International Journal of Geology, Earth and *Environmental Sciences ISSN: 2277-2081 (Online)*
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2014 Vol. 4 (1) January-April, pp. 196-201/Dahiwelkar and Husain
Research Article

PHOTO-CATALYTIC REMOVAL OF DETERGENT FROM SULLAGE

***Sanjaykumar Dahiwelkar[1] and Mujahid Husain[2]**
College of Engineering, Shahada, MS, India
Civil Engineering, SSBT's College of Engineering & Technology, Bambhori, Jalgaon, MS, India
**Author for Correspondence*

ABSTRACT
Photo-catalysis has emerged as a powerful technological boon to ultimately decompose and recycle the non-biodegradable organics. Detergents that are considered to be stringently non-biodegradable or sparingly degradable are severe concerns for the agriculturists as they gradually render the soil unfit for agriculture. The present research study has applied photo-catalysis technology to degrade commercial detergents available in the sullage (washroom wastewater) of the residential campus of an engineering college. The COD (Chemical Oxygen Demand) has been taken as a parameter for monitoring the degradation rate of detergent. Photo-catalyst used is TiO_2. The degradation studies are conducted under artificial source of UV radiations in an indigenously designed reactor. Dose of photo-catalyst is varied and optimized. It has been observed that the COD has been effectively brought down to the level of 40 mg/L with an optimal dose of 35 mg/L photo-catalyst. The sullage is rendered to be fit for gardening applications. The research outcomes find significant applications in the recycling of sullage for gardening and irrigation applications and will save huge amount of water and electricity both.

Keywords: *Sullage Recycling, Photo-Catalysis, Water Conservation*

INTRODUCTION
Till 1960s BOD was the most important parameter of concern in wastewaters (Metcalf *et al.,* 2002). However with the advancement in science and technology, the synthesis of variety of non-biodegradable organics has become very common. They have become integral part of our day to day life. The concentration of detergents, variety of cleansers used in households, pesticides, fertilizers, insecticides, plastic traces, polythene traces etc is increasing in wastewaters rapidly. They are non-biodegradables and are persisting in nature. They create difficulties in conventional wastewater treatment. They join food chains and accumulate in human bodies exhibiting long term disorders. Conventional technologies for removal of non-biodegradable organics are quite inefficient. However, photo-catalysis has emerged a powerful boon for degradation of non-biodegradable organics (Somorjai *et al.,* 1989). Detergent is one such commonly used non-biodegradable organics which is commonly present in domestic wastewaters, and laundry wastewaters.

With rising population and over exploitation, the water resources are depleting day by. There is great need for recycling of water. Sullage is the wastewater generated from bathrooms (Steel *et al.,* 1985). It is rich in terms of urine but BOD is not high. It also contains significant quantity of detergents. At may water scarce places the sullage is recycled for gardening applications. However the detergents present in the sullage affect to the fertility of soil in long term. Thus they require to be removed. Photo-catalysis can be applied for removal of detergents from sullage as well as from various wastewaters. The present work explores the photo-catalysis technology for treatment of detergent containing wastewaters. Some parameters of process are investigated experimentally and optimized for highest rate of degradation.

Detergents and their Chemistry
In a dictionary detergent is simply defined as cleaning agent. However, the word detergent has tended to imply synthetic detergents specifically, generally termed as surface-active agent or surfactant. The synthetic detergents are made from petrochemicals (Tyebkhan G 2002). Synthetic detergents dissolve or tend to dissolve in water or other solvents. To enable them to do this, they require distinct chemical characteristics. Hydrophilic (water loving) groupings in their molecular structure, and hydrophobic (water hating) groupings, help the detergent in its "detergency" action. This detergency depends on the balance

of the molecular weight of the hydrophobic to the hydrophilic portion. This is called the HLB value. There are four main classes of detergents, anionic, cationic, onionic, mphoteric.

Problems due to Detergents in Wastewater

Detergents pose a variety of problems in the wastewater treatment. They are surfactants. Thus they hinder the transfer of oxygen from atmosphere to the water in the process of aeration. They reduce the oxygen transfer efficiency to 15%. The hinder the biological treatment also. They trap the colloidal particles and keep them on surface thus reducing the efficiency of coagulation. Once they find a way in to surface of sub-surface waters, they join to food chain. They accumulate in body and exhibit long term disorders like carcinogentity, mutagenicity, fertility loss, loss of potency, allergy etc in long term. During coagulation of water they form halides. The above-mentioned bad effects are even exaggerated.

Limitations of Conventional Wastewater Treatment Technologies in Detergent Removal

The linear alkyl sulfonates are biodegradable under aerobic conditions, but not in anaerobic conditions. The benzyl sulfonates are strongly resistant to biodegradation. Generally the removal of detergents from wastewater is favored by methods like adsorption. But these methods simply transform the problem from one phase to another. They do not solve the problem. The final disposal of solid sorbent material containing detergents is again a problem. From this bulk, detergents may again find way in to surface and sub-surface waters.

The Photo-Catalysis Technology

The photo-catalysis is a phenomenon recognized by Fujishime (1972). Blake *et al.,* (1991; 1996) described the reactor design and process parameter aspects in his bibliographic work: semiconductors have a property that they emit an electron when light wave of appropriate wave length fall upon them. Some of the common conductors are Titanium di oxide, silicon di oxide, zinc oxide etc. Titanium di oxide is considered to be the most active. TiO_2 emits electron when UV radiation falls on it which ultimately results into hydroxyl radical formation (Turchi *et al.,* 1990):

$TiO_2 + UV = TiO_2^+ + e$

$H_2O = H^+ + OH^-$

$OH^- - e + TiO_2^+ = TiO_2 + OH^*$

$OH^* +$ organic compound = products of mineralization

The UV radiation is obtained from sun or it can be obtained from UV lamps.

Review of Research in Photo-Catalysis

The process has so many variables listed as- pH, temperature, intensity of light, concentration of organic compound, concentration of catalyst, specific surface area of catalyst etc. The process is complex and is still in nascent stage for degradation kinetics modeling (Okamoto *et al.,* 1985a; Okamoto *et al.,* 1985b). Alberici *et al.,* (1997) have used this technology for removal of VOCs. Brillas *et al.,* (1998) presented a scientific look into the process and described the electron transfer phenomenon. Augugliaro *et al.,* (1999) and Cao *et al.,* (2000) applied the process for treatment of toluene in gaseous phase. Alex *et al.,* (2003) used this technology for removal of benzoic acids using specially designed cascade reactor configuration. Later researchers showed interest in the investigations of formation of intermediate products of the process too Pal *et al.,* (2000). Al Hakimi *et al.,* (2003) applied photo-catalysis technology for treatment of industrial wastewaters. Alpert *et al.,* (1991) treated hazardous waste using photo-catalysis. Chong *et al.,* (2010) has presented a review of recent developments in photo-catalysis technology. In fact the great deal of research going on in the arena of photo-catalysis can be described by the bibliography given at the end. The present work proposes to use the same technology for removal of detergents from sullage.

MATERIALS AND METHODS

The detergent used for experimental studies is commercial detergent available from the local market in the brand name of *Nirma*. It is dissolved in distilled water to obtain desired concentrations. The photo-catalyst used is Qualigens grade. The indigenously designed reactor is as shown in the figure 1. Figure 2 gives the inside view of the same. The reactors are provided with mercury vapor lamps - Narva UVK-125 W (Germany) having peak wavelength at 332 nm.

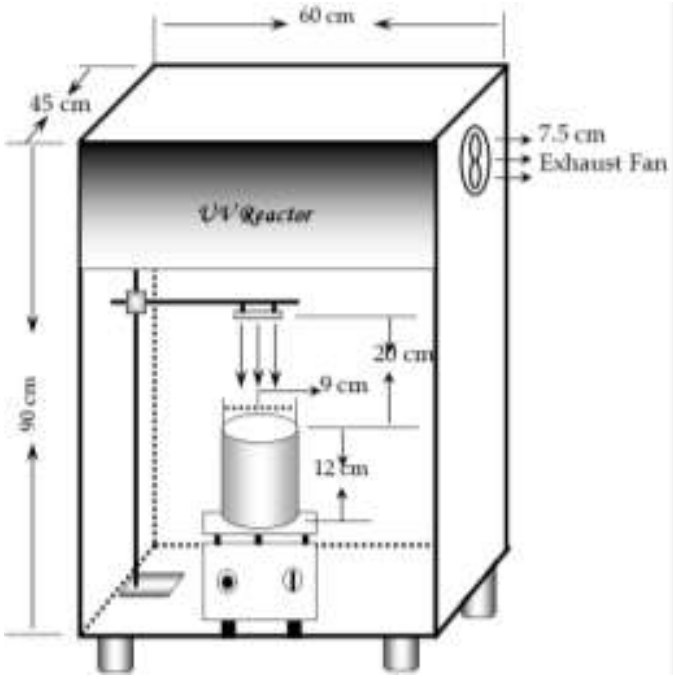

Figure 1: Schematics of slurry type reactor

Figure 2: Inside view of slurry type reactor

RESULTS AND DISCUSSION

The present work has focused on optimization of the most crucial parameter of the process that is catalyst concentration. The same has been varied in the range 25 to 45 mg/L and the COD removal with time is observed. The results are depicted in figure 3 to 7:

The overview of figures from 3-7 makes it evident that the TiO_2 is a powerful photo-catalyst to decompose detergent. In fact as the process has used commercial detergent, which is not 100% pure. As per the technical information provided by the producer of the Nirma detergent, it is only 11% detergent and rest is boosters, binders, enzymes and some base materials including aromatic compounds. The COD is a combined parameter that takes into account all organics together. The figures also indicate that the catalyst concentration has a profound effect on the degradation rate. 35 mg/L catalyst concentration has come out to be the optimum as it results into the minimum COD.

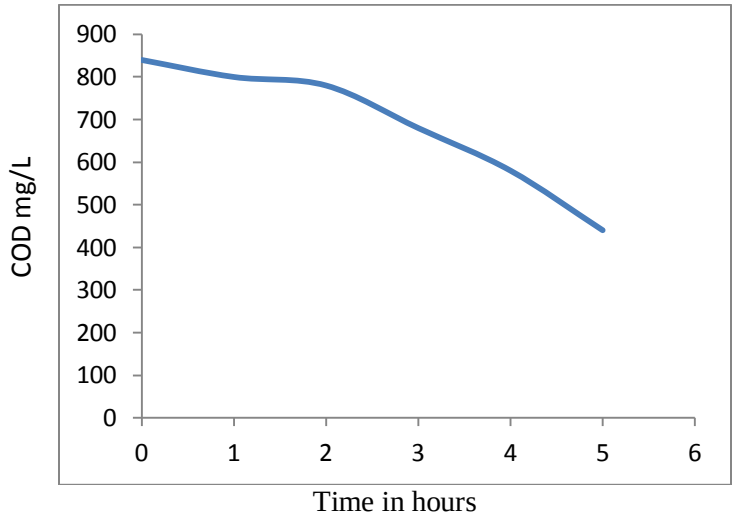

Fig 3: COD Removal with time, catalyst concentration is 25 mg/L

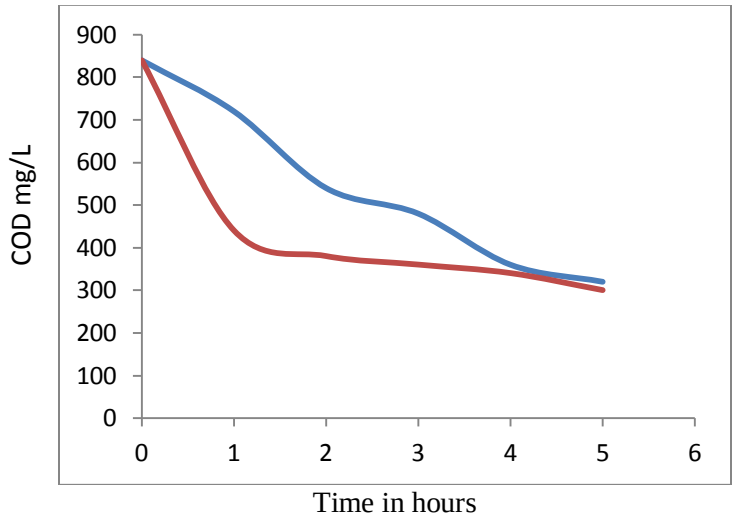

Fig 4: COD Removal with time, catalyst concentration is 30 mg/L

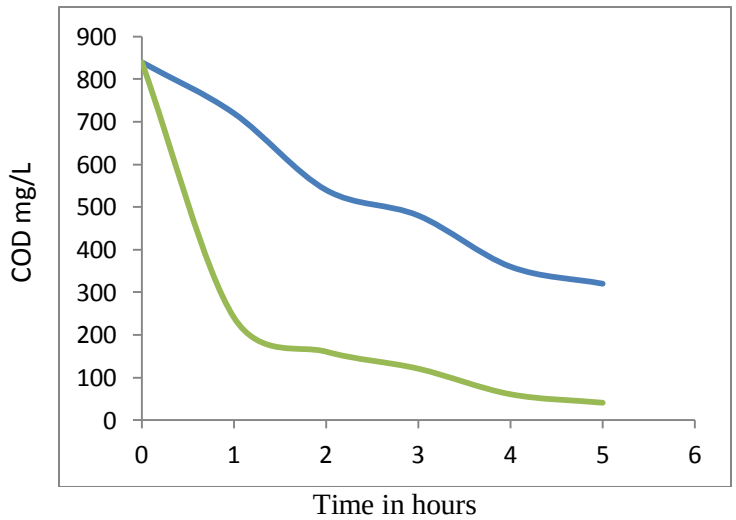

Fig 5: COD Removal with time, catalyst concentration is 35 mg/L

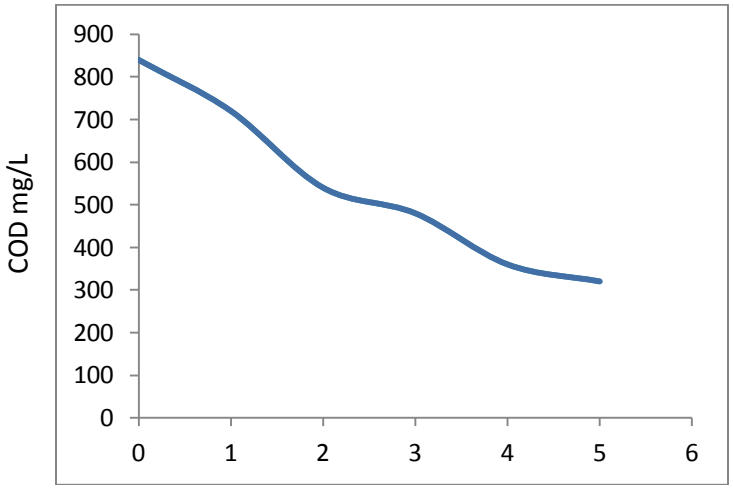

Fig 6: COD Removal with time, catalyst concentration is 40 mg/L

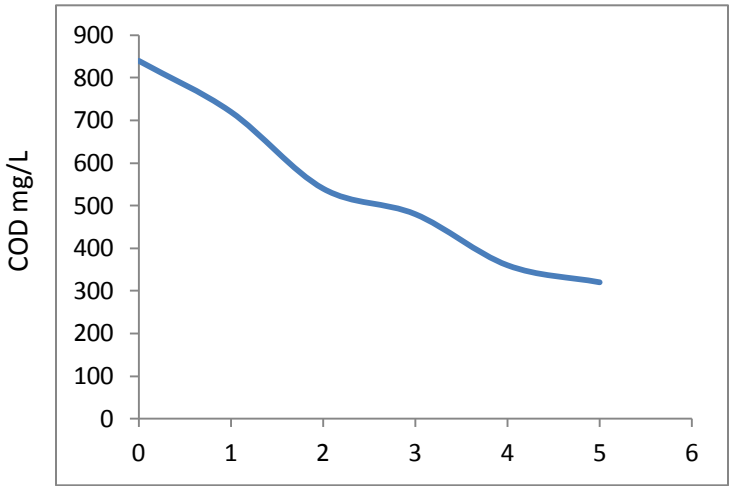

Fig 7: COD Removal with time, catalyst concentration is 45 mg/L

The catalyst concentration has complex effect on degradation of organics. As the degradation reaction takes place on the surface of the catalyst, the higher surface area will obviously have high degradation rate. In consequence, it requires higher concentration of the catalyst. However. The reaction is driven by UV radiation. Hence its penetration in the liquid slurry is also equally important. The higher concentration of the catalyst can hinder the radiation penetration, resulting into lowered reaction rate. Hence, an optimization is required. In the present study, the optimal catalyst concentration comes out to be 35 mg/L. it must be recognized that the optimum dose is subjected to other variable combinations like pH, intensity of light, initial organic concentration etc.

Conclusions

Photo-catalysis is an effective method of removal of detergents from water. The method can be effectively applied for sullage which is produced in large quantity from residential areas and campuses. It can be easily recycled for irrigation applications. The laundry wastewaters are rich in terms of detergents. They can also treated by this method. The present work has optimized the catalyst concentration for degradation of detergent, the future researchers may like to optimize other parameters also for the same.

REFERENCES

Alberici Rosana M and Wilson F Jardim (1997). Photocatalytic destruction of VOCs in the gas-phase using titanium dioxide. *Applied Catalysis B: Environmental* **14** 55-68.

Alex HC, Chak K Chan, John P Barford and John F Porter (2003). Solar photocatalytic thin film cascade reactor for treatment of benzoic acid containing wastewater. *Water Research* **37** 1125–1135.

Alpert Daniel J, Jeremy L Sprung, James E Pacheco, Michael R Prairie, Hugh E Reilly, Thomas A Milne and Mark R Nimlos (1991). Sandia National Laboratories' work in solar detoxification of hazardous wastes. *Solar Energy Materials* **24** 594-607.

Augugliaro Vincenzo, Coluccia S, Loddo V and Schiavello M (1999). Photocatalytic oxidation of gaseous toluene on anatase TiO_2 catalyst: mechanistic aspects and FT-IR investigation. *Applied Catalysis B: Environmental* **20** 15-27.

Blake Daniel M (1996). Bibliography of work on the heterogeneous photocatalytic removal of hazardous compounds from water and air. Update No. 2 To October 1996, NREL, Golden Co, Technical Information Service, US Department of Energy, Springfield.

Blake Denial M, John Webb, Craig Turchi and Kimberly Magrini (1991). Kinetic and mechanistic over view of TiO_2-Photocatalyzed oxidation reactions in aqueous solution. *Solar Energy Materials* **24** 584-593.

Brillas Enric, Eva Mur, Roser Sauleda, Laura Sanchez, Jose Peral, Xavier Domenech and Juan Casado (1998). Aniline mineralization by AOP's: anodic oxidation, photocatalysis, electro-fenton and photoelectro-fenton processes. *Applied Catalysis B: Environmental* **16** 31-42.

Cao Lixin, Zi Gao, Steven L Suib, Timothy N Obee, Steven O Hay and James D Freihaut (2000). Photocatalytic oxidation of toluene on nano-scale TiO_2 catalysts: studies of deactivation and regeneration. *Journal of Catalysis* **196**(2) 253-261.

Fujishime Akira and Rao Tata N (1998). Interfacial photochemistry: fundamentals and applications. *Pure and Applied Chemistry* **70**(11) 2177-2187.

Hakimi Gamil, Lisa H Studnicki and Muftah Al-Ghazali (2003). Photocatalytic destruction of potassium hydrogen phthalate using TiO_2 and sunlight: application for the treatment of industrial wastewater. *Journal of Photochemistry and Photobiology A: Chemistry* **154** 219–228.

Meng Nan Chong, Bo Jin, Christopher WK Chow and Chris Saint (2010). Recent developments in photo-catalytic water treatment, technology: A review. *Water Research* **44** 2997- 3027.

Metcalf and Eddy Inc (2002). *Wastewater Treatment, Disposal and Reuse* 4edition (Tata McGraw Hill Publication, New Delhi).

Okamoto Ken-ichi Yasunori Yamamoto, Hiroki Tanaka, Masashi Tanaka and Akira Itaya *et al.*, (1985a). Heterogeneous photocatalytic decomposition of phenol over TiO_2 powder. *Bulletin Chemical Society Japan* **58** 2015-2022.

Okamoto Ken-ichi, Yasunori Yamamoto, Hiroki Tanaka and Akira Itaya *et al.*, (1985b). Kinetic of heterogeneous photocatalytic decomposition of phenol over anatase TiO_2 powder. *Bulletin Chemical Society Japan* **58** 2023-2028.

Pal Bonmali and Maheshwar Sharon (2000). Photodegradation of polyaromatic hydrocarbons over thin film of TiO2 nanoparticles; a study of intermediated photoproducts. *Journal of Molecular Catalysis A: Chemical* **160** 453-460.

Somorjai GA, Serpone N and Pelizzetti E (1989). *Photocatalysis- Fundamentals and Applications Hand Book* chapter 9 (Wiley-Interscience, New York).

Steel EW and Terence J McGhee (1985). *Water Supply and Sewerage* 5edition (McGraw Hill Publishing Co., New York).

Turchi Craig S and David F Ollis (1990). Photocatalytic degradation of organic water contaminants: mechanisms involving hydroxyl radical attack. *Journal of Catalysis* **122** 178-192.

Tyebkhan G (2002). Skin cleansing in neonates and infants-basics of cleansers. *Indian Journal of Pediatrics* **69**(9) 767–9.