ELIMINATION OF REACTIVE BLUE 250 DYE FROM TEXTILE EFFLUENTS BY USING MGO NANOPARTICLES.

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ABSTRACT: Decoloration of textile effluents is an environmental problem. This study deals with the application of MgO nanoparticle for the elimination of Reactive Blue 250 from wastewater of textile industry. MgO nanoparticle were synthesized by Co-precipitation method of and characterization is done by FT-IR and XRD. The adsorption pattern of these magnesium oxide nanoparticles was studied in batch experiments setup for the elimination of Reactive Blue 250 synthetic dye from textile effluent. It was evaluated that optimum dose of adsorbent is 0.35g, optimum shaking speed is 200rpm, 90 minutes is the optimum contact time of adsorbent with dye solution and optimum pH is 7 for this adsorption setup. The adsorption data obtained from batch setup was then applied to adsorption isotherms and it was observed that data is well fitted to the Langmuir and Fruendlich isotherms which shows the feasibility of adsorption phenomenon.

Keywords: *Nanoparticles, Reactive Blue 250, Adsorption, MgO nanoparticles*

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INTRODUCTION

Water is the most basic need for all life on Earth, yet millions of people still struggle to get clean water and proper sanitation. To deal with this crisis, we need affordable and energy-efficient ways to clean water that use less chemicals and cause less harm to the environment. Researchers are working on new methods for decontaminating water. Industrial growth has released countless pollutants into rivers, lakes, and underground water, leading to serious health risks. Textile industry processes are extremely water intensive. In Pakistan, almost 8.5% of GDP is contributed by textile industry [1]. High doses of dyes and chemicals are used in wet processes such as dyeing and bleaching etc. Synthetic dyes are visible even at very minor quantities in water bodies, that's why they are aesthetically problematic along with their hazardous and persistent nature [2-3]. Reactive dyes are widely used due to easy use, almost 70-80% of used reactive dyes are fixed during dyeing process and remaining 20-30% goes into the effluent. Owing to their anionic nature, the process of dye fixation is carried out in alkaline bath that results in high salt concentration in spent dye bath [4-5]. High water solubility, heat stability and resistance to light makes dyes persistent pollutant.

Several treatment methods are used for water purification, including adsorption, membrane filtration, ion exchange, precipitation, and biological techniques. However, these approaches often require high energy, intensive chemical use, advanced technical expertise, and costly infrastructure [6-7]. Against this backdrop, nanotechnology has emerged as a promising alternative for improving water quality. Nanomaterials possess unique physical, chemical, and biological properties because of their structural features, large surface area, and quantum effects [8-9]. Adsorption is a process where contaminants (adsorbates) stick to the surface of a solid material (adsorbent). Nanoparticles are excellent adsorbents because of their extremely small size, which gives them a huge surface area and plenty of active sites for binding pollutants. Their surface chemistry and pore structures also allow them to interact with a wide range of contaminants.

Nanoparticles are becoming one of the most exciting tool in textile wastewater treatment. In present study Synthetic Reactive Blue 250 dye removed from wastewater by using MgO Nanoparticles. Nanoparticles have emerged as promising adsorbents for the removal of textile dyes due to high surface area and nanoparticles surface chemistry. Recent era highlight that metal oxide nanoparticles, such as MgO and TiO_2, exhibit strong dye adsorption and photocatalytic degradation abilities [10]. Similarly, nanocomposites and nano-adsorbents are gaining attention for efficiently removing both dyes and heavy metals from wastewater[11]. Research also suggests that sustainable nanomaterials offer eco-friendly alternatives to conventional adsorbents, improving dye removal efficiency under optimized conditions [12]. Overall, nanoparticles represent a vital advancement in developing cost-effective and green solutions for textile wastewater treatment [13].

METHODOLOGY

A. Nanoparticles Preparation: Magnesium oxide (MgO) nanoparticles were prepared by first dissolving 10.1g $MgCl_2 \cdot 6H_2O$ in 500 ml of distilled water. Half liter of 0.20 M NaOH was then taken in a separating funnel and drop by drop of NaOH added in to the magnesium chloride solution, this process needs constant stirring with a magnetic stirrer. Then precipitate which form during this process was filtered and washed to remove impurities. It was then dried in an oven at 120 °C for 2-3 hours, followed by the placement of these precipitates into a muffle furnace (Model: Vecstan ECF2) at 500 °C for another 3–4 hours. This process yielded fine, white powdered MgO nanoparticles.

B. **Characterization of Mgo Nanoparticles:** Prepared nanoparticles of MgO were characterized through Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction (XRD). This characterization gives the information about the structure of molecules and the chemical bonding of the nanoparticles and for particle size of MgO nanoparticles. Stock solutions (1000ppm) of RB250 Dye was made by dissolving 1000mg of dye in one liter of distilled deionized water. Further dilutions were prepared from these stock solutions when required.

C. **Batch Experiments:** A set of batch experiments were conducted to assess the effect of different adsorption parameters. A known concentration and volume of dye solution were taken in beakers and calculated amounts of MgO Nanoparticles as nanoparticles were added to all beakers. All experimental conditions kept same or constant except only one which is under study.

EXPERIMENTAL RESULTS AND DISCUSSION

A. **FTIR Analysis:** The prepared nanoparticles of MgO were characterized through Fourier Transform Infrared Spectroscopy. It was measured at the range of 400-4000 cm^{-1}. The peak at 36285.10 cm^{-1} indicates the OH antisymmetric stretching while the peaks at 788.89 cm^{-1} & 698.23 cm^{-1} and are due to stretching vibration of Mg-O. Peaks at 1687.71 cm^{-1} and 1872.88 are attributed to bending vibration of water. It is shown that FTIR spectra of MgO nanoparticles loaded with dye is slightly differing with the original one (Fig.2) with a peak at 1155.36 cm^{-1} which may be due to the process of binding on the surface of adsorbent.

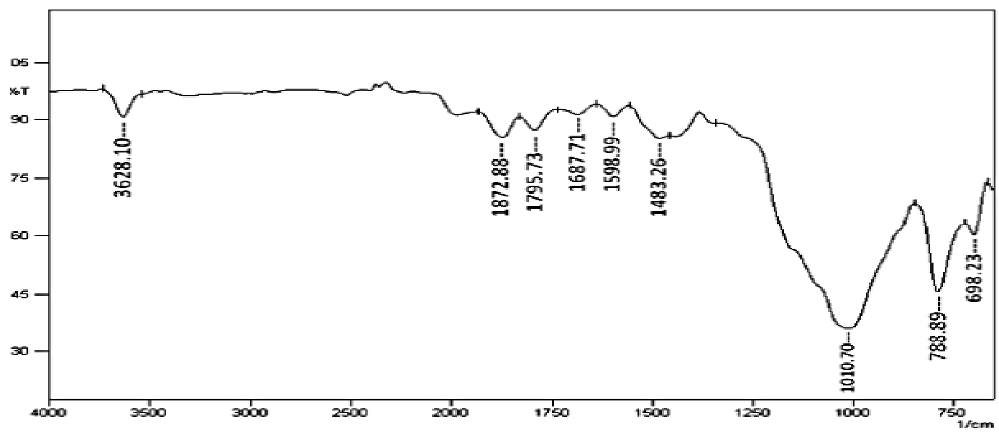

Figure 1. FTIR Spectrum of Nanoparticles

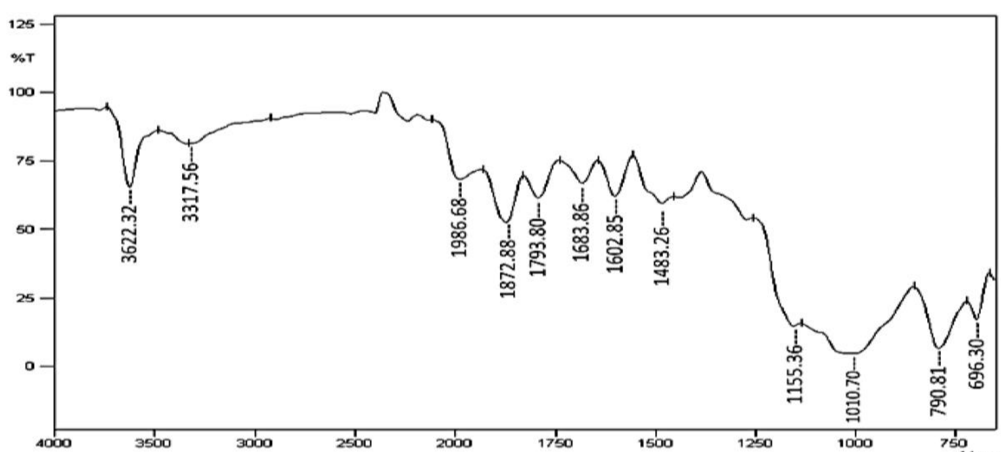

Figure 2. FTIR spectrum of Nanoparticles loaded with dy

B. **XRD Analysis:** Nanoparticles of MgO were also characterized by XRD to analyze their crystalline nature and size The results showed cubic crystalline structure with size of 19 nm and density measured about 4.21g/cm^3 (Fig 3 and 4).

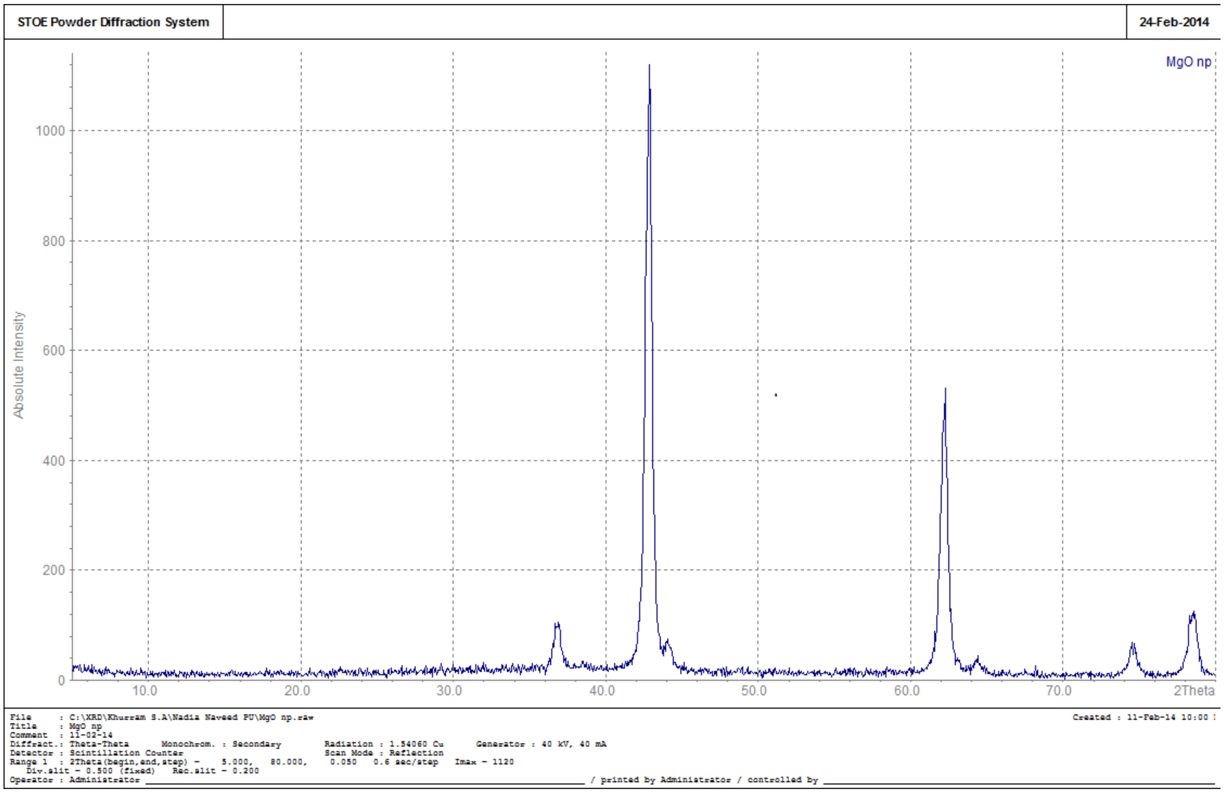

Figure 3: XRD peak pattern of Nanoparticles

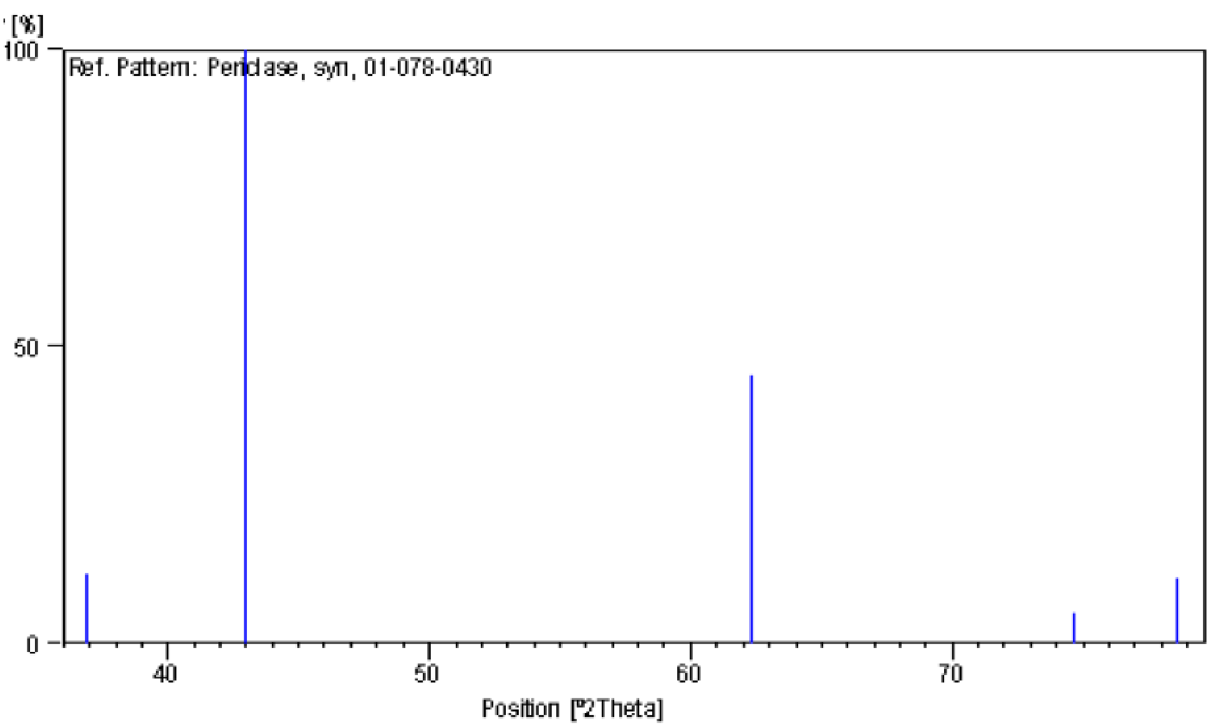

Figure 4: XRD Stick pattern of Nanoparticles

C. **Optimization of adsorption parameters:** Batch experiments were carried out to optimize various factors including shaking speed, initial dye concentration, pH, temperature, contact time, and adsorbent dose which influence the adsorption efficiency for dye removal.

Shaking speed: To study the effect of shaking speed on adsorption of RB-250 on MgO nanoparticles the shaking speed varied from 0-250rpm. The optimum removal efficiency was observed at 200rpm with 70% removal, other operational parameters were 0.05g nanoparticles dose, 100mg/L dye, pH 7 and time is 60 minutes at 25 ^{o}C. The Fig below show initially removal efficiency increases by increasing the shaking speed but after reaching to it optimum it starts decreasing which may be due to the fact that high shaking speed effect the weak binding forces between dye and nanoparticles [14-15].

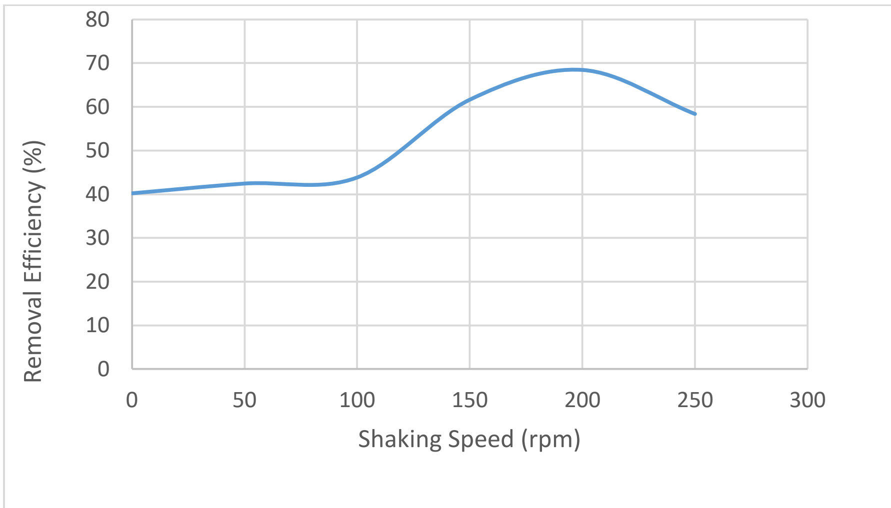

Figure 5.: Shaking speed and removal efficiency

Contact time: To investigate the effect of time on adsorption of RB-250 on MgO nanoparticles the shaking time varied from 10-90min. The optimum removal efficiency was observed at 90min with 80% removal. Other operational parameters of the experiment were 0.05g nanoparticles dose, 100mg/L dye, pH 7 and shaking speed 200rpm at 25 ^{o}C. The Fig 6. shows initially removal efficiency increases with the increase of contact time then become constant but again there is a rise as time increase. These results may be justified that in start all the sites on adsorbent are easily available to the dye molecules for binding, so they can adhere on them easily. As time passes maximum sites become occupied which explains no further increase in removal efficiency and due to constant shaking some sites start detaching dye molecules again and new arrangement of attachment starts [16-17].

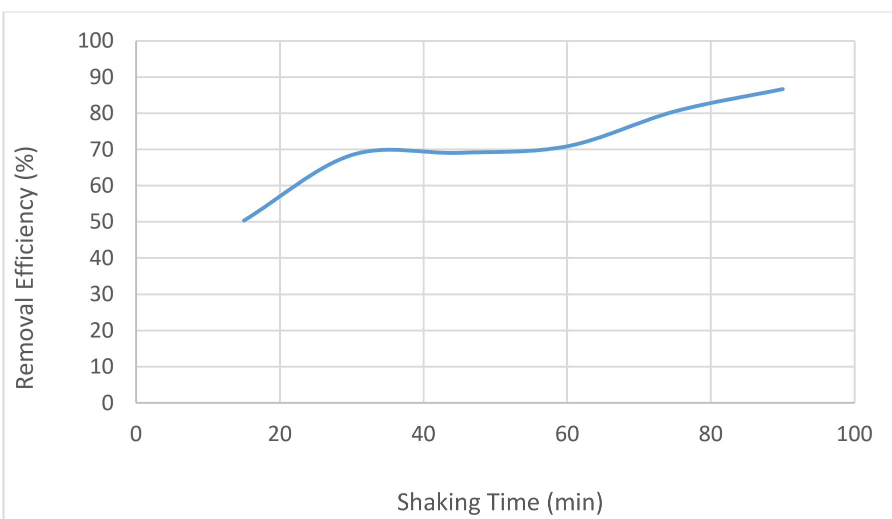

Figure 6: Contact time and removal efficiency

Adsorbent Dose: The effect of dose of adsorbent on adsorption of RB-250 on MgO nanoparticles is studied by varying adsorbent dose from 0.1-0.35g. The optimum removal efficiency was observed at 0.35g with 70% removal, other operational parameters were 100mg/L dye, pH 7 and time is 90 minutes, shaking speed 200 rpm and temperature 25^{o}C. The Fig 7 shows removal efficiency increases by the increase of dose of adsorbent. This increase in the removal efficiency is directly related with the fact that more number of the available binding sites for adsorption available as dose of adsorbent increases [18].

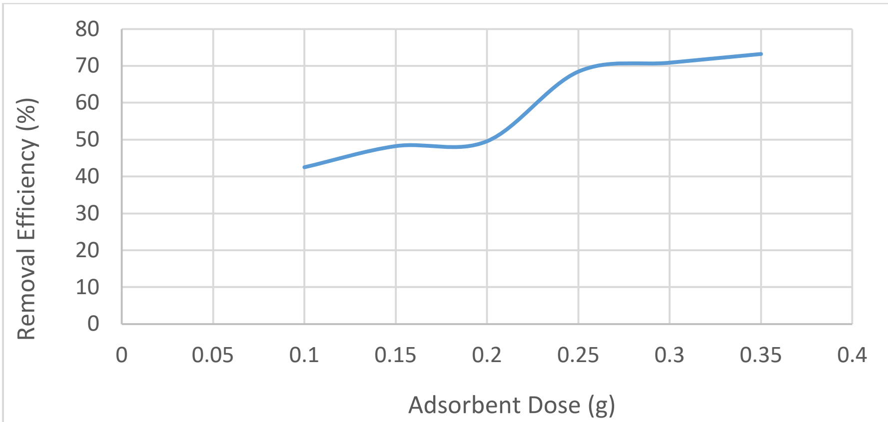

Figure 7: Adsorbent dose and removal efficiency

pH: To evaluate the effect of pH on RB-250 and MgO nanoparticles adsorption system, the pH varied from 3-11. The optimum removal efficiency was observed at 7, other operational parameters were 3.5g nanoparticles dose 100mg/L dye, time is 90 minutes, shaking speed 200 rpm and temperature 25^{o}C. The Fig 8 shows removal efficiency is maximum at pH 7 after that it starts declining. This may be due to the fact that in alkaline media OH- hydroxyl ions compete with the dye molecules to attach on adsorbent surface which results in decline adsorption efficiency [19].

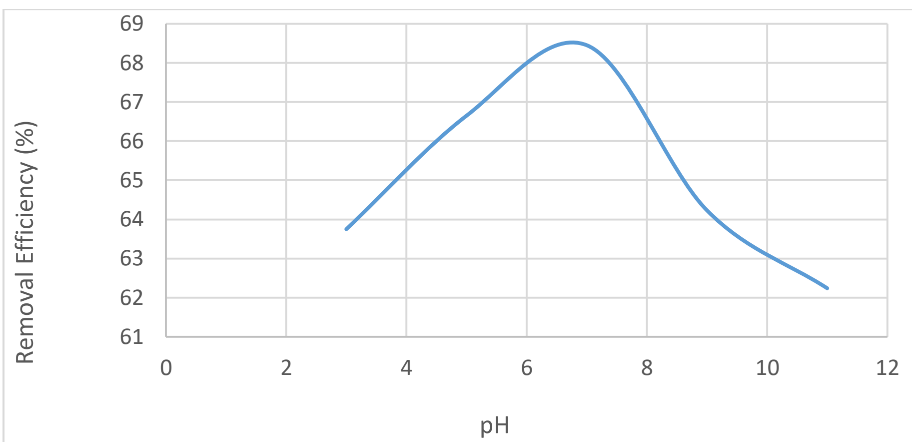

Figure 8: pH and removal efficiency

Temperature: To evaluate the effect of temperature on MgO nanoparticles and RB-250 adsorption the temperature varied from 10-70 ^{o}C. Other Operational parameters are 200rpm shaking speed, 0.35g adsorbent dose, pH 7 and 100mg/L dye concentration. The Fig 9 shows removal efficiency is maximum at 25^{o}C after that it starts declining. This may be due to the temperature increases kinetic energy of molecules and nanoparticles increases and due to these collisions adsorbent efficiency decreases [20].

Langmuir Isotherm: The adsorption behavior was studied at different concentrations of dyes under the optimized parameters, and the resulting data was then used to assess the Langmuir isotherm model. A straight line was obtained between Ce and Ce/qe.

Freundlich Isotherm: The data of adsorption was also applied for Freundlich model which explains the adsorption behavior of RB250 on prepared nanoparticles of MgO. This isotherm was applied between log Ce and log qe resulting in a straight line, indicatingcthe favorability of this model towards the data of experiments of RB250 adsorption on prepared nanoparticles of MgO.

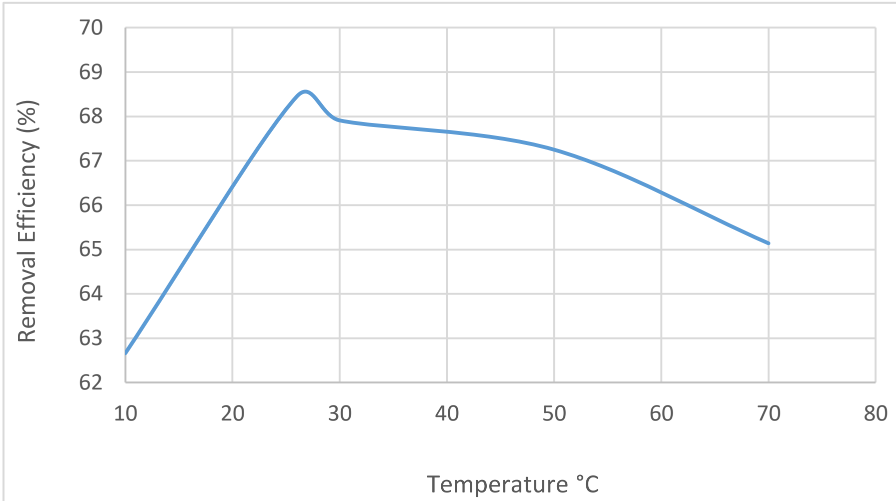

Figure 9: Temperature and removal efficiency

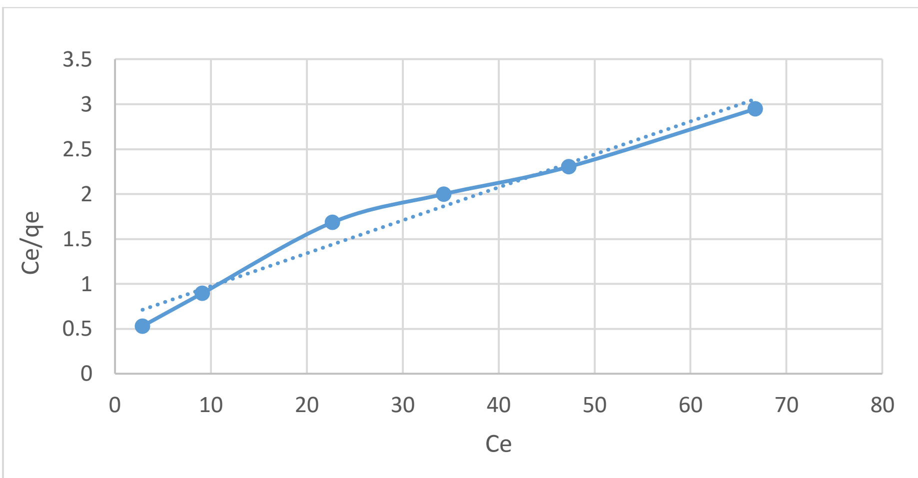

Figure 10: Langmuir linear regression

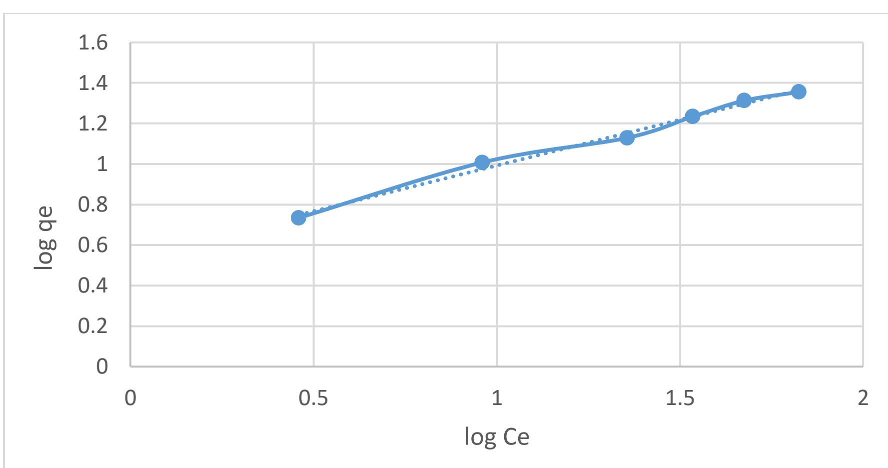

Figure 11: Freundlich linear regression.

Conclusion: The findings of this study revealed that MgO nanoparticle are excellent adsorbent for RB250. The XRD and FTIR were used for characterization of prepared MgO Nanoparticles, for determining the crystal structure , size and morphology. A series of batch experiments were carried out to examine the adsorptive removal efficiency of nanoparticles for RB250. Use of MgO nanoparticle for the removal of RB 250 is cost effective and economically viable. Replacement of costly methods and adsorbents with comparatively low cost nanoparticles and its use at large scale is recommended. MgO nanoparticles can be used to eliminate reactive dyes to great extent from textile industrial effluent.

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