Treatability Study Of Chemical Wastewater By Hydrodynamic Cavitation Process

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ABSTRACT: *Over the other advanced oxidation process, hydrodynamic cavitation is chosen due to the ease of operation and simple reactor design. In present work, degradation of chemical effluent has been investigated using hydrodynamic cavitation process. In this study, the effect of hydrodynamic cavitation was examined for different time intervals from 0 to 120 mins. In hydrodynamic cavitation pump was used of 1 H.P capacity and reactor capacity was 50 liters. With hydrodynamic cavitation, maximum COD removal achieved was 78% by calcium hypochlorite and 60% by hydrogen peroxide.*

Key words: chemical wastewater, hydrodynamic cavitation, COD removal, bleaching powder, hydrogen peroxide

I. INTRODUCTION

The water used in various industrial processes comes in contact with toxic chemicals, heavy metals, organic sludge, and even radioactive sludge. So, when such polluted water is thrown into the ocean or other water bodies without any treatment, they become unfit for any human and agricultural use. Wastewater discharge from industrial units containing newer and stubborn chemicals is a noteworthy issue for ordinary treatment plants. Industrial wastewater treatment is a complex problem for a variety of highly polluting chemical industries such as sulfur, asbestos, poisonous solvents, polychlorinated biphenyl, lead, mercury, nitrates, phosphates, acids, alkalis, dyes, pesticides, benzene, chlorobenzene, carbon tetrachloride, toluene, and volatile organic chemicals. Chemicals like sulfur are harmful for marine life, while asbestos is known to be a potential carcinogen. Drinking water contaminated with asbestos may increase the risk for benign intestinal polyps. Industrial water pollution can have far reaching effects on the ecosystem. Volatile organic chemicals are basically solvents used in a wide range of industrial and household products. When not disposed properly, these chemicals can pollute the groundwater. They can cause a wide range of health problems like headaches, nausea, liver damage, and memory impairment. Thus industrial wastewater treatment is a need for current environmental scenario.

The chemical industry comprises the companies that produce industrial chemicals. Fundamental chemicals or item chemicals are a wide chemical class including pharmaceutical chemical, polymers, bulk petrochemicals and intermediates, different subordinates and essential industrials, inorganic/natural chemicals, and fertilizer, dye and pigment, textile and specialty chemical. The water used in various industrial processes comes in contact with toxic chemicals, heavy metals, organic sludge, and even radioactive sludge. So, when such polluted water is thrown into the ocean or other water bodies without any treatment, they become unfit for any human and agricultural use. The chemical industry is of significance as far as its effect on the environment. Wastewater discharge from industrial units containing newer and stubborn chemicals is a noteworthy issue for ordinary treatment plants. Industrial wastewater treatment is a complex problem for a variety of highly polluting chemical industries such as sulfur, asbestos, poisonous solvents, polychlorinated biphenyl, lead, mercury, nitrates, phosphates, acids, alkalis, dyes, pesticides, benzene, chlorobenzene, carbon tetrachloride, toluene, and volatile organic chemicals. Chemicals like sulfur are harmful for marine life, while asbestos is known to be a potential carcinogen. Industrial water pollution can have far reaching effects on the ecosystem. Volatile organic chemicals are basically solvents used in a wide range of industrial and household products. When not disposed properly, these chemicals can pollute the groundwater. Thus industrial wastewater treatment is a need for current environmental scenario.

Chemical industry effluents can be very unpredictable, exceptional, and in light of expansive contrasts in the materials, procedures and source waters utilized as a part of chemical manufacturing, the subsequent wastewaters can show a lot of variety regarding volume, quality, and composition. For the most part, the modern effluents are portrayed as far as wide parameters, for example, Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (A), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and so forth that barely help in recognizing the idea of contaminations in the effluents. The complexity arises mainly from the issues pertaining to the removal of refractory pollutants that are difficult to remove/degrade using conventional methods of treatment, in general, and biological treatment, in particular.

II. TREATMENT TECHNOLOGY

Cavitation can be define as a degradation of chemical species by physical breakage/ thermal decomposition with a use of cavitation device, in which physicochemical process takes place which follows the oxidation mechanism.

The phenomenon of cavitation is summarized as follows:

1. Formation of bubbles inside the liquid being pumped
2. Growth of bubbles
3. Collapse of bubbles

TABLE 1:- On the basis of cavity creation mechanism, four types of cavitation can be defined.

Sr. no.	Types of cavitation	Mechanism of cavity formation
1	Acoustic cavitation	Cavitation utilization of sound waves
2	Hydrodynamic cavitation	Hydrodynamic gadgets delivering pressure drop
3	Optic Cavitation	use of laser
4	Particle cavitation	Through bombardment of particles

(Sorokhaibam, Bhandari and Ranade, 2014)

Cavitation generated using ultrasound irradiation has been categorized as acoustic cavitation whereas when generated using hydrodynamic means (interchange of flow energy and pressure energy), it is described as HC. (Gogate P,). Compared to acoustic cavitation (AC), hydrodynamic cavitation has advantages of lower investment costs and easier scale-up. (Zupanc et al 2012)

Mechanism:

Cavitation forms and develops in a flowing liquid through zones, in which pressure of the liquid falls below a critical value, normally close to the saturated vapor pressure at a given temperature for the liquid. the value for this pressure is dependent not only on the type of liquid, but also on amount of pollutants such as micro-particles or macro-particles and micro-bubbles containing incompletely dissolved gases.(ozonek j 2012)

Cavitation is a dynamic process; depend on continuous changes over time to the volume and geometry of the bubbles and cavities. the timescale for this is in order to milliseconds. After moving through the cavitating liquid into regions exceeding the critical pressure, the bubbles and cavities undergo sudden implosions in time periods significantly smaller than milliseconds, thus creating a local rise in pressure in different zones of the region. Recovery of static pressure in the downstream section of the cavitating device causes violent collapse of these cavities resulting into the formation of localized hot spots and highly reactive OH**.** and H**.** radicals **(**Franke et al 2011)

III. FACTORS AFFECTING HYDRODYNAMIC CAVITATION

cavitation device, Cavitation number, Inlet pressure, Diameter of the constriction, Physicochemical properties of the liquid and the initial size of nuclei, Percentage of free zone for the flow(Chanda S K, 2008) The quality and quantity of formation of cavities it mainly depends on cavitation device. 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 watched that in hydrodynamic cavitation, chemical and thermal effect are playing supporting role to mechanical effect in microbial disinfection. (Jyoti and Pandit, 2004) connected ozone and hydrodynamic cavitation to exhaust well water and discovered this process significantly more viable in water disinfection contrasted with other individual physical-chemical process 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 solubilizing it. The efficiency of the HC/H_2O_2 process depends on several factors: the amount of added H_2O_2, duration of cavitation (number of cycles) and cavitation intensity.(Zupanc et al 2012)

IV. EXPERIMENTAL PROCEDURE

For hydrodynamic Cavitation, tests were performed in reactor of limit 50 liters in which liquid was lifted and course by the pump of limit 1 H.P. for various interims of time with utilization of bleaching powder and hydrogen peroxide was utilized an oxidizing operator. The initial COD for waste 1 and waste 2 are simultaneously considered as 12040mg/l and 7280mg/l. Test was kept for quiescent condition for 2 hours for the settlement of the precipitate. All tests were completed in batch mode. A few arrangements of investigations were done to check the optimum range of time. Every one of the Experiments were completed in ordinary ambient temperature at 28°C.

fig. 1 hydrodynamic cavitation reactor

V. RESULT AND DISCUSSION

table 2:- raw effluent characteristics

SR. NO.	PARAMETER	Waste 1	Waste 2
1	Chemical Oxygen Demand (COD)	10000-14000 (mg/l)	3500-7500 (mg/l)
2	pH	7.8-8.2	8.5-8.9
3	TDS	17500-37600 (mg/l)	400-1000 (mg/l)
4	TSS	800-3200 (mg/l)	100-200 (mg/l)

The wastewater characteristics play an important role on its treatment. Raw wastewater parameters were measured and recorded in Table 2. These outcomes demonstrate that this wastewater contains high heap of organic and inorganic issue. Thusly, this wastewater can make harm the environment when released straightforwardly without appropriate treatment.

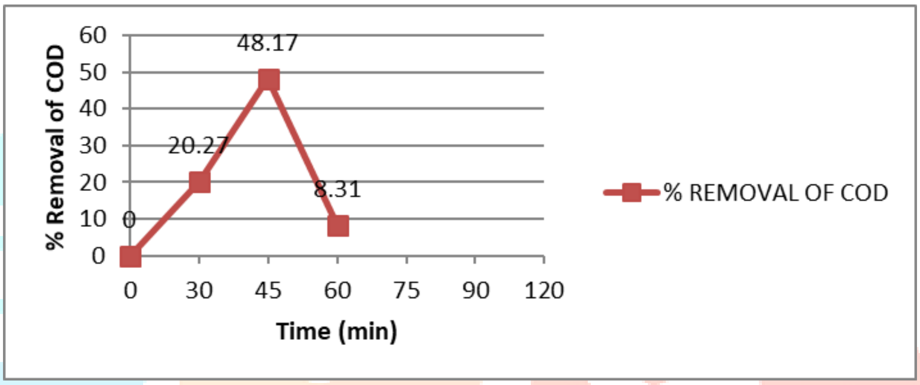

Figure 1% COD removal for waste 1 with bleaching powder at pH 6.5, COD:Cl_2 = 2:1

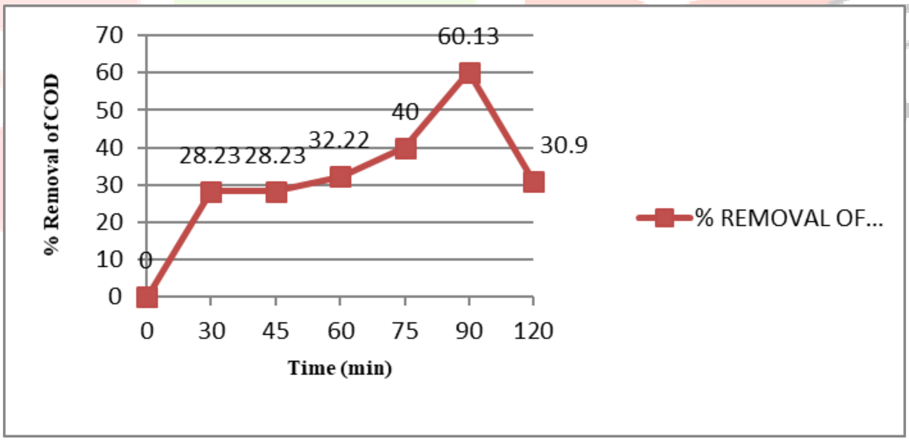

Figure 2 % COD removal with hydrogen peroxide at pH 4, COD:H_2O_2 concentration ratio 2:1

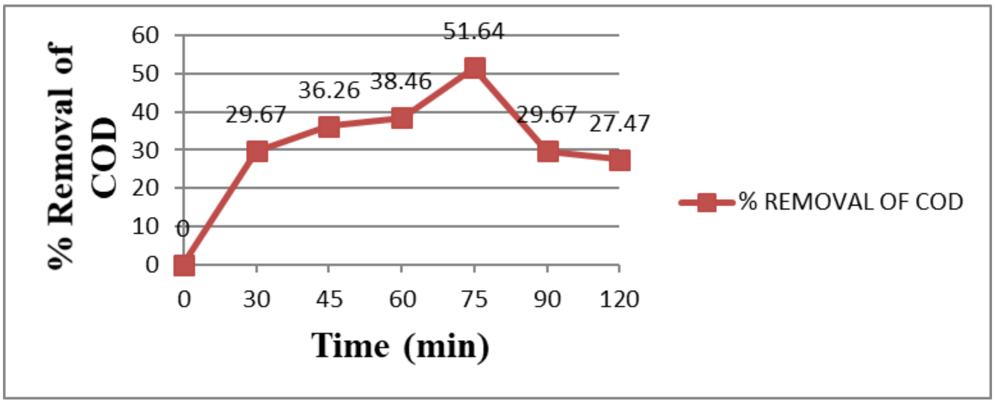

Figure 3 % COD removal for waste 2 with hydrogen peroxide at pH 4, COD: H_2O_2 concentration ratio 2:1

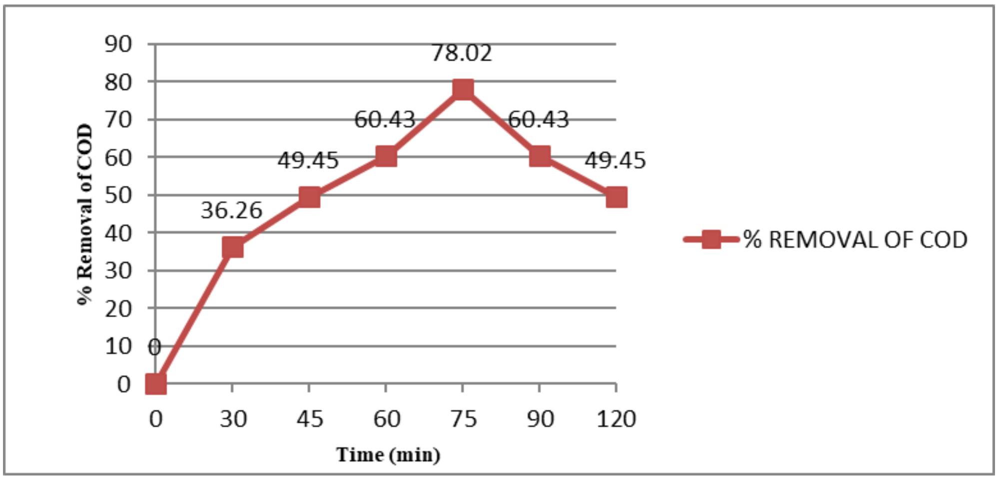

fig. 4 % COD removal for waste2 with bleaching powder at pH 6.5, COD:Cl_2 concentration ratio 4:1

VI. CONCLUSION

The degradation of wastewater from chemical wastewater was investigated by the hydrodynamic cavitation process. Therefore, maximum efficiency of COD removal is achieved at 75 mins, 78% with bleaching powder (COD:Cl_2=2:1) and at 90 mins, 60.13% with hydrogen peroxide (COD: H_2O_2 =2:1). 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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