RED CLAY-DERIVED NANOPARTICLES FOR REMEDIATING WASTEWATER THROUGH PHOTOCATALYTIC DYE DEGRADATION AND HEAVY METAL ADSORPTION

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Abstract: Water pollution due to industrial discharge is a critical environmental issue. These pollutants have detrimental effects on human health. This study primarily focused on the synthesis of red clay-derived magnetite (Fe_3O_4) and maghemite (γ-Fe_2O_3) nanoparticles (NPs) and investigating their remediating ability on wastewater that is contaminated by textile dyes and heavy metals. These NPs were synthesized through acid digestion of red clay, precipitating the resulting solution under alkaline conditions in the presence of sodium dodecyl sulphate, followed by calcination of the obtained product at 600°C for 4 hours. The formation of NPs was investigated by UV-visible spectrometry, which shows two characteristic peaks at 271 nm and 372 nm, that indicates the presence of γ-Fe_2O_3 and Fe_3O_4, respectively. Fourier transform infrared analysis showed characteristic bands at 617 cm^{-1} and 532 cm^{-1}, which implicates the vibrational modes of Fe—O bonds in both types of NPs. The peak pattern obtained by powder X-ray diffraction also matched the Miller indices of γ-Fe_2O_3 and Fe_3O_4. Further, the topological characteristics of NPs were studied through scanning electron microscopy. The ability of the resultant NPs on degrading textile dyes was investigated by using methylene blue (MB) dye under solar irradiation. For this experiment, the optimum conditions were found to be 4 mg of NPs in a 5 ppm MB solution at pH of 6. Photocatalytic degradation was evaluated through UV-visible spectrometric analysis over a period of 240 minutes. The obtained data showed a ~70% of photocatalytic degradation efficiency. Heavy metal removal ability of NPs was investigated by using an aqueous Pb^{2+} solution. An improved heavy metal remediation was found with an adsorption capacity of 141.08 mg g^{-1} at pH 5. Overall, these findings suggested that these red clay-derived Fe_3O_4 and γ-Fe_2O_3 NPs have the potential of treating wastewater that is contaminated by MB and Pb^{2+}.

Keywords: Nanoparticles; Magnetite; Maghemite; Methylene blue; Heavy metal