Simultaneous Disinfection And Trace Heavy Metals Removal From Hospital Wastewater By Advanced Oxidation Techniques

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Abstract- *Hospital wastewater may contain various potential hazardous materials including microbiological pathogens, radioactive isotopes, disinfectants, drugs, chemical compounds and pharmaceuticals. Hospital wastewater is characterized by high COD and BOD with* BOD_5*/COD ratio varying between 0.250.5(JSS) and 0.38-0.5(KRH) with greenish blue colour. The present study aims at carrying out Disinfection studies on Fenton and photo Fenton process for removal of COD and Removal of trace heavy metals from hospital wastewater under various sets of operating conditions such as dosage of Iron, Hydrogen peroxide, contact time and pH and Irradiation time. The result showed in JSS Hospital wastewater reduction in COD, TSS, and Turbidity removal efficiency of 96.83%, 94.30%, and 84.48% for 0.4g* Fe^{2+} *+ 1.65ml* H_2O_2 *Fenton dosage at 50 RPM and 90 minutes reaction time, at the pH of 3.5. The improvement in* BOD_5*/COD ratio (0.25 to 0.41) was observed at the end of 90 minutes, the result showed in KR Hospital wastewater reduction in COD, TSS, and Turbidity removal efficiency of 89.58%, 85.81%,and 87.27% for 0.4g* Fe^{2+} *+ 1.65ml* H_2O_2 *Fenton dosage at 50 RPM and 60 minutes reaction time, at the pH of 3.5. The improvement in* BOD_5*/COD ratio (0.25 to 0.41) were observed at the end of 60 minutes. 11W UV lamp used to disinfect the wastewater showed reduction in microbial parameters like fecal coliform, fecal streptococci and total coliform, the removal efficiency of TC, FC, FS for JSS and KR hospital wastewater are 99.72 %, 99.72 %, 99.72%. And 99.72%, 99.17%, 98.63% respectively. Studies carried out for Photo Fenton process showed 99% removal efficiency microbial and heavy metals complete removal at optimum* H_2O_2 *dose of 1.65 ml and 0.4 g/l of iron, at wastewater pH of 3.5 and the irradiation time from 0th minutes to 120th minutes, the optimum irradiation time were 60th minutes for both JSS and KR Hospitals wastewater at speed of 50 RPM.*

Keywords- Hospital Wastewater, Advanced Oxidation Processes (AOPs), Chemical Oxygen Demand (COD), Total Suspended Solids, Turbidity, Heavy Metals and Microbial Parameters.

I. INTRODUCTION

Hospital wastewater is generated from all the actions of hospital such as medical and non-medical from the activities of operating, laboratory, diagnosis, radiology, emergency laundry and kitchen activities. This wastewater contain potential hazardous materials like microbiological pathogens, disinfectants, radioactive isotopes, drugs, chemical compounds and pharmaceuticals and also cause an adverse impact on environment and human health by hospital wastewater. To solve this problem, there is an efficient pre-treatment options which can effectively deplete or modify the characteristics of wastewater. Hospital waste is a dangerous pollutant and hazardous to the environment such as human beings, animals and plants. Waste in general is any substance like solid, gas or liquid which has no direct use and is discarded permanently. Wastewater effluents are heavy loaded with huge number of toxic chemicals, radioactive isotopes, pathogenic organisms and pharmaceutical partially metabolized elements. So it is necessary to take precautionary measures to prevent hazardous wastes let into the environment by acting good treatment method and disposal technology (Mohan Kumar et al., 2011).

Advanced oxidation processes (AOPs) has so many technologies such as photo Fenton and photo oxidation like processes emerging a promising technology for the treatment of Wastewater containing non – biodegradable organic compounds. This photo Fenton process is an emerging and very promising technology based on the oxidation of hazardous organic compounds in various kind of wastewater (Kulkarni et al., 2015).

The main objective of this present study is to treat hospital wastewater using photo Fenton oxidation techniques. Specific objectives are (1) Characterization of Raw wastewater from two major hospitals in Mysuru city for wastewater quality parameters. (2) To determine ideal conditions of Fenton oxidation of hospital wastewater such as pH, dosage and contact time. (3) To conduct simultaneous

disinfection cum heavy metal oxidation at ideal condition using UV-Fenton oxidation of hospital wastewater

II. MATERIALS AND METHODS

1. Wastewater Collection and Its Characteristics: -

Present study makes an attempt to treat Hospital wastewater using Advanced Oxidation Processes: Fenton and Photo Fenton process. Hospital wastewater were collected from JSS Hospital and KR Hospital, Mysuru

2. Fenton Experiment: -

All Fenton experiments were carried out with a mixing speed of 50 RPM. Preliminary Fenton studies were carried with Fenton dose of 0.2g Fe^{2+} + 0.33ml H202 0.4g Fe^{2+} + 1.65ml H202 and 0.6g Fe^{2+} + 3.3ml H202 to check the efficiency of the COD, TSS and Turbidity removal. Several experiments were done in this regard to find optimized Fenton dosage. Further pH studies were carried by varying pH from 2.5 to 6.5, where 0.1N HCL was used for pH adjustments.

3. Photo Fenton Experiment: -

The preliminary study was conducted having a reactor size of 2.5 L capacity. For all the tests, the reactor was filled with 1 L of raw wastewater. 11 W Ultraviolet lamp surrounded by Quartz glass tube as jacket for lamp were immersed in a solution in the beaker. The size of the reactor are 11cm diameter and 21cm height and the Quartz glass tube as jacket for UV lamp height is 12 cm, length 1 m, outer diameter 3.3 cm and inner diameter 3 cm. The study was conducted for intervals of 120 min, where for every 30 min interval samples were drawn and analyzed for COD and BOD, microbial and heavy metals parameters respectively.

III. RESULTS AND DISCUSSION

1. The physic-chemical characteristics of hospital wastewater: -

The Hospital wastewater is characterized by high concentration of COD and relatively low concentration of BOD_5/COD ratio varying between 025 to 0.50 (JSS Hospital) and 0.38 to 0.5 (KR Hospital). Initial Characteristics of Raw hospital wastewater as showed in table 3.1

Table 1.

Parameter	JSS Hospital Wastewater	KR Hospital Wastewater
pH	6.71-6.9	6.69-7.08
Temperature	25-25.2	23.8-24.5
Turbidity	57-60	43-73
Conductivity	3.02-4.34	3.47-3.75
COD (mg/L)	3510-4600	2720-3200
BOD_5 (mg/L)	1143-1800	1059-1560
BOD_5/COD	0.25-0.5	0.38-0.5
TSS (mg/L)	1600-2388	1284-1736
Chloride (mg/L)	120-135	116-130
Nitrate (mg/L)	1.39-1.73	1.374-1.733
Phosphate (mg/L)	9.599-18.78	8.320-12.848
Al	1.56-1.8	NIL
Cr	0.01	0.01
Cu	0.01	0.01
Fe	4.2-4.4	2.8-3.3
Ni	NIL	NIL
Zn	3.9-4.5	1.58-2.1
Total Coliform	≥110000	≥110000
Fecal Coliform	≥1100	≥1100
Fecal Streptococci	≥1100	≥1100

2. Fenton Experiments for Hospital Wastewater Treatment: -

To investigate the optimum H_2O_2/ Fe^{2+}, the several experiments were conducted for varying Fenton dosages from 0.2g Fe^{2+} + 0.33ml H_2O_2, 0.4g Fe^{2+} + 1.65ml and 0.6g Fe^{2+} + 3.3ml H_2O_2 from wastewater pH 6.5, 50 RPM speed, reaction time of 2 hours. Figure 3.1 and Figure 3.2 represents COD, TSS and Turbidity concentration v/s different Fenton dosages of JSS and KR Hospitals and it is clearly seen that the better results of COD,TSS and Turbidity removal dosages are obtained for JSS and KR Hospitals are 0.4g Fe^{2+} + 1.65ml H_2O_2 and 0.4g Fe^{2+} + 1.65ml H_2O_2. This dosage was considered as optimum dosage of JSS and KR hospital. The removal efficiency of COD, TSS and Turbidity JSS is 94 %, 90 % and 83 % and KR hospital is 89%, 85% and 85% respectively

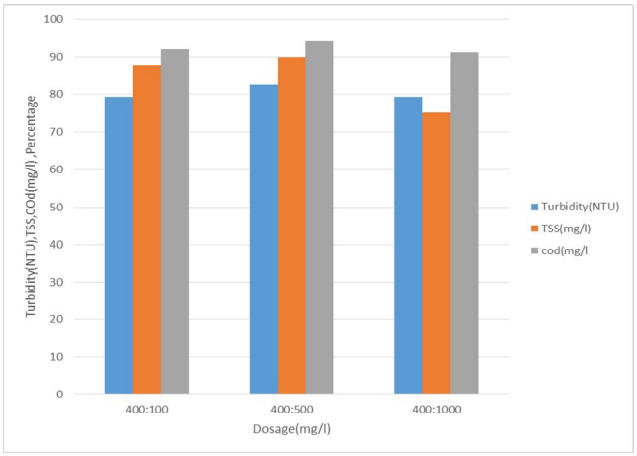

Figure 1. COD, TSS and Turbidity Concentration v/s Different Fenton Dosages (JSS Hospital) at 3.5

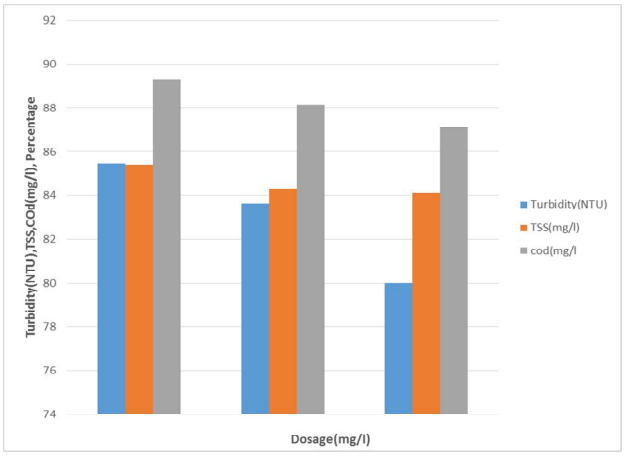

Figure 2. COD, TSS and Turbidity Concentration v/s Different Fenton Dosages (KR Hospital) at 3.5

3. Contact Time studies: -

The optimum dose of 0.4g Fe 2+ + 1.65ml H_2O_2 was repeated for the study. The total time of reaction considered was 3 hours with 50 RPM speed at existing wastewater pH. Supernatant was collected from the reactor at every interval of 0 min, 30 min, 60 min, 90 min, 120 min, 150 min and 180 minutes for both JSS and KR Hospitals and analyzed for parameters in considerations. From the Figure 3.3 and 3.4, the COD, TSS and Turbidity removal efficiency of both JSS and KR hospitals at pH 3.5 achieved was resulting of COD, TSS and Turbidity are 96 %, 94 %, 84% and 89 %, 86%, 87% respectively. Figure 3.3 and 3.4 clearly shows the gradual increases in parameters removal at every time interval reaching maximum removal at 90 minutes and 60 duration respectively.

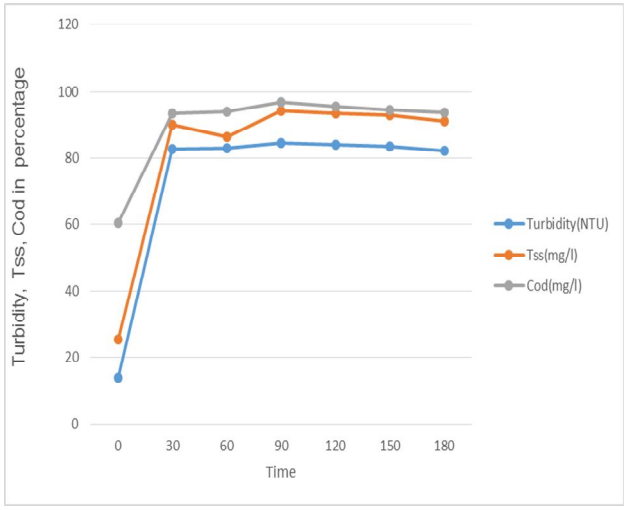

Figure 3. Percentage Removal v/s Contact Time (JSS Hospital) at pH 3.5, Dosage (mg/l) 400:500

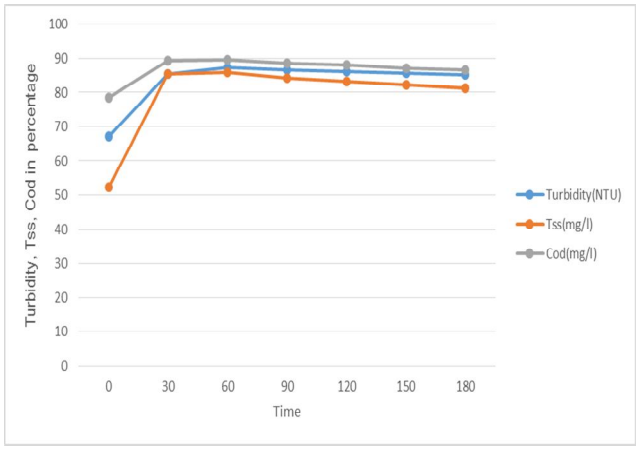

Figure 4. Percentage Removal v/s Contact Time (KR Hospital) at pH 3.5, Dosage (mg/l) 400:500

4. Photo Fenton Experiments for Hospital Wastewater Treatment: -

The aim of this study bacteria inactivation by the photo-Fenton process at optimum Fenton pH in water. With this purpose in mind, individual effects of solar irradiance, concentrations of H_2O_2 and $Fe^{2+/3+}$ and pH on bacteria inactivation by photo-Fenton were studied. All the experiments were conducted with varying the contact time 0 minutes to 120 minutes, with optimum pH, and optimum Fenton reagent.

5. Experiments for Optimum Hydrogen Peroxide and Iron Dosage, Contact Irradiation Time: -

The disinfection of hospital waste water has been determined through photo Fenton technology and the heavy metals detection in facilitated laboratory. In this studies the

99% of disinfection and complete removal of heavy metals were achieved. The microbial test were conducted to find the microbial presence through multiple fermentation techniques. The parameters of microbial test were analyzed are fecal coliform, fecal streptococci, and total coliform.

As shown in Figure 3.5, 3.6 and Table 3.2 indicate the Disinfection by using 11w UV lamp with irradiation time for JSS hospital and KR hospital (MPN/100ml), Optimum Fenton doses have been studied for maximum disinfection and heavy metals removal for JSS and KR hospitals wastewater by keeping distance 11W UV lamp, speed 50 RPM, at Optimum pH of 3.5 and reaction time of 0 minutes to 120 minutes. And determine the fecal coliform, fecal streptococci, and total coliform, and heavy metals. Here the best optimum disinfection found in JSS hospital were 60 minutes and KR hospital were 60 minutes. The percentage removal of JSS hospital wastewater of TC, FS and FC are 99.72%. And the KR hospital percentage removal of TC, FS, and FC are 99.72%, 99.17% and 99.63%.

Table 3.3 and 3.4 shows the removal of heavy metals such as Aluminum, Chromium, Copper, Iron, Nickel, And Zinc, at the end of the photo Fenton process, the treated wastewater taking in to heavy metals detection in lab and here the results shows the photo Fenton process were capable for complete removal of heavy metals at optimum irradiation time is 60 minutes.

All the experiments were performed in glass reactors containing 1000 mL of the wastewater. The initial concentration of TC, FC and FS of JSS hospital are ≥ 110000, ≥ 1100 and ≥ 1100. And the KR hospital are ≥ 110000, ≥ 1100 and ≥ 1100. The solution was continuously stirred with a magnetic stir bar at 50 rpm. For the experiments in dark conditions, the reactors were covered with cardboard mesh. The experiments under 11W UV lamp were carried out.

The reactors were then spiked with 0.4 g/l of $Fe^{2+/3+}$ or/and 1.65 ml/l of H_2O_2 from freshly prepared stock solutions to achieve the desired concentration according to the experimental conditions. Finally, for the photo-inactivation experiments the lamp were turned on. The samples were exposed to the desired conditions for 120 min. All the material and solutions were sterilized at 126ºC for 20 min. the reactors containing the water matrix and virus suspension were placed in the dark and stirred for 5 min. The reactors were then spiked with 0.4 g/l of $Fe^{2+/3+}$ or/and 1.65 ml/l of H_2O_2 from freshly prepared stock solutions to achieve the desired concentration according to the experimental conditions. Finally, for the photo-inactivation experiments the lamp were turned on. The samples were exposed to the desired conditions for 120 min. Experiments shows that bacterial photo-inactivation was ended. The results shows that 99 % removal efficiency of total coliform, fecal coliform and fecal streptococci.

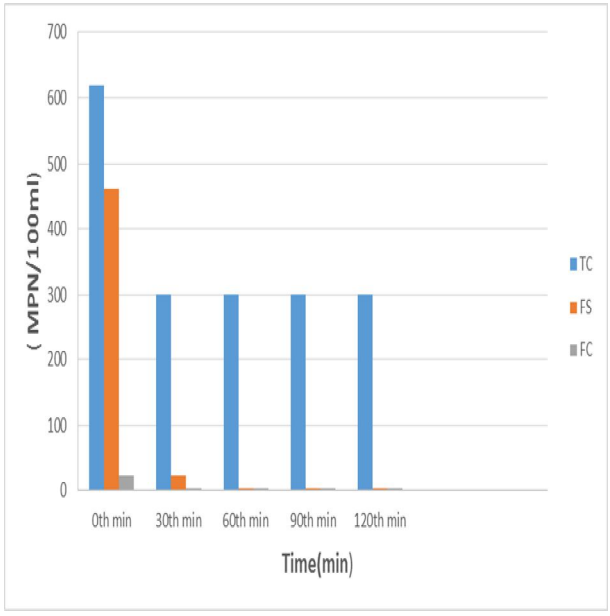

Figure 5. Disinfection of Hospital Wastewater by Using 11w UV Lamp with Irradiation Time at pH 3.5 and Dosage 400:500 mg/l –JSS Hospital (MPN/100ml)

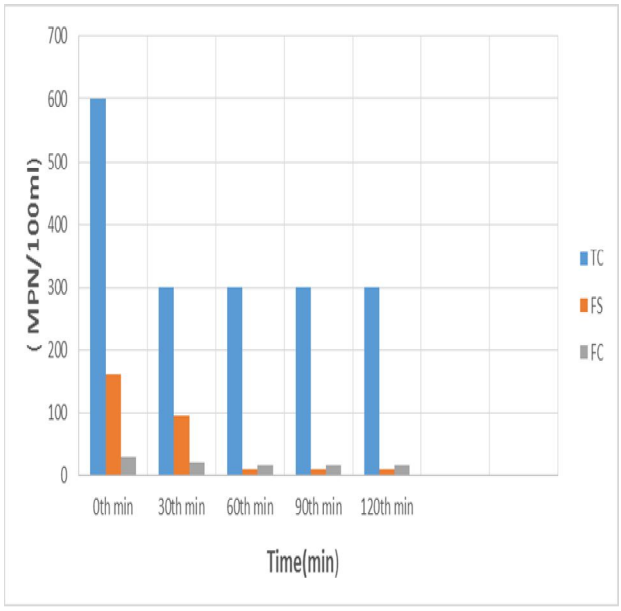

Figure 3.6 Disinfection of Hospital Wastewater by Using 11w UV Lamp with Irradiation Time at pH 3.5 and Dosage 400:500 mg/l – KR Hospital (MPN/100ML)

Table 2.Percentage Removal of TC, FS and FC (MPN/100ml)

	JSS Hospital		% Removal	KR Hospital		% Removal
	Raw	Treated		Raw	Treated	
TC	≥110000	300	99.72	≥110000	300	99.72
FS	≥1100	3	99.72	≥1100	9.1	99.17
FC	≥1100	3	99.72	≥1100	15	98.63

Table 3. Heavy Metals Removed by Photo Fenton Process-JSS Hospital

JSS Hospital	0^{th} min	30 min	60^{th} min	90^{th} min
Al	1.8	0.02	NIL	-
Cr	0.01	NIL	NIL	-
Cu	NIL	NIL	NIL	-
Fe	4.2	0.2	NIL	-
Ni	NIL	NIL	NIL	-
Zn	4.5	0.45	NIL	-

Table 4. Heavy Metals Removed by Photo Fenton Process.-KR Hospital

KR Hospital	0^{th} min	30 min	60^{th} min	90^{th} min
Al	1.8	0.02	NIL	-
Cr	0.01	NIL	NIL	-
Cu	NIL	NIL	NIL	-
Fe	3.3	0.02	NIL	-
Ni	NIL	NIL	NIL	-
Zn	2.1	0.30	NIL	-

IV. CONCLUSION

Hospital wastewater is characterized by high COD and BOD with BOD_5/COD ratio varying between 0.25-0.5 (JSS) and 0.38-0.5 (KRH) with greenish blue colour. Treat ability studies carried out for Fenton process showed reduction in COD, TSS and Turbidity for JSS Hospital wastewater is 128 mg/L, 108 mg/l and 9 NTU and KR hospital wastewater is 311 mg/l, 209 mg/l and 7 NTU resulting in removal efficiency of JSS Hospital wastewater is 96 %, 94% and 84% and KR hospital wastewater 90%, 86%, 87% for optimum Fenton dose of JSS and KR Hospital wastewater is 0.4g Fe^{2+} + 1.65ml H_2O_2 at pH of 3.5. Dosages administered above 0.4g Fe^{2+} + 1.65ml H_2O_2 showed increasing COD values. Thus 0.4g Fe^{2+}+ 1.65ml H_2O_2 was considered as an optimum dosage and 90th minutes for JSS and 60th minutes for KR hospital wastewater for Fenton process.

11W UV lamp used to disinfect the wastewater showed reduction in microbial parameters such as fecal coliform, fecal streptococci and total coliform, the removal efficiency of TC, FC, FS for JSS and KR hospital wastewater are 99.72 %, 99.72 %, 99.72%. And 99.72%, 99.17%, 98.63% respectively. Studies carried out for Photo Fenton process showed 99% removal efficiency microbial and heavy metals complete removal at optimum H_2O_2 dose of 1.65 ml and 0.4 g/l of iron, at wastewater pH of 3.5 and the irradiation time from 0th minutes to 120th minutes, hence optimum irradiation time was 60th minutes for both JSS and KR Hospitals wastewater at speed of 50 RPM. Based on the work carried out in this studies, the following recommendation for the future work is made to assess the effect of alternative dosages and treatment by different irradiation intensity configuration.

REFERENCES

[1] Al Harbawi, Mohammed and Yakoob, (2013) "Use of Fenton's Reagent for Removal of Organics from Ibn Al-Atheer Hospital Wastewater in Mosul City", 21(5).

[2] Almomani and Baranova, (2013) "Kinetic study of electro-Fenton oxidation of azo dyes on boron-doped diamond electrode", Journal of Environmental Technology, 34 (11), 1473–1479.

[3] Alrhmoun, Carrion, Casellas, and Dagot, (2014) "Hospital Wastewater Treatment by Membrane Bioreactor: Performance and Impact on the Biomasses", International Conference on Biological, Civil and Environmental Engineering, 17-18.

[4] Amouei, Asgharnia, Mohammadi, Fallah, Dehghani and Miranzadeh, (2012) "Investigation of hospital wastewater treatment plant efficiency in north of Iran during 2010-

2011", International Journal of Physical Sciences, 7(31), 5213 – 5217

[5] Azmal, Kalhor, Goharinezhad, Heidari and Farzianpour, (2014) "Going toward Green Hospital by Sustainable Healthcare Waste Management: Segregation, Treatment and Safe Disposal", International Journal of Science Health, 6, 2632-2640.