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TREATABILITY STUDY OF PHARMACEUTICAL WASTEWATER BY HYDRODYNAMIC CAVITATION PROCESS

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Abstract- In the present work, degradation of pharmaceutical effluent has been investigated using hydrodynamic cavitation process. In this study, the effect of hydrodynamic cavitation was examined for the different time intervals from 0 to 150 mins. In hydrodynamic cavitation pump was used of 1 H.P capacity and reactor capacity was 50 litres. With hydrodynamic cavitation, maximum COD removal achieved was 80.36% in 90 mins.

Key word: Advanced oxidation process, COD removal, pharmaceutical wastewater, cavitation

INTRODUCTION

The existence of pharmaceutical substances in the aquatic environment and their possible effects on living organisms are a growing concern. The treatment of pharmaceutical wastewater to the desired effluent standards has always been difficult due to the wide variety of the products that are produced in a drug manufacturing plant. Variable wastewater composition and fluctuations in pollutant concentrations cannot be treated by conventional treatment plants. Activated sludge process is a well-for removing various organic contaminants and organic carbon. However, the substances synthesized by pharmaceutical industries are organic chemicals that are structurally complex and resistant to biological degradation. The treatment of pharmaceutical wastewater requires some complementary techniques that could efficiently remove pollutants and enable the wastewater to be discharged into receiving water or be reused for industrial purposes.

Pharmaceutical and antibiotic residues from human, animal and medical waste enter in the water and soil from

1) The effluent treatment plants of manufacturing facilities, 2) The municipal sewage treatment plant, 3) Hospital waste treatment plants, or 4) Animal farms.

Most pharmaceutical substances are, by nature, biologically active and hydrophilic, in order that the human body can take them up easily, and persistent, to avoid degradation before they have a curing effect. Depending on the pharmacology of a medical substance it will be excreted as a mixture of metabolites, as unchanged substance, or conjugated with an inactivating compound attached to the molecule. When they enter a wastewater treatment plant, xenobiotic are not usually completely mineralized. They are either partially retained in the sludge, or metabolized to a more hydrophilic but still persistent form and, therefore, pass through the wastewater-treatment plant and end up in the receiving waters.

TREATMENT TECHNOLOGY

Cavitation is described as the formation of micro bubbles in solution that implode violently after reaching a critical resonance size. These micro bubbles can be produced by a number of mechanisms (**Madhu G M, Rajanandam K S, Thomas A, 2010)**:

1) Local increase in water velocity as in eddies or vortices, or over boundary contours; 2) Rapid vibration of the boundary through sonication; 3) Separation or parting of a liquid column owing to water hammer; or 4) An overall reduction in static pressure.

The rapid implosion of cavitation micro bubbles results in high temperatures at the bubble/water interface, which can trigger thermal decomposition of the toxic elements in solution or thermal dissociation of water molecules to form extremely reactive radicals. The extreme conditions generated during cavitation decomposes water to create both oxidizing (•OH) and reducing (•H) radical (**Gogate P R and Pandit A B, 2000)**.

There are three known methods of producing hydroxyl radicals using cavitation — namely, ultrasonic irradiation or sonication, pulse plasma cavitation, and hydrodynamic cavitation. Sonication causes the formation of micro bubbles through successive ultrasonic frequency cycles until the bubbles reach a critical resonance frequency size that results in their violent collapse. Pulse plasma cavitation utilizes a high voltage discharge through water to create micro bubbles. In hydrodynamic cavitation, micro bubbles are generated using high velocity or pressure gradients (**Gore M M and Chavan P V, 2013)**.

Factors affecting hydrodynamic cavitation:-

Cavitation number, Inlet pressure, Diameter of the constriction, Physicochemical properties of the liquid and the initial size of nuclei, Percentage of free area for the flow (**Chanda S K, 2008)**

Hydrodynamic cavitation has great potential in water disinfection due to its capability to generate highly reactive free radicals and turbulence. The mechanism involved in disinfection of microorganisms by cavitation is thought to involve the following effects **(Gogate and Kabadi, 2009)**.

1. Mechanical effect: Associated with the generation of currents, shear stresses and turbulence due to liquid circulation.
2. Chemical effect: Generation of free hydroxyl radicals.
3. Heat effect: Hot spot generation due to high local pressure and temperature.

It has been observed that in hydrodynamic cavitation, chemical and thermal effects play supporting roles to mechanical effects in microbial disinfection. **(Jyoti and Pandit, 2004)** applied ozone and hydrodynamic cavitation to bore well water and found this technique much more effective in water disinfection compared to other individual physical-chemical techniques including ozonation, hydrodynamic cavitation and acoustic cavitation.

Cavitation can also be used as supplementary technique to a conventional biological oxidation process to increase substrate biodegradability or to reduce toxicity by degrading bio refractory materials **(Gogate and Kabadi, 2009)**. It can also be used with an anaerobic digestion process to improve the digestibility of the sludge by solubilising it.

Hydrodynamic vs. acoustic cavitation

Acoustic cavitation in the form of ultrasound has been observed capable of removing a wide variety of contaminants from water. Significant research has been done in this field compared to hydrodynamic cavitation, but most of the studies have been done at laboratory scale. Scale-up is a big issue in acoustic cavitation compared to hydrodynamic cavitation. Designing large scale acoustic cavitation equipment involves information from a variety of fields compared to the hydrodynamic cavitation. Hydrodynamic cavitation reactors offer versatility and ease of operation. Several studies have proven that hydrodynamic cavitation is much more energy efficient and effective than acoustic cavitation (Gogate and Pandit, 2005; Gogate and Kabadi, 2009; Jyoti and Pandit, 2004; Kalumuck and Chahine, 2001; Save et al., 1997).

EXPERIMENTAL PROCEDURE

For hydrodynamic cavitation, experiments were performed in reactor of capacity 50 liters in which effluent was lifted and circulate by the pump of capacity 1 H.P. for different intervals of time without use of any chemical. Sample was kept for quiescent

condition for 2 hours for the settlement of the precipitate. All experiments were carried out in batch mode. Several set of experiments were carried out to check the optimum range of time.

FIG. 1 HYDRODYNAMIC CAVITATION REACTOR

RESULT AND DISCUSSION

TABLE 1:- RAW EFFLUENT CHARACTERISTICS

SR. NO.	CHARACTERISTICS	VALUES
1	CHEMICAL OXYGEN DEMAND (COD)	8900 – 9500 mg/L
2	pH	7.8 – 8.2
3	TDS	47500 mg/L
4	TSS	8300 mg/L

The wastewater characteristics play a significant role on its treatment. Raw wastewater parameters were measured and listed in Table 1. These results indicate that this wastewater contains high load of organic and inorganic matter. Therefore, this wastewater can cause damage to the environment when discharged directly without proper treatment.

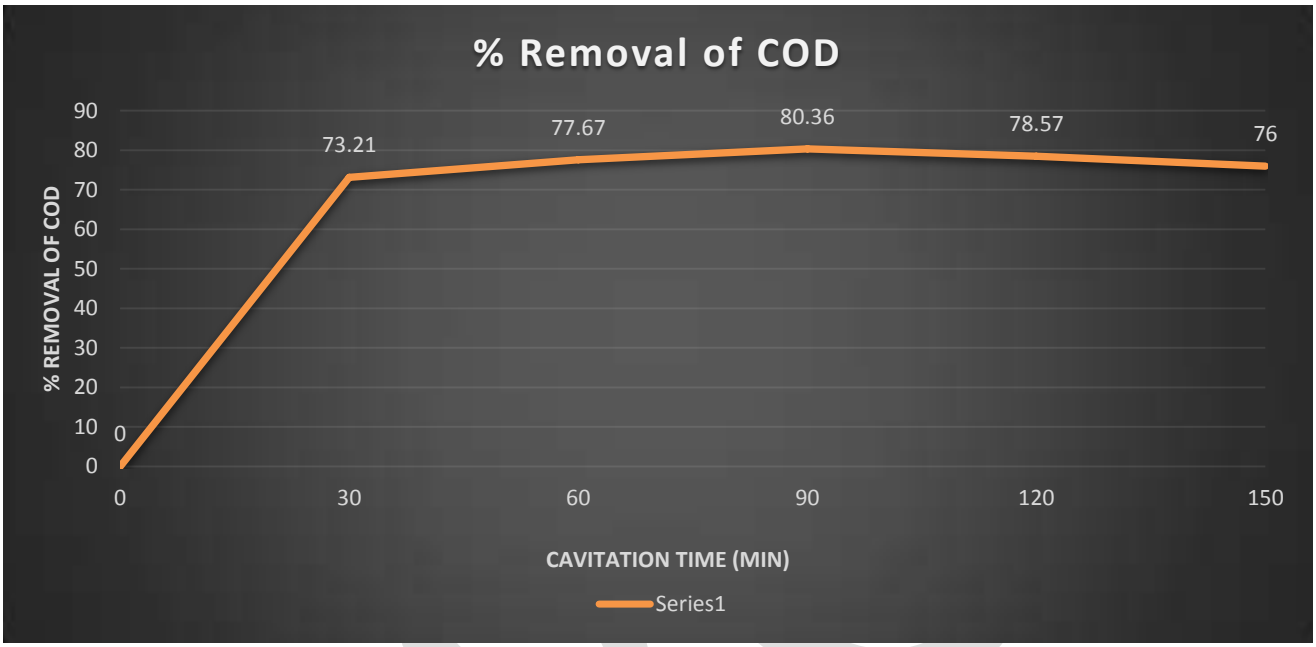

FIG. 2 % COD REMOVAL WITH HYDRODYNAMIC CAVITATION PROCESS

In this study, the effect of cavitation was examined for the different time intervals from 0 to 150 mins. In hydrodynamic cavitation pump was used of 1 H.P capacity and reactor was 50 liters. With hydrodynamic cavitation, maximum COD removal achieved was 80.36% in 90 mins as shown in Fig.

CONCLUSION

The degradation of wastewater from pharmaceutical wastewater was investigated by the cavitation process. The cavitation process was done in two ways acoustic and hydrodynamic. Therefore, maximum efficiency of COD removal is achieved at 90 mins, 80.36% with hydrodynamic cavitation without any use of chemical.

Cavitation is eco-friendly way to reduce the pollution load of wastewater. These processes differ from the other treatments processes because wastewater compounds are degraded rather than concentrated or transferred into a different phase and secondary waste materials are not generated. Sludge generation is very less compare to other processes.

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