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Decontamination of Textile Dyeing Industry Effulent Using Iron Oxide Nanoparticles

KEYWORDS: Decontamination, textile dyeing effluent, iron oxide nanoparticles

M.R.Rajan	M.Khousalya	R.Ramesh
Department of Biology Gandhigram Rural Institute- Deemed University Gandhigram -634302, Tamil Nadu, India	Department of Biology Gandhigram Rural Institute- Deemed University Gandhigram -634302, Tamil Nadu, India	Department of Biology Gandhigram Rural Institute- Deemed University Gandhigram -634302, Tamil Nadu, India

ABSTRACT *The present study deals with the decontamination of Textile dyeing industry effluent using iron oxide nanoparticles. The iron oxide nanoparticles were synthesized by chemical precipitation method and characterized using SEM, EDAX and FTIR.SEM image of iron oxide nanoparticles was observed at the wavelength range from 10.87 mm, 10.91 mm, 10.86 mm and 10.94 mm. EDAX spectrum recorded on the iron nanoparticles is shown as three peaks located between 2 keV and 10 keV. The FTIR spectrum of iron nanoparticles was analyzed in the range of 400-4000 cm-1 and spectral bands were observed .Textile dyeing industry effluent was exposed to low and high dose of iron nanoparticles and sunlight for a period of half an hour. The pH of the effluent in control is 7.3 and the pH is lowered with increasing dose of iron nanoparticles. The electrical conductivity, COD and Calcium content decreased with increasing dose of iron oxide nanoparticles. From the present study, it is concluded that the iron oxide nanoparticles remove toxicants present in the textile dyeing industry effluent.*

INTRODUCTION:

Wastewater from textile industries poses a threat to the environment as large amount of chemically different dyes are used for various industrial applications and a significant proportion of these dyes enter the environment via wastewater. Around 10-15% of all the dyes used in the industry are lost within wastewater during synthesis and processing . The presence of even very low concentrations of dyes in effluent is highly visible and degradation products of these textile dyes are often carcinogenic. Many dyes are visible in water at concentrations as low as 1 mg $l^{-1.}$ There are more than 10,000 commercially available dyes with over $7x10^5$ tones of dyestuff produced annually across the world. With the increased use of a wide variety of dyes, pollution by dye wastewater is becoming increasingly alarming. Thus, there is an urgent need to develop effective methods to treat these toxic textile effluents. Biological treatment systems that can effectively remove dyes from large volumes of wastewater at low cost are preferable alternatives (Robinson et al., 2001). Nevertheless these methods merely transfer the dye to a solid phase which requires further treatment. In this context nanotechnology is currently engaged in an extended range of fields, including environmental and water treatment technology (Prema *et al.,* 2011)). Because of their relatively low cost and unique properties such as large surface area, high reactivity, high specificity, self-assembly and dispensability nanoparticles have promising perspectives for Textile dyeing effluent treatment. Among the various oxide nanoparticles, Iron Oxide Nanoparticles have unique properties of small size, larger special surface area and magnetic property and useful in Environmental Applications. Therefore, Iron oxide nanoparticles can be used as a potential Nano adsorbent for Textile dyeing effluent treatment. Due to the high surface area, good absorbing capacity and a nature of catalyst, the synthesised iron oxide nanoparticles was used in the decolorization of Textile dyeing Industry effluent. Hence, the present study is aimed at investigating the effectiveness of the magnetic iron oxide nanoparticles for the decontamination of Textile dyeing effluent .

MATERIALS AND METHODS

Ferrous chloride ($Fecl_2$) and Sodium hydroxide was purchased from Loba chemie, India .

The precipitation method was adopted for synthesis of iron oxide nanoparticles. Synthesized iron oxide nanoparticles were characterized by using Scanning Electron Microscopy (SEM), Energy Dispersive X-Ray Spectroscopy (EDX) and Fourier Transform Infrared Spectroscopy (FTIR).The physico – chemical parameters were determined using standard methods (APHA,2012) .

Role of iron oxide nanoparticles(Dosage- 250&500 mg) on physical-chemical parameters of textile Dyeing Industry effluent:

The role of different dose(250&500mg) of iron oxide nanoparticles on the physico-chemical parameters of Textile Dyeing Industry effluent such as colour, pH, electrical conductivity, COD and calcium were estimated after exposing the effluent in the sunlight for a period of half an hour.

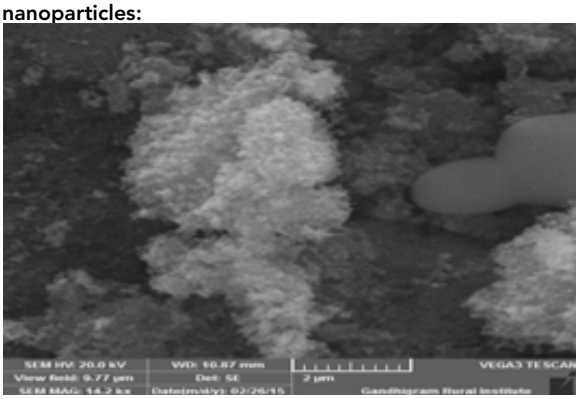
RESULTS AND DISCUSSION:

Scanning Electron Microscopy:

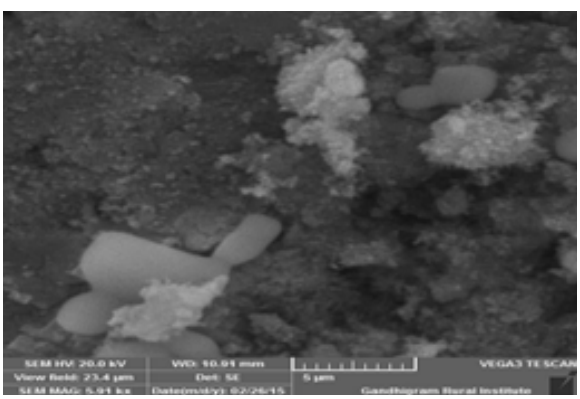
The SEM image (Fig.1) showing the high density chemical synthesized Fe_3O_4 further confirmed the development of iron oxide nanostructures. Obtained nanoparticle showed that hexagonal and spherical in nature. The microscopic image shows that the Fe_3O_4 nanoparticles did not appear as discrete particles but form much larger dendritic flocks whose size could reached micron scale size range about 10.87 mm (scale bar 2µm), 10.91mm (scale bar 5µm), 10.86mm (scale bar 10µm), 10.94mm (scale bar 20µm)for Fig. 1a,b,c and d respectively.

Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

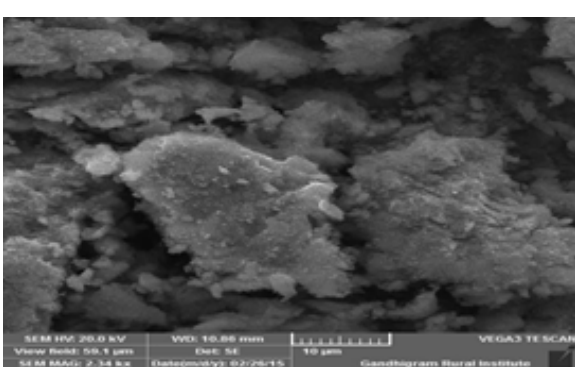
Fig1.Scanning Electron Microscopy Image on iron oxide nanoparticles:



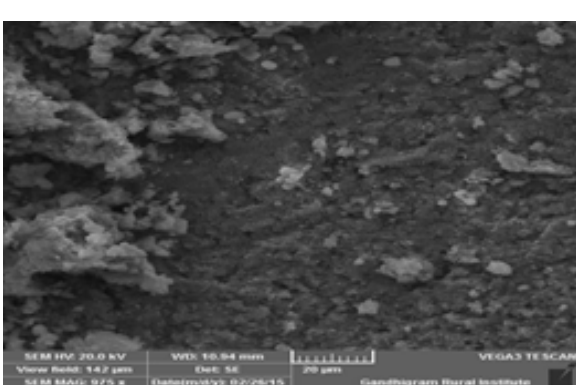
a)2µm of iron nanoparticles



b)5µm iron nanoparticles



c) 10µm of iron nanoparticles



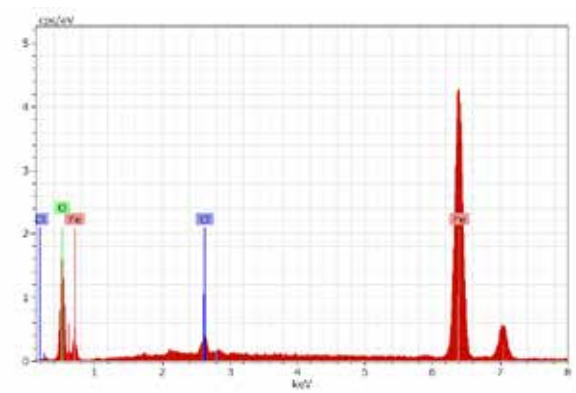
d) 20µm of iron oxide nanoparticle

The reaction between ferrous chloride occurs within a few minutes at room temperature by increasing the pH and indicated by color changes from brown to black color .The high density of iron oxide nanoparticles was assumed by SEM. Obtained nanoparticles showed that hexagonal and spherical in nature.(Poedji Loekitowati Hariani *et al.*, 2013).Analysis of the SEM image of synthesized iron oxide nanoparticles, showed a clear image of the nanoparticles ranges from 30 nm to 110 nm. However the percentage of nanoparticles beyond 100 nm is very less. The average percentage of nanoparticles present in the synthesized sample is 66 nm. From the image,it is confirmed that the sample contains various sizes of nanoparticles which are indeed agreement with the result obtained from DLS particle analyses(Behera *et al.*,2012).

EDX spectroscopy:

EDX spectrum recorded on the iron oxide nanoparticles is shown as three peaks located between 2 KeV and 10 KeV(Fig. 2) Those maxima are directly related to the iron characterized lines K. The maximum peak located on the spectrum at 6.4 KeV clearly coming from iron. The second maximum peak located on the spectrum at 0.3 KeV clearly indicates comes from oxygen. Third peak located at 2.6 KeV are connected with the oxygen characteristics line. The Chemical synthesized iron nanostructure by employing textile dye effluent was further demonstrated and confirmed by the characteristic peaks observed in the EDX image.

Fig2.Energy Dispersive X-Ray Spectroscopy (EDX) Image:

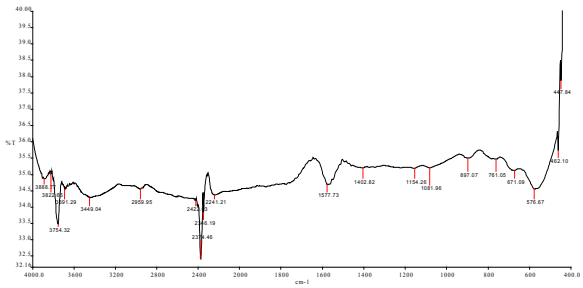


Fourier Transform Infrared Spectroscopy (FTIR):

75 minutes after the decolourization reaction, particulate materials were collected by centrifugation and removed from supernant solution. The collected particles were vacuum dried at 60°C for 6 hours and characterized by FT-IR spectroscopy. By FT-IR technique we can identify groups of the degraded product of dyes on the iron nanoparticle surface. The infrared spectra of nanoparticles before and after the decolourization process were observed the range of 4000-400 cm^{-1}. The iron oxide nanoparticles after decolourization including the vibration at 3754.32 cm^{-1},2374.46cm^{-1},2241.21 cm-1, 462.10 cm^{-1},447.84 cm^{1},respectively(Fig. 3). The above findings suggest that some amount of degraded product gets attached on the surface of the nanoparticles.

Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

Fig 3.Fourier Transform Infrared Spectroscopy (FTIR) Image:



Physico-chemical parameters textile dyeing Industry on Low and High concentration of iron oxide Nanoparticles:

Physico- chemical parameters of textile dyeing industry effluent on Low and high dose of iron oxide nanoparticles exposed to sunlight is presented in Table 4.The colour of the effluent is reddish brown, light brown and no colour for control, low and high dose iron oxide nanoparticles respectively (Fig.4).The pH in control is 7.3 and the pH decreased with increasing dose of iron nanoparticles. The electrical conductivity is 2900,2200 and 1600 in control, low and high dose respectively. Like electrical conductivity the COD and Calcium content in the effluent decreased with increasing dose of textile dyeing industry effluent.

The result indicated that iron oxide nanoparticles was effective to reduce the colour, pH,electrical conductivity COD and calcium chemically synthesized iron nanoparticles can be used for the removal of contaminants present in the textile dyeing industry effluent. Kale et al (2014) reported the decolorization of dye using nickel nanoparticles. Fan et al (2009) also reported the rapid decolorization of azo dye methyl orange in aqueous solution by nanoscale zerovalent iron particles. From the present study, the physico-chemical parameters were reduced with increasing dose of iron oxide nanoparticles.

Fig 4 .Decolourization of textile Dyeing effluent Industry using iron oxide nanoparticles:

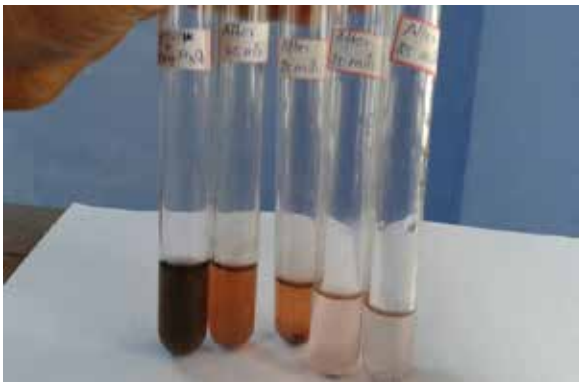


Table 2. Physico-chemical parameters textile dyeing Industry on Low (250mg) and High (500 mg) concentration of iron oxide Nanoparticles exposed to sunlight

Parameters	Control	Iron oxide nanoparticles concentration	
		Low (250 mg)	High (500mg)
Colour	Reddish Brown	Light brown	Nil
pH	7.3	6.03	5.26
Electrical conductivity	2900	2200	1600
COD	402	300	165
Calcium	14.96	9.01	6.68

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