be used to treat wastewater and it can achieve more quality and overcome the drawbacks of conventional methods. Many treatment methods based on adsorption, activated carbon, zeolite, micro and ultrafiltration have been researched to eliminate the presence of dyes in wastewater There are many techniques such as point of care treatment, nano technology, oxidation, and reduction processes and many more. But the application of nanoparticles of metal oxides is a proven method and huge research has been carried out in this area.

This research highlights the effectiveness of adsorption for the removal of dye from wastewaters which has been made as an ideal alternative to other expensive treatment methods. The adsorption of MB dyes was performed using ZnO Nps with different time intervals and different concentration of wastewater and it's analysis was carried out at respective concentrations.

1.1 Objectives

- To apply nanoparticles in treating wastewater that is contaminated with the presence of dyes.
- To achieve time reduction in decolorization using nanoparticles.
- To study the effect of contact time with varying dosage of initial and final concentration of the dye wastewater that is to be treated.

2. Materials and Methodology

2.1 Adsorbent used and its preparation

Preparation of aqueous solution (0.2M) of zinc nitrate and 0.4M solution of KOH using distilled water was carried out at the laboratory. Slowly adding KOH solution to Zinc nitrate solution at room temperature while stirring vigorously. White precipitate will be formed which is visible to the naked eyes. The white product is crystallized at 5000 rpm for 20 minutes and washed three times with distilled water and absolute alcohol in the end. The product thus obtained is calcined at 500 °C in atmospheric air for 3 hours. Lastly, it is grounded to make a fine powder which is the final ZnO NP.

2.2 Experimental procedure

The most commonly used dyes in industry are Methylene Orange (MO), Methylene Blue (MB), Methylene Red (MR). Methylene blue is taken as the target dye for this research study. The number of dilutions were prepared to synthesize the wastewater. The initial characteristics such as colour and type of the dye are analysed. The ZnO nano particles were produced in the laboratory using simple precipitation method. ZnO NPs were analysed for various parameters to evaluate NPs such as SEM, XRD, FTIR. Various wastewater samples of different concentrations are treated with different doses of ZnO NPs. The treated samples are analysed again for reduction in various parameters tested with raw samples.

2.3 Wastewater Treatment

The wastewater sample to be treated is taken in a quantity of 50ml in 3 different glass beaker and dose of 0.1g of ZnO Nps is added to the beaker. Each beaker contains a magnetic stirrer for vigorous mixing of ZnO Nps to perform the treatment for 3-time intervals of 15minutes, 30 minutes and 45 minutes. This is carried out respectively for each individual wastewater sample of different concentrations starting from 30ppm to 100ppm with a constant difference of 10ppm. After the adsorption takes place, each of the sample is centrifuged at 2000rpm to separate the ZnO Nps. The colour of treated wastewater is checked for light absorption (Abs) at wavelength of 665nm using the UV-vis spectroscopic method. By putting the Abs value(y) in the standard equation, we will derive the final ppm of the treated wastewater(x) and further the percentage removal of MB dye is calculated. The standard equation for MB calibration curve is as stated below:

$$y = 0.112x - 0.030;$$

$$R^2 = 0.980$$

Where, y= the light absorption (Abs) value , and

x=Concentration in ppm (mg/L)

2.4 Parameters considered

The following parameters were considered while performing the experiment:

Table 1: The varying parameters that were taken during the time of experiments

Sr. No.	Parameters	Value
1.	Contact time	15 min,30 min and 45 min.
2.	Initial Colour Concentration	30, 40, 50, 60, 70, 80, 90 and 100 mg/L
3.	Adsorbent Dosage (ZnO Nps)	0.1, 0.2 and 0.3 gm

2.5 Analysis of the samples.

The intensity of treated wastewater sample before and after adsorption process were measured using spectrophotometer by calibrating and adjusting the spectrophotometer for the wavelength of 665nm for the color considered of Methylene blue dye. From the calibration curve obtained, the color intensities after adsorption were measured based on percentage adsorption results recorded from spectrophotometer.

3. Characterization of ZnO Nano Particles.

ZnO nanoparticles are characterized based on the purpose for which they are produced. The most adopted techniques for this characterisation are electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Brunauer–Emmett–Teller (BET), X-ray photoelectron spectroscopy (XPS), dynamic light scattering (DLS), photoluminescence (PL), and ultraviolet– visible (UV–Vis).

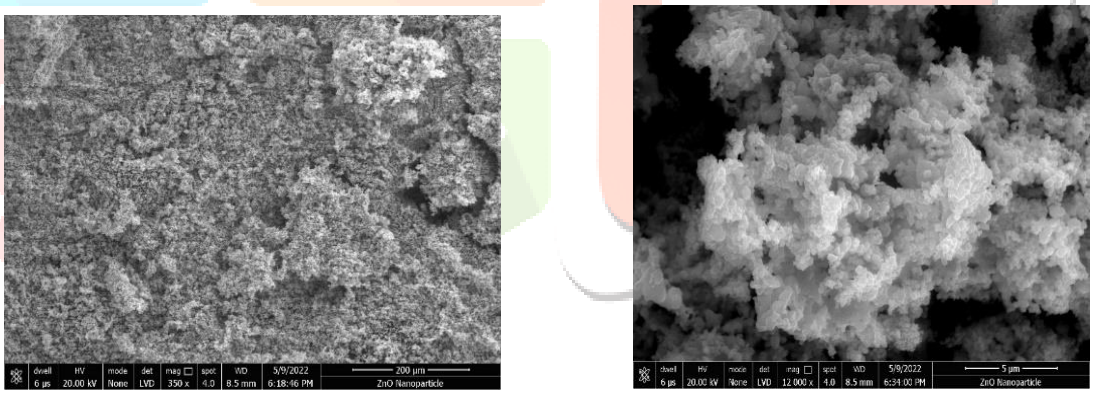

Fig 1. SEM image of prepared ZnO nanoparticles as synthesized and calcined at 500 °C for 3 hours

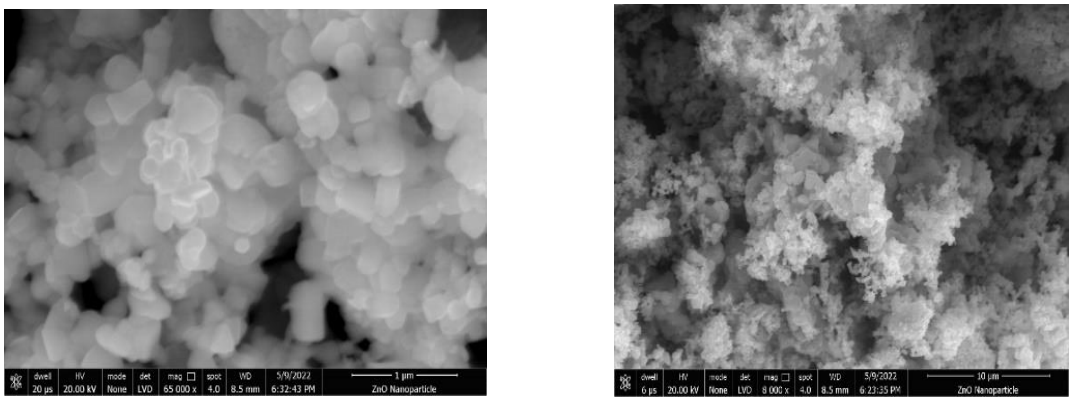

Fig 2: SEM images of ZnO Nano particles created in the laboratory.

4. Results and discussion

Findings of the experimentation carried out to evaluate the percentage removal of ZnO nano particles in removing methylene blue dye under varied experimental conditions of Adsorbent dosage, contact time, Initial concentration are presented in table 2 based on the experimental observation discussions were made and thereby inferences were drawn.

Table 2: Experimental finding with % removal of MB dye with varying dose of Adsorbent ZnO NPs at contact time of 15, 30 and 45 minutes.

Initial Concentration(ppm)	Adsorbent -ZnO Dose(gram)	Percentage removal at 15 min.	Percentage removal at 30 min.	Percentage removal at 45 min.
30	0.1	68.37	90.67	90.50
	0.2	65.03	86.67	85.40
	0.3	63.23	92.60	92.53
40	0.1	77.40	74.53	74.90
	0.2	75.20	91.00	90.45
	0.3	68.65	96.25	95.93
50	0.1	73.90	94.60	94.32
	0.2	69.40	96.20	95.92
	0.3	69.02	87.86	87.68
60	0.1	77.25	93.08	92.83
	0.2	63.70	82.60	83.30
	0.3	69.25	78.62	78.45
70	0.1	75.07	96.50	96.19
	0.2	69.96	86.79	86.07
	0.3	75.30	84.35	85.90
80	0.1	79.48	95.61	94.68
	0.2	73.15	90.39	90.21
	0.3	77.01	91.22	91.03
90	0.1	76.87	95.92	95.90
	0.2	75.08	86.22	87.26
	0.3	73.91	88.22	87.78
100	0.1	78.39	97.81	97.57
	0.2	75.18	87.89	87.40
	0.3	72.61	85.68	85.13

4.1 Effect of Initial Concentration

The lower and higher removal efficiency recorded at 30, 40, 50, 60, 70, 80, 90 and 100 mg/L respectively indicated that removal efficiency is a function of concentration of colour and is directly proportional.

4.2 Effect of Contact Time

To evaluation of optimum time for maximum adsorption of MB dye on ZnO NPs, time varied from 15 to 45 minutes. The maximum colour removal efficiency for MB dye was observed at 30 min above this a slight decrease in efficiency was recorded. Also observed that as contact time is increased the removal efficiency keeps increasing.

4.3 Effect of Adsorbent Dosage

The relationship between dosage and colour removal has been obtained as similar to linear. It was observed as adsorbent dosage increased from 0.1 g to 0.3 g and the removal efficiency was also found to increase. For MB dye maximum [Adsorbent dosage 0.1 g, Co= 100 mg/L, Contact time t =30 min] and minimum [Adsorbent dosage 0.3 g, Co =30 mg/L, Contact time t =15 min] removal efficiency recorded were found to be 97.81 % and 63.23 % respectively as shown in table 2.

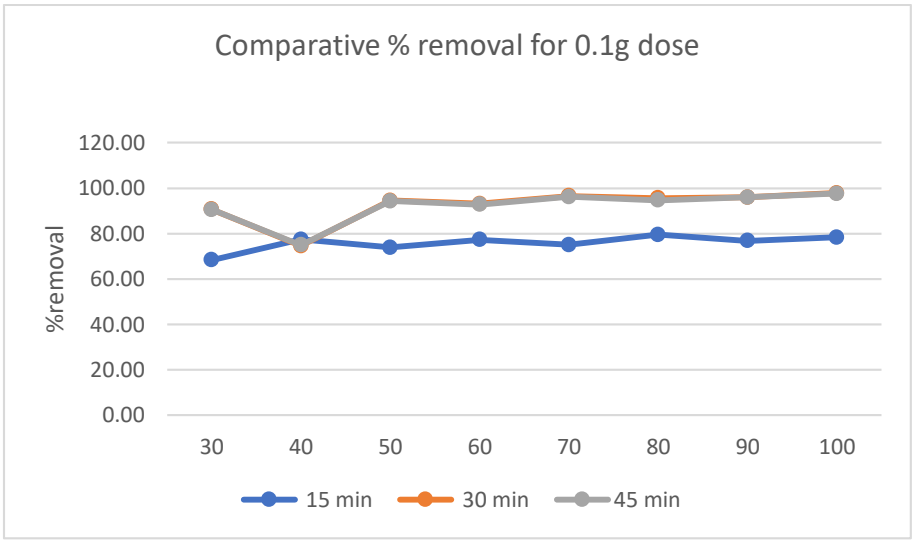

Fig 3: Effect of contact time on removal efficiency of MB dye at different mg/L when Adsorbent dose is 0.1gm.

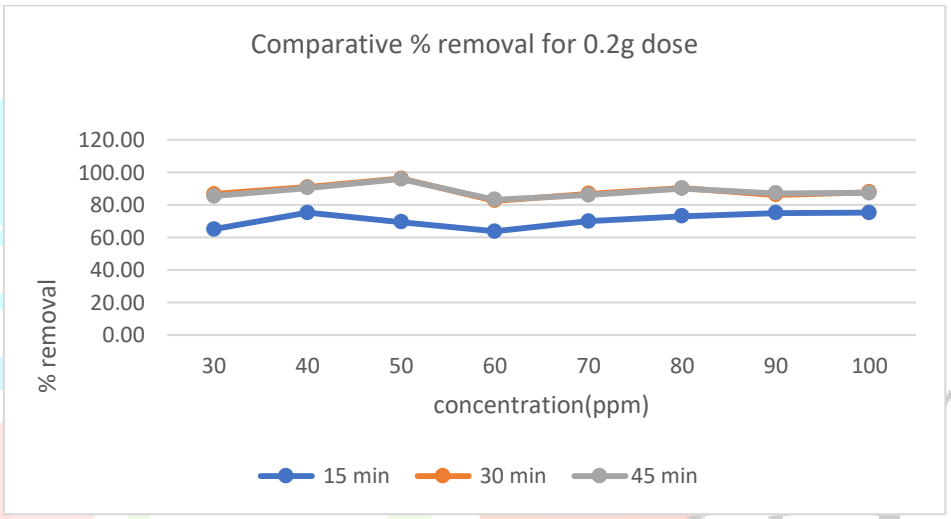

Fig 4: Effect of contact time on removal efficiency of MB dye at different mg/L when Adsorbent dose is 0.2 gm.

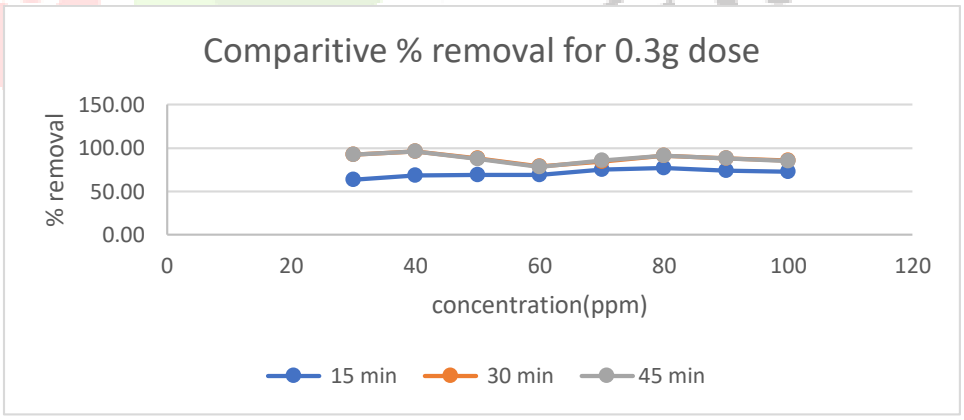

Fig 5: Effect of contact time on removal efficiency of MB dye at different mg/L when Adsorbent dose is 0.3gm.

5. Conclusion

It is concluded from the above figures that the ZnO Nps with the dose of 0.1gm and 0.2 gm gives the maximum result with the % removal of MB dyes for a 50 ml wastewater sample. The nano particles gave decolourization efficiency of 95±2.5% for 30 minutes reaction time in ambient conditions (Room temperature=25 C; pH= 6-8). ZnO Nps can be prepared using number of methods, but direct precipitation method is convenient and most preferred. ZnO Nps prepared in this method provide a scope of reusability and hence can be used to treat the same or different concentration of the sample. Removal of dyes using this method is time saving and efficient and hence can be used as a full-fledged treatment or a polished treatment as and when required. The experiments have shown good results in every permutation and combination but keeping in view the amount of ZnO Nps dosage, contact time and percentage removal 0.1gm dosage for 50 ml sample for 30 minutes can be determined as the most suitable combination. Fresh water resources are depleting at an alarming rate and hence this method can serve to keep one of the polluting parameters in check and help in saving the receiving stream from getting polluted.

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