Cavitation: A tool for treatment of industrial waste water.

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Abstract

Many industries release polluted waste water in the surrounding environment which is most toxic to the aquatic life and human health. Cavitation is one of the phenomena which is applied for treatment of waste water for reduction of different hazardous parameters that are released in environment. The aspects of medicinal consumption and release of waste water from textile and dairy industry are increasing day by day which leads to release of different chemicals, by-products and waste into water. This contaminates the natural water, so its effect should be mitigated, for this there are several processes utilize viz. Sonoelectrochemical catalytic oxidation, Acoustic cavitation, Advanced Oxidation processes. Conspicuously, variety of dyes, chemical dye stuff, pharmaceutical compounds, textile raw materials, etc increases the water polluting parameter. By usage of techniques namely Sonofenton, ultrasound cavitation, Sonolysis, AOP, Ozonation and Ultrasonic dying the toxicity of chemicals is reduced. To meet the need of better and safer environment cavitation is the good process to degrade the several pollutants that causes pollution. All analysis gives the result that fulfils the required outcome with an effective result.

Keywords: Cavitation, Advanced oxidation processes, Pharmaceuticals, Textile, Dairy wastewater.

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Introduction

Sonolysis or ultrasound is the prodigy seen in wide number of practical situations i.e. in different equipments. When pressure of liquid falls below the vapour pressure, liquid gets vaporised and converts in vapour, the process continues up to liquid pressure become equal to vapour pressure. Due to this procedure in low pressure region bubbles are formed. These bubbles get collapsed when came into high pressure region [1]. During collision; bubbles have property to damage the surface of material by producing erosion. The rapid and continuous explosion of micro bubbles due to cavitation results in high temperature at water, which causes thermal decomposition of toxic elements in water sample. The very extreme condition generated during cavitation process, water decomposes to create both oxidizing and reducing radicals [2].

Cavitation is defined as the technique of formation, growth and continuous collapse of microbubbles which is occurring in short intervals of time. It is the procedure that produces conditions which is extremely suitable for the degradation or destruction of pollutants. The degradation of pollutants is need current condition that has to be solved efficiently to meet the need of better and safer environment [3].

Literature Review

Types of cavitation

Acoustic cavitation: Cavitation is occurred by pressure variation in wastewater using ultrasound. Generally, ultrasound of 16-100 MHz is used of this process. The degradation of the contaminants is induced by the introduction of ultrasonic waves. The process is known as sonochemistry as it includes both ultrasonic and chemistry [4].

Hydrodynamic Cavitation: Cavitation is occurred by pressure variation in wastewater by using the geometry of system to create velocity variation. This phenomenon is usually seen in the orifice meter, venturi meter, etc.

Optic Cavitation: Cavitation is occurred by photons of high frequency light rays that rupture the wastewater solution continuously. It involves the focus of short pulsed lasers in liquid solution, which induces the degradation of contaminants.

Particle Cavitation: The beam of elementary particles is used to produce cavitation. It is used in rubber toughening.

Waste water

The treatment of wastewater to reduce the pollution is an important need in modern society to conserve the contents of water [5]. This can be done by using different techniques and traditional methods to abate the contamination of water and get rid of water disposal problem. There are different steps involved to drop the water pollution that includes mechanical purification, aeration and removal of microorganisms to obtain balance of clean water. Pharmaceutical industries comprise of different types of reactants, solvents, solid water during their manufacturing and releases effluent water containing bulk drugs which is hazardous to the environment, human being and mostly to the aquatic life. Moreover, the water used for cleaning and washing purpose in these industries cannot be reused due to strict standards and hence the toxicity is to be reduced for environmental purpose [6].

Studies of Harvey and Loomis have investigated the destruction of the micro bubbles formed due to cavitation was taken under considerable interest. The research focused on understanding the process of ultrasonic interaction between

liquid and gas in solution and associated with the shear disruption, heating and free radical production. The amount of dyes disposed into water causes contamination released from industries like textile and paper industries. These dyes sustain in environment for longer period under the conditions of temperature and high stability of life [7]. This is responsible for reduction of solubility of oxygen into water which is the major requirement for photosynthesis for marine life. The dye used in treating effluent textile water is Triphenyl nitrogen that has cationic dye.

Combining the technique of ultrasound with Fenton process to reduce the content of Dye called as C.I acid orange 7 from the textile waste water. The oxidising agent like H2O2 used to modify the parameters and the properties of waste water to increase its efficiency. The result concluded that the rising content of oxidising agent with intensity of power increases the decolourisation rate. Wastewater contains a number of pollutants and contaminants that includes:

- Plant nutrients (nitrogen, phosphorous, potassium)
- Pathogenic microorganisms (viruses, bacteria, protozoa and helminths)
- Heavy metals (Cadmium, Chromium, Copper, Mercury, Nickel, Lead, Zinc)
- Organic pollutants (polychlorinated biphenyls, polyaromatics hydrocarbons, pesticides, biodegradable organics like BOD, COD)
- Micro-pollutants (medicines, cosmetics, cleaning agents)

These pollutants can cause adverse effects to the environment and eco system. Some of these adverse effects include metal poisoning, irritation and pathogenic infections; eutrophication. Eutrophication causes bio accumulation, bio magnification, toxic material release, and nutrients enrichment effects [8]. To avoid these negative and hazardous impacts there is need to treat the wastewater properly that is releasing into various water bodies.

Pharmaceutical waste water

Numerous kinds of pharmaceutical drugs being used for treatment of human as well as animals are emerging as pollutant in environment. Different type of drugs like Antibiotics, contraceptives, Antiseptics, Antivirals, Antipyretic, Analgesic, etc. are being released to the environment causing pollution rate rise day by day [9]. Some of the pharmaceuticals like Acetaminophen, Codeine, DCF, Aspirin, Caffeine, Amoxicillin, etc. are found in pharmaceutical wastewater that is harmful to the environment. The microbial toxicity, high salt content and high concentration of organic matter are difficult to bio degrade, which are the main components complex pharmaceutical wastewater. In spite of various treatments, the quantity of dissolved organic matters and suspended solids are found in high amount. Different processes applied for treating pharmaceutical wastewater like coagulation, sedimentation, membrane separation, advanced oxidation processes, active carbon adsorption, biological treatment etc. to balance environmental safety [10].

Analysis

Pharmaceutical industries are taken as a rising environmental issues due to their continuous contact and persistence with aquatic environment and hazardous effects on various living species. Treatment of pharmaceutical waste water up to the required standards has always been a challenge due to wide range variety of products produced in pharmaceutical industry. Some of the biologically toxic and refractory pharmaceutical waste water like cephalosporin is tremendous hazardous to the environment. For the degradation of such toxic waste water. Sonoelectrochemical catalytic oxidation process is used by using nanocoated electrode. This Sonoelectrochemical technology is applied as the advanced treatment method for different industries which releases toxic contents, organic contents, refractories, aromatic and phenolic derivatives, etc. Ultrasound can effectively promote the oxidation activity by producing hydroxyl radicals [11].

The non-steroidal, anti-inflammatory drug like Diclofenacis consumed by human being, whose excretion of 15% from body is remain unchanged, from many pharmaceutical industries it affects the environment and aquatic life too. This toxicity of DCF is decreased by using ultrasound with increasing frequency with different oxidising agents. The Amoxicillin encountered in the pharmaceutical waste water is found toxic and hazardous to the environment. For degradation of such pharmaceutical compound, the aid of ultrasound waves with high frequency is applied along with hydrogen peroxide as an oxidising agent. The highest degradation of Amoxicillin is achieved within 90 min.

Across the globe number of pollutants is encountered each and every year, one of them are pharmaceutical pollutants. For the degradation of aspirin in the waste water from pharmaceutical waste water many kinds of advanced oxidation process are discovered. Advanced oxidation with ultrasound is one of the processes which give some benefits compared to the conventional methods. Using probe sonicator system, the degradation of aspirin is carried out for natural and induced conditions are studied and thoroughly concluded that this process can be good option for degrading various pollutants in waste water [12]. The most commonly used drug Ibuprofen that is used to treat fever, pain, injuries and inflammation. By various routes this drug can easily enters into environment. Several researchers reported that partial degradation of IBP is dangerous because after its transformation the products formed are more toxic and hazardous. Using Sonolysis and sono-Fenton process, the degradation of IBP drug is carried out with satisfactory results.

The photocatalytic degradation of pharmaceutical compounds using Titanium dioxide is an effective process for the degradation of Azithromycin and Esomeprazole. Up to 60% COD reduction was achieved with utilization of TiO_2 nano par ticles. For treatment of pharmaceutical waste water various for Sonochemical degradation along with various additives are utilized viz. activated carbon, Fe^{3+}, Hydrogen peroxide, and Potassium dichromate. These additives affect the degradation process thoroughly and give effective outcome [13].

Table 1. *Overview of pharmaceutical wastewater treatment.*

Sr. No.	Type of WasteWater	Treatment Method	Operating Condition/ Parameters	Results	Comments
1	Pharmaceutical WW [EI products, Parwanoo (H.P.), India	Acoustic Cavitation (20 kHz)	Ultrasound wave frequency = 20kHz	COD removal up to 75.53 % (75min)Time = 2 hrs for settlement of precipitate	COD degradation increases up to 75min and start decreases after 75min.
2	Solution containing Diclofenac.	Ultrasonic degradation by using horn sonicator	Power density =25-100 kWSubstrate concentration = 2.5-80 mg/lit	Toxicity of the solution is reduced	Total degradation of toxicity cannot be achieved

Textile waste water

The demand for textile material produced from textile industries and finished products are at high demand due to its high quality. However, the different toxic material released from textile industries particularly dye into the water considerably creates water pollution and degrades the efficiency of environment. The generated contaminants can be reduced by varied range of processes, divided into primary, secondary and tertiary treatments, and the purification of such water depends upon type of matter present in it.

Textile industries include variety of components during production, processing and finishing of the product along with the raw materials and different chemicals. Sizing materials like starch, Polyvinyl Alcohol (PVA), polyacrylates and carboxymethyl cellulose in waste water outlet from the unit, increases the level of BOD, COD and suspended solids. Contaminations present in natural fibres are basically fats, oils, waxes, minerals with plant matter [14]. During the process of scouring the materials used for washing and cleaning purpose are detergents, assisting agents, soaps, defoamer, and lubricants. Wool carbonising, Cotton Merce rising, Dyeing, Bleaching, Printing, Sizing and Desizing releases the effluents that are hazardous to environment to create pollution.

Analysis

The textile waste water comprises of a dye namely acid blue 80 (AB80), which can be degraded by using ultrasound cavitation. Where the parameterslike pH, volume, amplitude and temperature are indulged. Higher concentration of dye from textile waste water retards the human health along with aquatic life. The reagent highlighted is basically hydrogen peroxide to sample for treatment to obtain required parameters useful to mitigate pollution. A new technology emerged to drop down the organic contaminants by using Hydroxide radicals is primarily called as Advanced Oxidation Processes (AOP's). The largest manufactured group of dye is azo dye that creates domestic environment pollution when emitted into water and resist itself for longer time. The Advantages of treating wastewater by ultrasound process increases the efficiency of water content, saves energy, reduces the time required and enhances the environmental conditions. Ultrasound process increases the technique of adsorption and promotes diffusion between molecules and particles of dye in solution by adjusting the fibre structure.

Table 2. *Overview of Textile wastewater treatment.*

Sr. No.	Type of WasteWater	Treatment Method	Operating Condition/ Parameters	Results	Comments
1	Acid Blue 80 textile waste water	Ultrasound cavitation	Amplitude =75% PH =2.5 Temperature=30˚C Volume= 200 ml	34.94% AB80 degraded	
2	Dye Waste Water	Ultrasonic Cavitation Hydrodynamic Cavitation,	Frequency =20 kHz Model ICS =204 Ultrasonic reactor =20-40˚C	According to economic considerations cavitation process is effective for textile waste water treatment.	The technique used for lab scale should be evaluated for industrial scale.
3	Varied Dyes in waste water	Advanced oxidation process for COD removal, Sonolysis	Sonolysis without dipping= 90 min pH=6 Sonolysis with dipping= 90 min pH=6	COD value Obtained 1200-1300 mg/L pH=5.9 - 6.5	High amount of organic and inorganic matter in waste water indicated through results.

These parameters increase their content during further additions of chemicals for textile manufacturing process that widely includes Polyvinyl Alcohol (PVA). During combustion of coal, fly ash is been obtained as a by-product that can be initiated to degrade azodye acid orange. This can be achieved through the process of ultrasonic irradiation, eventually this pace proves that there is no alteration of crystal structure of fly ash. The study of structural dimension along with impact of ultrasound was enhanced by the X-ray diffraction and X-ray energy dispersive analysis. The study involves the reduction of the textile dye called as Azo Dye Acid Red B (ARB) by succour of sonication along with presence of pH, anions of (Cl^- NO^{3-}, $(SO_4)^{2-}$) with saturated gas namely argon and oxygen. The conditions applied conspicuously tend to adsorb ARB on oxidising agent MnO2. Even the particle properties of this agent are studied for efficiency. The waste water containing CI reactive orange 127 and polyvinyl alcohol is treated with Sonofenton and Fenton processes by addition of oxidising agent ferrous ion Fe^{+2} and H_2O_2. Colour content in textile industrial waste water is tremendous and high enough to increase the COD, BOD, acidity salts, suspended solids, heat.

Dairy wastewater

Different sources for generating dairy waste water, is depended on the production of the dairy products. Dairy waste water contains fats, lactose, whey protein, nutrients, inorganic salt phosphates, ammoniaand also high concentration of BOD, COD, colour, odour, etc. The disposed waste water to the atmosphere should have low contaminants to mitigate the pollution. Various type of toxic chemicals, organic matter present in dairy waste water so it needs to remove because it effects on environment as well as human life. The different kind of treating processes are used such as coagulation, adsorption, membrane separation, charcoal treatment, High concentration of BOD is not removed directly to atmosphere so breaking up some of components to protect and keep safe environment.

Analysis

In Dairy waste water toxic chemicals are not present but high concentration of dissolved organic components such as fats, oils, grease and nutrients are present in it.The dairy waste water treating with different chemicals such as Hydrogen peroxide, Ferrous sulphate heptahydrate, Sulphuric acid and Sodium hydroxide etc. to find the different parameters like pH, Turbidity, TSS, COD and BOD. For this process Cavitation Reactor are used for the degradation. The different range of sonication poweris used for the reduction of COD of dairy industry waste water. Ultra-sonication and Cavitation processes is used for treated Industrial Dairy Waste Water and also modified physical and chemical properties of different milk constituents (Milk fat and proteins). This processes alsostudy the effects on other milk components. The energy released during both of the processes changes the properties of milk components.

Bougrier, etc. all that suggest COD released is always related to specific energy and contact time is depends on the temperature. Spectro-photometer model DR/2800, HACH this equipment is used for this process for removing the parameter such as COD, SCOD, TKN, TP etc. Ultrasonic wave irradiation processescause releasing nutrients from the solid state to soluble form. Ultrasonic membrane hybrid processes is used for dairy wastewater treatment. Hybrid process of Membrane filtration and Ultra sonication for treating industrial dairy waste water. In this processes, Dead-end stirred cell device is used in laboratories scaleto find out diffusion coefficients by Fick's law and determination of CMC, Reynolds number, Mass transfer coefficients and concentration on membrane surface.

Conclusion

The presence of Pharmaceuticals, Drug compounds, Dyes, Toxic chemicals, Organic compounds and many other pollutants in the wastewater of Pharmaceutical, Textile and Dairy industries is a huge challenge for the living organisms in environment. For degradation of such toxic and hazardous compounds in the wastewater to meet the need of safe environment can done by using ultrasound as an effective option with satisfactory results. The process is carried along with various oxidising reagents, using electro chemistry, photo catalysis and other chemicals to increase the percentage degradation. Use of ultrasound is eco-friendly option to degrade pollutants and reduce the pollution. It might be a best option for treating the industrial wastewater.

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