ADVANCED OXIDATION PROCESS FOR THE DECONTAMINATION OF TETRACYCLINE FROM WASTEWATER USING IMMOBILIZED MAGNETITE

VINCY ANTONEY[1], GAYATHRI P V[2,*], DIVYA NAIR[3], TELSA. T[1], SREELAKSHMI M.G[1], SNEHA V.S[1], and THARA SURENDRAN[1]

[1] Department of Chemistry, St. Albert's College, Kochi, India 682018, Low Carbon Technology and Sustainable Chemistry Alma Mater Studiorum - Universit`a di Bologna

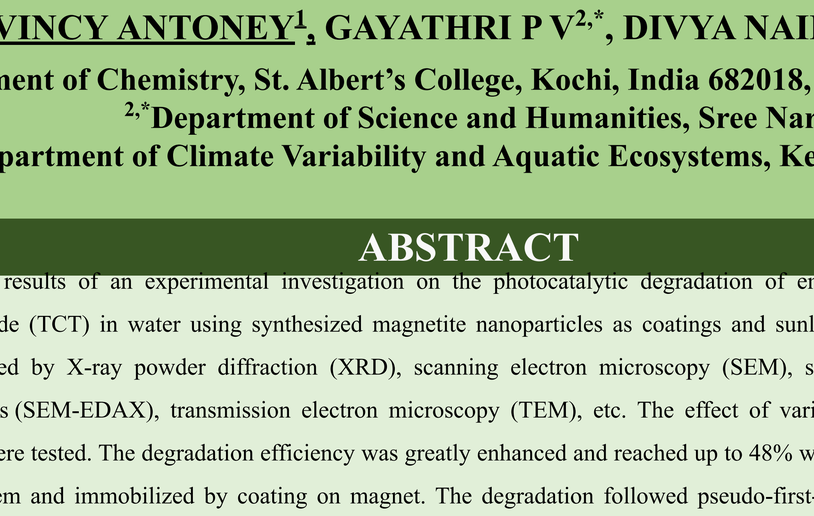
[2,*]Department of Science and Humanities, Sree Narayana Gurukulam College of Engineering, Kadayirippu, Ernakulam, India 682311

Department of Climate Variability and Aquatic Ecosystems, Kerala University of Fisheries and Ocean Studies (KUFOS), Puduveypu P O, Kochi, India 682508

Email: gayathripv@sngce.ac.in

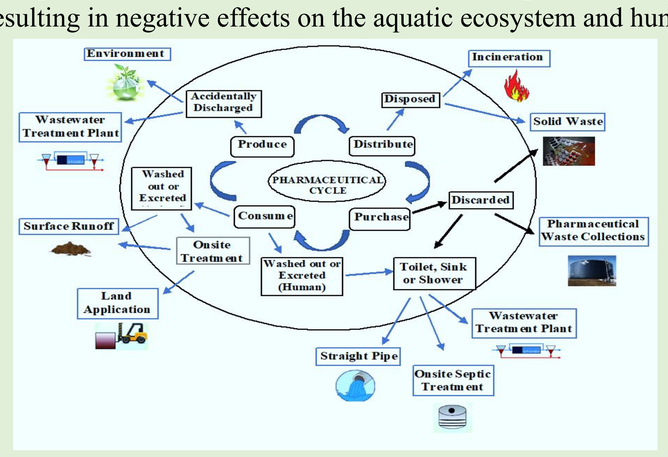
ABSTRACT

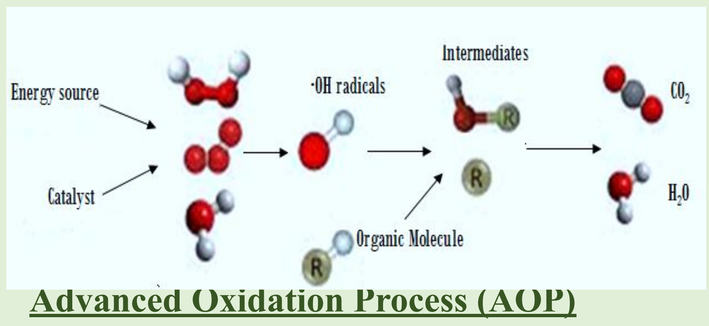
The paper presents the results of an experimental investigation on the photocatalytic degradation of emerging pharmaceutical contaminant Tetracycline hydrochloride (TCT) in water using synthesized magnetite nanoparticles as coatings and sunlight (SL) as the energy source. The catalyst was characterized by X-ray powder diffraction (XRD), scanning electron microscopy (SEM), scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDAX), transmission electron microscopy (TEM), etc. The effect of various operatational parameters on the degradation efficiency were tested. The degradation efficiency was greatly enhanced and reached up to 48% within 30 minutes when magnetite was introduced into the system and immobilized by coating on magnet. The degradation followed pseudo-first-order kinetics. The effect of Fenton Reagent (FR) on the TCT degradation efficiency was tested. With the increase in time, complete (100%) degradation of TCT was observed for the system with FR and 88% for the system without FR. The results suggest the possibility of using inexpensive natural, non-renewable solar energy to purify TCT-contaminated water, thereby enabling the reuse of scarce water resources. The results proved the possibility of using inexpensive natural, non-renewable solar energy combined with immobilized magnetite to purify TCT-contaminated water, thereby enabling the reuse of scarce water resources.



INTRODUCTION

Overproduction and extensive use of chemical pollutants especially pharmaceuticals is a serious issue throughout the world resulting in negative effects on the aquatic ecosystem and humans.





Advanced Oxidation Process (AOP)

EXPERIMENTAL

Synthesis of catalyst Magnetite: Precipitation method

81 g $FeSO_4 7H_2O$ was dissolved in 100 ml of distilled water. The solution is homogenized. 2 $mol.L^{-1}$NaOH solution is slowly added until pH is 11 to obtain a precipitate of iron oxide and oxyhydroxide. The system is placed in the water bath at 98^{0C} to complete the precipitation reaction. Theprecipitate is separated by several washings with distilled water and dried.

Figure 1: Magnetite catalyst obtained from the reaction of Fe^{2+} ions and OH ions, exposed in the magnet field of a magnet

Solar photocatalysis:

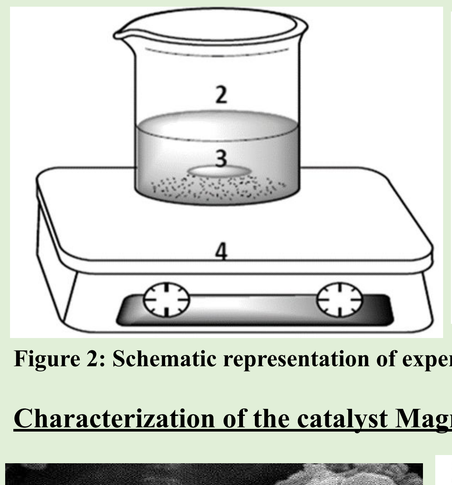
Step I: 25 ml of 20 ppm TCT sample is taken and 0.005 g/ml Magnetite is added to it.

Step II: The Magnetite is coated on a magnetic surface which offers an environmentally friendly approach to purifying the organic compounds.

Step III: Fenton reagent is added and degradation of the sample solution is noted in the presence of immobilized catalyst and solar energy.

Step IV: The experiment is conducted by providing continuous shaking under sunlight between 10 a. m -to 2 p.m. on sunny days.

Step V: The degradation efficiency is noted using a UV-visible spectrophotometer at 360 nm.



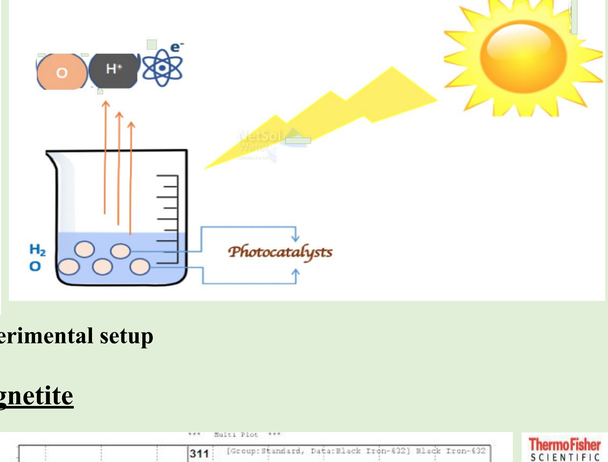


Figure 2: Schematic representation of experimental setup

Characterization of the catalyst Magnetite

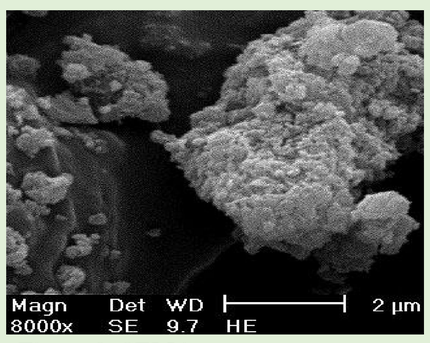


Figure 3: SEM image

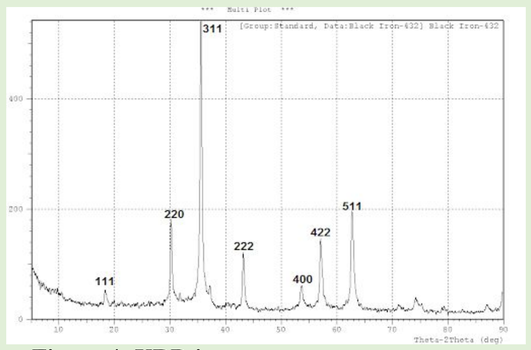


Figure 4: XRD image

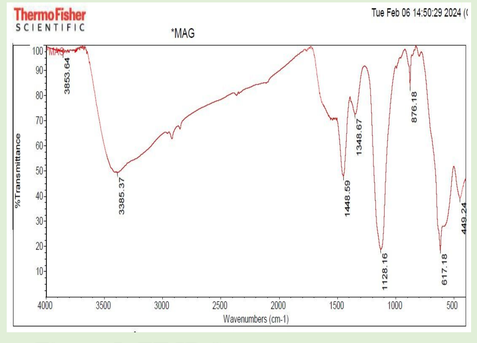
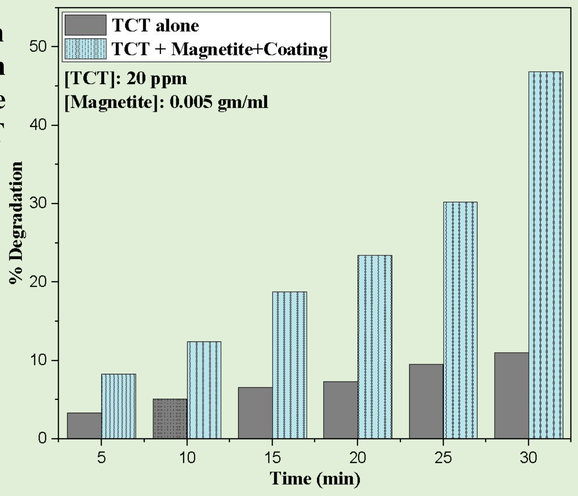


Figure 5: FT-IR Spectra

RESULTS & DISCUSSION

Effect of sunlight on the degradation of Tetracycline

Figure 6: The results of effect of sunlight on tetracycline showed high degradation efficiency in the case of magnetite immobilized with coating compared to TCT alone under same conditions



Absorbance vs Concentration graph

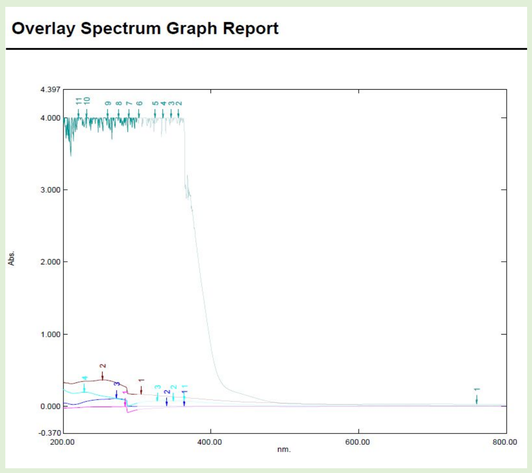
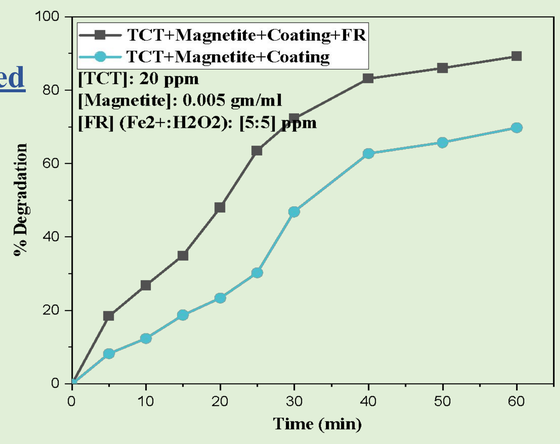


Figure 7: Spectrum showing the degradation efficiency of different systems after 240 min of solar irradiation

Effect of Fenton Reagent on immobilized catalyst

Figure 8: The effect of Fenton Reagent on degradation of Tetracycline using Magnetite coating under sunlight.

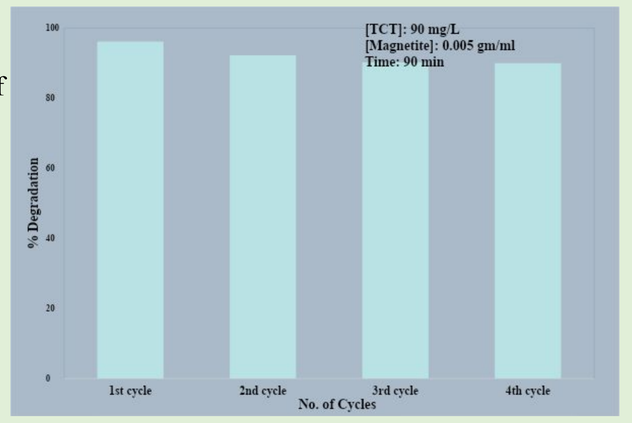
The degradation efficiency of Tetracycline enhanced in presence of Fenton Reagent and the catalyst.



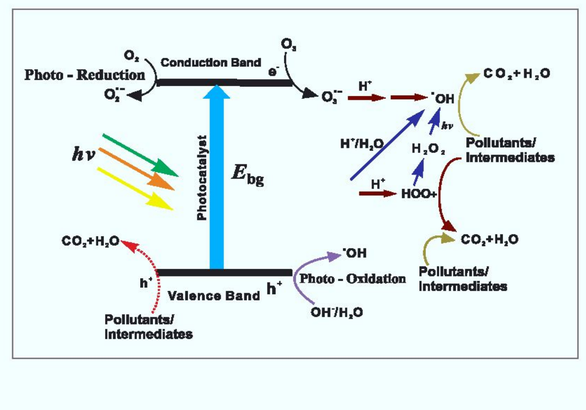
Recycling of used catalyst:

The efficiency of the process depends on the catalyst Magnetite. The potential of reuse of the catalyst is important from the environmental and economic angles. The efficency remains the same even after repeated use of catalyst.

Figure 9: The efficiency of degradation of Tetracycline after repeated cycles under sunlight



GENERAL MECHANISM



CONCLUSION

- **Results of photocatalysis (solar/magnetite) show the potential of the process for the decontamination of water from Tetracycline with degradation of 48% within 30 min and 99% within 120 min.**
- **The results conclusively establish that the synthesized magnetite is a highly efficient photocatalyst.**
- **The Fenton reagent enhanced the degradation efficiency of the TCT/magnetite system manyfold.**
- **Relevant parameters, identified as important from the investigations need to be further optimized and scaled up for commercial application.**
- **The potential of recycling synthesized magnetite is investigated and proved. Recycling of catalyst was possible even after 4 cycles of analysis. It offers an environment-friendly solution to the world.**
- **The application of natural solar energy as the source of activation makes the process especially relevant for the inexpensive and environment-friendly removal of toxic pollutants such as pharmaceuticals from water.**

REFERENCES

Yi, X.H., Ji, H., Wang, C.C., Li, Y., Li, Y.H., Zhao, C., Wang, A., Fu, H., Wang, P., Zhao, X. and Liu, W., 2021. Photocatalysis-activated SR-AOP over PDINH/MIL-88A (Fe) composites for boosted chloroquine phosphate degradation: Performance, mechanism, pathway and DFT calculations. *Applied Catalysis B: Environmental*, *293*, p.120229.

Midassi, S., Bedoui, A. and Bensalah, N., 2020. Efficient degradation of chloroquine drug by electro-Fenton oxidation: Effects of operating conditions and