# Assessing the Degradation of Organics in Surgical Cotton Processing Wastewater by Mixed Microbial Culture and Photo-Catalysis

**Karthika A, Karthike R, Swaminathan M, Naresh Kumar Sharma**

***Abstract*: *Cotton bandage processing textile industry is the major manufacturing product of Rajapalayam town in south Tamilnadu, India. Processing of surgical cottons consumes significant amounts of water during manufacturing, creating high volumes of wastewater which cannot be discharged without proper treatment. The complete oxidation of organic pollutants in such waste water remains a significant environmental issue. This research investigates different treatment methods like biodegradation and photo catalytic degradation to identify the most efficient and effective approach to treat cotton bandage textile wastewater. Chemical Oxygen Demand (COD) analysis was carried out to quantify and observe the amount of oxidizable pollutant in the waste water with different treatment methods. In photo catalytic degradation process different semi-conductor metal oxide nano particles like Titanium dioxide ($TiO_2$), Zinc Oxide (ZnO) and Bismuth Vanadium oxide ($BiVO_4$) were used. Comparing the three nanoparticles; $TiO_2$ proved to be the efficient one, which reduced the COD of the effluent significantly. For Biodegradation aerobic activated sludge was used to treat the cotton bandage textile waste water in along with mineral salt media. By comparing both photocatalytic degradation and biodegradation process, photo catalytic method was found to be efficient for treatment of organics in real cotton bandage processing effluent.***

***Key words: Photocatalysis, Aerobic biodegradation, Cotton processing waste water, surgical cotton wastewater, Chemical Oxygen Demand.***

## I. INTRODUCTION

Surgical cotton bandages (textile fabrics) are common household kit in the medical first aid boxes and are globally used in pharmaceutical and health care units to offer heat, insulation and support in many medical situations. Chatrappati village and Rajapalayam town in southern Tamilnadu comprises of more than 150 crepe bandage textile units in operation for more than three decades and exports tonnes of surgical cottons. Many units in this village are operated on continuous basis and therefore the amount of wastewater generated and its treatment is of critical importance. Excess of biomass sludge washout have been observed in the treatment units due to the recalcitrant and toxic nature pollutants present in this wastewater. (Georgiou et al., 2012). Surgical cotton textile materials are processed in following steps: knitting griege fabric, desizing, keiring, bleaching, mercerization, printing and finishing (Fig. 1). Generally, surgical cotton units do not use dyeing agents and the water discharged from these processing units are devoid of dye compounds.

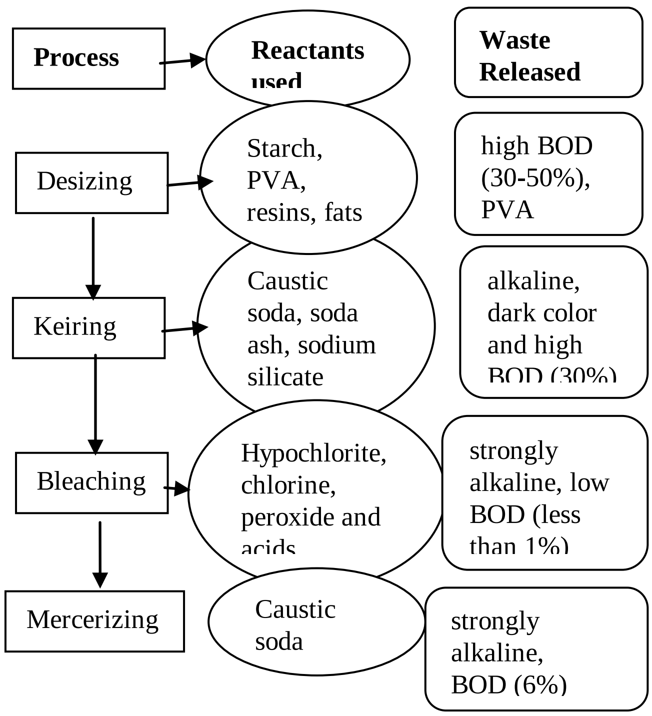


**Fig 1: Surgical cotton processing steps, reactants used and possible pollutants at each unit operation**

The effluent, however constitutes caustic soda, detergent, sodium and other chemicals which can increase the COD valve of water body if the effluent is not treated. Photo catalysis is the process uses to degrade organic pollutant using catalyst. The process involves using light Sunlight and ultraviolet light depending on the energy gap of the catalyst in use. Nanoparticles exploit photocatalytic property of metal oxides to generate hydroxyl radicals and have great potential to be used in waste water treatment. These methods are more cost-effective, less time and energy consuming with very less waste generations

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(EL-Mekkawi et al., 2016; Li et al.2012).

Aerobic wastewater treatment is a process where bacteria utilize oxygen to degrade organic matter and other pollutants involved in various production systems. A study by Sivakumar et al., (2011) showed the inadequacy of many textile effluent treatment plants to meet the discharge limits set by IS (201:2009). Their findings revealed that textile bleaching industries at Karur, Tamil Nadu, could cause severe pollution problems since the parameters measured have values above the tolerable limits compared to the world health organization (WHO) standards (Sivakumar et al., 2011). Similarly, Patel and pande, (2013) showed that the effluent treatment plant from clusters of textile industries in Gujarat had low performance efficiency especially with respect to dissolved solids, metals and organics. The main reasons for plant failure are due to presence of excess ions (evident from the high conductivity of untreated effluent), low BOD: COD ratio (toxic to micro-organisms in secondary treatment), high metal concentration and different operating conditions than that of the designed values. In a recent study, Georgiou (2012) showed that huge quantities of chemical agents (NaOH – 2%, $Na_2CO_3$ – 1%, Wetting agent, Vegetable Oil, Sodium Silicate, etc.,) are added in the desizing, bleaching and kiering steps of textile processing to increase the texture and whiteness of cotton fabrics. This approach results in excess of BOD, COD, dissolved solids and metallic wastes in the effluent. This work focuses on the degradation of organics in the real cotton bandage processing effluent by photo catalysis and biodegradation method. In photo catalysis three different nano particles namely Titanium dioxide ($TiO_2$), Zinc Oxide (ZnO) and Bismuth Vanadium oxide ($BiVO_4$) were used. Biodegradation process was carried out by using activated sludge mixed microbial culture. The degradation process was confirmed by the reduction of COD at regular intervals and appropriate controls.

## II. EXPERIMENTAL SETUP

### A. Photocatalytic degradation

The photocatalytic oxidation was carried out by using multi lamp photo reactor (Heber scientific, 2015) as a light source. UV Light with wave length of 365 nm was passed onto a flask containing, respective nanoparticles and culture broth (Ahmadi et al., 2008). All glass wares used in the experiment were autoclaved. To each tube, 20 ml of actual surgical cotton processing waste water was taken. To that around 0.05g of $TiO_2$, ZnO and $BiVO_4$ was added. The reaction temperature was maintained at 25º C throughout the experiment. The reaction was carried out for 2 – 4 hrs and sample were collected at every 30 min regular interval.

### B. Biodegradation Experiments

All aerobic biodegradation experiments using the acclimated mixed culture were performed in 500 mL Erlenmeyer flask containing 100 mL of MSM containing real surgical wastewater of different dilutions. Upon incubation of the flasks at 30$^o$C under agitation condition (150 rpm), samples were withdrawn at regular time intervals, centrifuged (6708 g for 5 min) and analyzed for residual pollutant, using COD estimation. Each experiment was carried out for a period until the system reached a steady state. Abiotic controls were also maintained and monitored during the experiments.

### C. COD Analysis

COD of liquid samples was estimated from the centrifuged samples using closed reflex method as suggested in standard methods (APHA, 2005). Closed reflux digestion was conducted in HACH COD digester (Model No 45600, USA) fitted with temperature controller and timer. COD of liquid samples were estimated as per standard methods (APHA, 2005).

## III. RESULT AND DISCUSSION

Photocatalysis can be very easily carried out under ambient conditions and leads to the total mineralization of organic carbon to carbon dioxide ($CO_2$), without the formation of significant photo catalyzed intermediate products (Ollis et al. 1991). During photodegradation $TiO_2$, ZnO and $BiVO_4$ catalysis the oxidation of organics and therefore decreases COD levels of wastewater. This oxidation is carried by the ability of the catalyst to generate OH• radicals which are non-specific and powerful oxidizing agents. The initial COD value of the surgical wastewater was found to be around 1600 mg/l, while after photo degradation of 2 hrs the COD value decreased to 800mg/l in $TiO_2$; 1056 mg/l in ZnO and 896 mg/l in $BiVO_4$. (Table 1 and Fig. 2) Comparing these three catalysts $TiO_2$ was found to be more effective in photo catalytic degradation of the surgical cotton wastewater.

**Table 1 Removal of COD in different nanoparticles on cotton bandage waste water treatment**

| Metal oxide nanoparticle | Initial COD (mg/l) | Final COD (mg/l) |
|---|---|---|
| $TiO_2$ | 1600 | 800 |
| ZnO | 1600 | 1056 |
| $BiVo_4$ | 1600 | 896 |

Although $TiO_2$ was observed to be effective in oxidizing the organics in wastewater, nonetheless, the effluent COD from TiO2 photocatalytic degradation was still higher (800mg/l) compared to standard discharge levels. Hence the wastewater was diluted using distilled water (1:19; 2:18; 3:17; 4:16; 5:15) to achieve the discharge standards after photocatalysis with TiO2. From the result it was observed that COD of 80mg/l was obtained at dilution of 1:19. (Table 2 and Fig. 3)

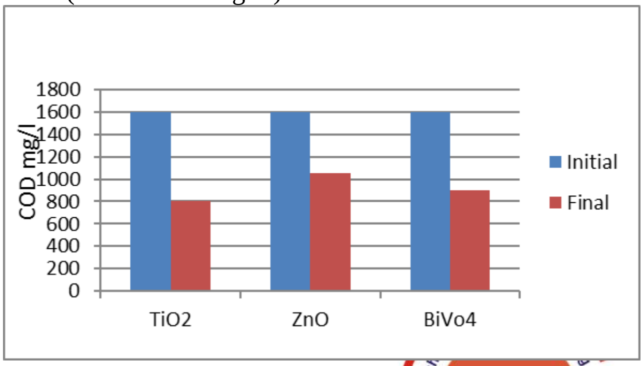

**Fig 2: Comparison of COD removal in presence of different nanoparticles on cotton bandage waste water treatment**

**Table 2 COD removal during different dilution of wastewater with $TiO_2$ nanoparticles**

| S.No | Initial COD (mg/ml) | Final COD (mg/ml) |
|---|---|---|
| 1 (1:19) | 1000 | 80 |
| 2 (2:18) | 1080 | 160 |
| 3 (3:17) | 1160 | 240 |
| 4 (4:16) | 1240 | 320 |
| 5 (5:15) | 1320 | 400 |

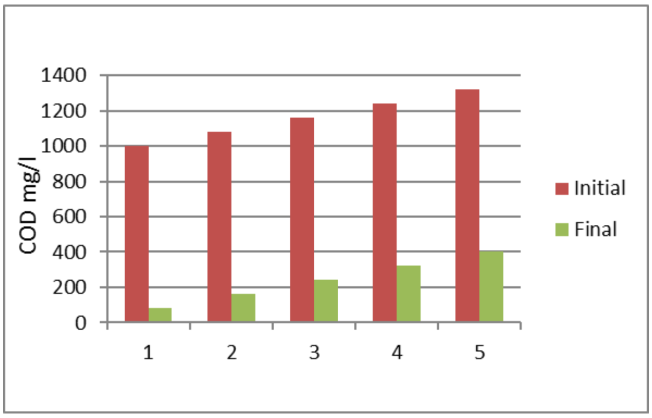


**Fig 3: COD removal in surgical wastewater using mixed aerobic microbial culture**

**B Biological Degradation**

Aerobic treatment using activated sludge is currently the most frequently used method where microorganisms are used to degrade the pollutants or toxins (Tumpa et al., 2017). In this study there a constant decline in COD 1536 to 1152 mg/ l during 5 days of treatment process was observed without any dilution (Table 3 and Fig. 4).

The biodegradation rate depends primarily upon the inoculum source, type, acclimatization methods and time period of acclimatization, which could be the reason for the difference in biodegradation rates among various authors. With the reduction in COD, it could be concluded that the aerobic biomass can utilize the organics present in surgical cotton wastewater as the sole source of carbon, while nitrogen, macro and micro nutrients need to be supplemented separately.

**Table 3 Removal of COD on biodegradation of cotton bandage textile waste water**

| No of Days | Aerobic sludge COD (mg/l) |
|---|---|
| 1 | 1468 |
| 2 | 1440 |
| 3 | 1248 |
| 4 | 1152 |
| 5 | 1074 |

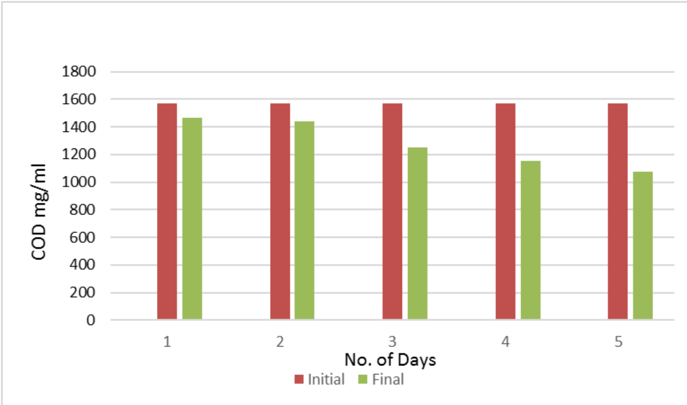


**Fig 4 Comparison of COD Removal between control and sludge on biodegradation of cotton bandage textile waste water**

## IV. CONCLUSION

Waste water discharged from surgical cotton processing industries contains many organic pollutants. Hence Photocatalytic degradation as well as biological degradation has been investigated to determine the effective treatment method in this study. During photocatyalytic degradation, $TiO_2$ with 1:19 dilution was found to have 98% degradation of organic pollutant in terms of wastewater COD. Aerobic degradation using mixed activated sludge was also studied for treating waste water. Aerobic degradation was found to achieve only 36% of COD removal without any dilution. From this batch studies it could be concluded that photocatalytic degradation using $TiO_2$ was more efficient in treating cotton processing waste water when compared to ZnO and $BiVo_4$. Although biological method could not oxidize much of COD from undiluted wastewater, it was found to be cost effective for treatment of this wastewater as photo-catalysis requires expensive chemicals and UV light source.

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