AISSMS COLLEGE OF ENGINEERING

ज्ञानम् सकलजनहिताय

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Sewage Disposal System
(Sewage Treatment Plant (STP))

at

AISSMS College of Engineering

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Introduction

Currently, world is facing treacherous problems associated with the treatment of wastewater as well as drinking water. In 2010, UNICEF published a report, which showed current status of the virtual water crisis in the world. It has been pointed out that more than 1.4 million children of age less than five years die every year due to diarrhea disease only, and this is the second largest cause of human death in the world. Situation is even graver in the developing countries, as the mortality rate was 1000/day in these countries for similar age group in 2014. This clearly indicates that the existing methods or technologies have completely failed to treat the wastewater to approved discharge standards.

Various processes have been developed to treat waste water, which includes activated sludge process, advanced oxidation process, aerobic granulation, bioreactors, trickle bed reactor, moving bed bio film reactors (MBBR) etc. Conventional water treatment plants are costly to construct and rely upon vast tracts of land for large settling and aeration basins, treated effluent does not meet BOD and COD targets and moreover one of major environmental challenge is generation and treatment of secondary waste. Advanced oxidation processes (AOPs) although making use of different reacting systems, are all characterized by same chemical feature; production of OH radicals. Advanced oxidation processes are defined broadly as those aqueous phase oxidation processes which are based primarily on generation and attack of hydroxyl radicals resulting in destruction of target pollutants. Some of AOP's which have shown considerable promise for waste water treatment applications, include cavitation, fenton chemistry and photocatalytic oxidation. Usually a combination of different AOP's has been found to be more efficient for waste water treatment as compared to individual oxidation process.

Cavitation is basically a phenomenon of nucleation, subsequent growth and implosion of vapour/gas filled cavities. It is a process of producing cavities, generated in low pressure region that is a throat or a contraction, because of pressure fluctuation when a fluid is flowing through a constriction. A principle type of cavitation includes acoustic, hydrodynamic, optic and particle cavitation. Acoustic and hydrodynamic cavitation generates desired intensity suitable for chemical and physical processing. However it has been observed that use of sonochemical rectors pose significant problems for design and efficient operation at large scale operation due to substantially lower energy efficiencies and higher cost of operation. Use of hydrodynamic cavitation reactors which has been recently looked as an alternative to acoustic cavitation is an emerging technology and there are no instances where these reactors have been investigated for sewage treatment applications.

Hydrodynamic cavitation is a technology that has been successfully developed at laboratory scale and it is also proven to be effective on pilot scale for various applications, viz. extraction, crystallization, degradation and water purification, biodiesel due to its intense effects in terms of mass and heat transfer at otherwise atmospheric conditions. Hydrodynamic cavitation can be generated using venturi, orifice plate, throttling valve and high speed homogenizer. However, it is still lacking in its implementation on large/commercial scale applications. Based on the primary objective, there is an urgent need to develop an affordable technology/process, which can disinfect water so as to avoid water borne diseases. As the major sources of water contamination can be agricultural runoff, human activities and industrial effluents, the new technology has to be capable of treating them effectively.

In the present study, hydrodynamic cavitation has been used for sewage treatment of All India Shri Shivaji Memorial society's college of Engineering which is situated in Pune. In the present work, various parameters have been investigated based on venturi hydrodynamic cavitation.

Along with cavitation, chemical treatment such as ozone and hydrogen peroxide also being used to intensify the process. The optimized parameters such as pressure, ozone concentration, flow rate, H_2O_2 dosage and pH will be investigated in the future studies. The present technology is versatile, cost effective and energy efficient as well.

STP Facility

a) Sewage Water Input

Sewage wastewater has been collected from the spent water in Laboratories, wash water sinks in the college premises at All India Shri Shivaji Memorial society's College of Engineering, Pune campus. It has high value of COD, BOD along with odor and color. The initial COD of 1200 ppm. The BOD was content was about 10 ppm.

b) Ozone Generator

Ozone was produced on site using water cooled corona discharge ozonation (Capacity of 10g/hr max, Concentration of 50-100 gm/m^3) was procured from Ozone Engineers. Hydrogen Peroxide (30% w/v industrial grade, with remaining water) was used.

c) Hydrodynamic Cavitation Setup

Schematic depiction of the flow loop for hydrodynamic cavitation has been shown in the Figure. The flow loop essentially consists of a treatment tank, a centrifugal pump (1 m^3/hr) and series of valves to adjust the flow through the main line and bypass line. The suction side of the pump is connected to the bottom of the tank and a foot valve is used. The discharge from the pump branches into two lines; mainline and the bypass line. The main line consists of a venturi, which acts as a cavitating device. The mainline as well as the bypass line discharges into tank with their ends dipped well into the liquid in the tank to avoid any entrainment of air into suction line of the pump. Pressure gauges are mounted to measure the upstream and downstream pressure of the cavitational device (P1 and P2).

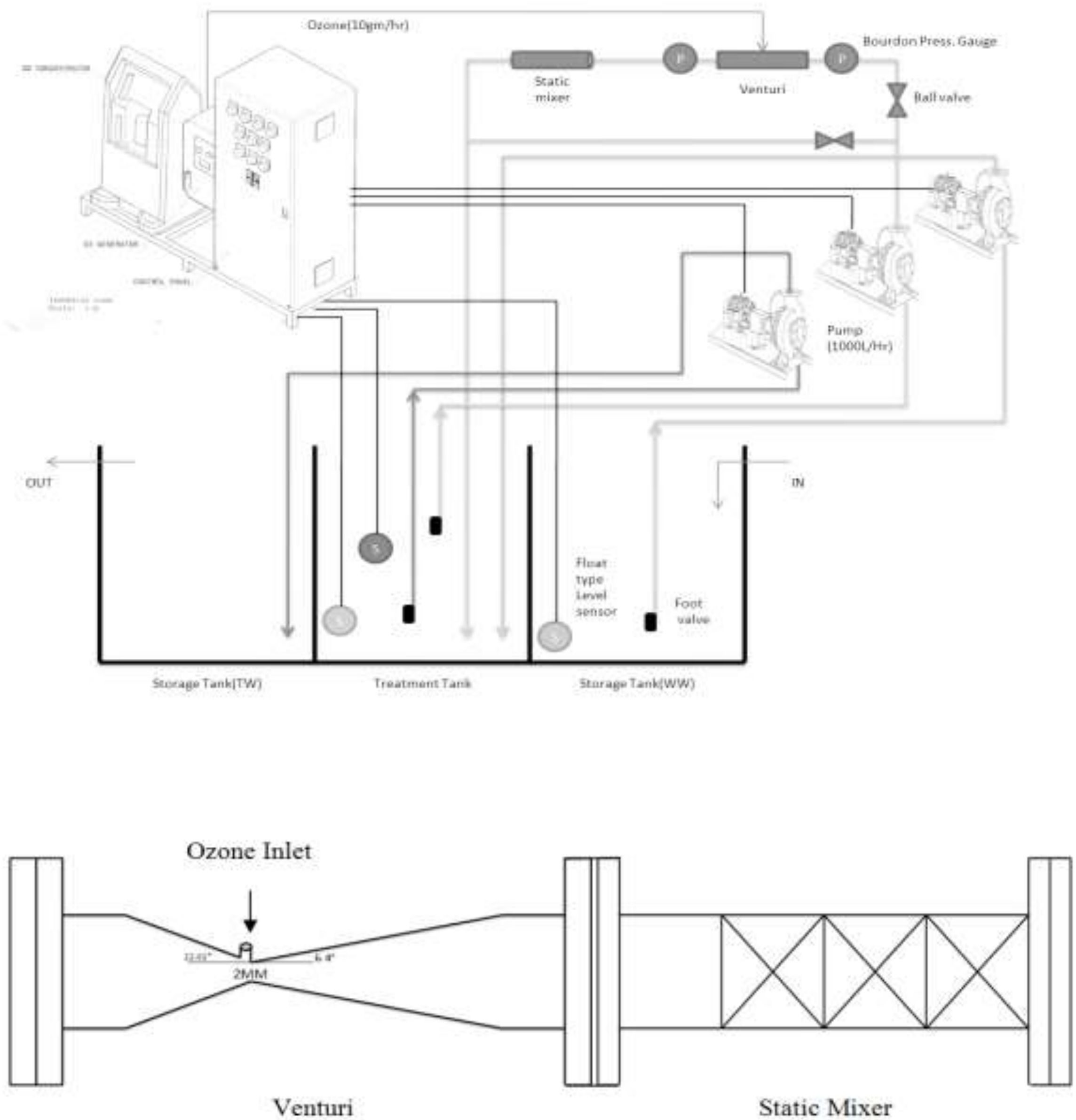

Fig. 1. Schematic representation of STP using hydrodynamic cavitation

d) Treatment Process

Sewage of AISSMSCOE campus is collected in storage tank. Using centrifugal pump (1/2 HP), sewage is pumped into treatment tank. Combination of hydrodynamic cavitation and O_3/H_2O_2 system is used for treatment. The treatment system consists of cavitation loop and ozone injector. Ozone is produced on site using oxygen pre concentrator and ozonation. Air contains 21% oxygen and 78% nitrogen. Oxygen concentration systems separate oxygen from compressed air through a process known as pressure swing adsorption (PSA). This process employs molecular sieves which adsorbs nitrogen from air at high pressure and releases the nitrogen at low pressure. Typically, these systems employ two tanks filled with the absorbent. As compressed air flows through flows through one tank, the nitrogen is adsorbed. The oxygen passes through the system to the ozone generator. When the tank begins to saturate with nitrogen, the flow is switched to the other tank. At that point the pressure in the first tank is lowered releasing the adsorbed nitrogen. It is purged with oxygen from the other tank. This process is repeated when the second tank is saturated with nitrogen. The result is a constant flow of gas with 90-95% oxygen content. The molecular sieve has long life and relatively inexpensive. Ozone is generated using corona discharge ozonator. Any electrical spark or discharge will create ozone. In discharge ozone generator, the electrical discharge will take place in an air gap within the corona cell designed specifically to split the oxygen molecule and produce ozone. In this air gap a dielectric is used to distribute the electron flow evenly across this gap to spread the electron flows to as great a volume of oxygen as possible. Produced ozone is injected and mixed using static mixer. Venturi injectors do attain fairly good mass transfer, but using a static mixer can greatly improve mass transfer efficiency. After treatment, the treated water is pumped into storage tank. Float switches were used to detect and indicate level of sewage inside the tank, and automatically controls the pump .A variable frequency drive is used for adjusting flow or pressure to the actual demand. It controls the frequency of electrical power supplied to pump.

Fig. 2. Actual set up with control unit

More than 5000 litres of waste water is being generated from building every day. The capacity of pilot plant was 9000 litres per day. The sewage water treatment phenomenon is based on hydrodynamic cavitation, in which intense collapse of cavity occur which gives physical as well as chemical effects associated with it useful for water treatment. Ozone is added because of its excellent disinfection and oxidative qualities (oxidizing potential: 2.07) .Ozone also helps in removal of organic and inorganic matter, micro-pollutants and odor elimination. Ozone is mixed using static mixer. An O_3/H_2O_2 system is an AOP in which hydrogen peroxide is used in conjunction with ozone to enhance the formation of hydroxyl radicals. The hydroxyl radicals are a stronger oxidant than molecular ozone alone. H_20_2 is added ahead of ozone so that H_2O_2 treated water is ozonation. HC-O_3/H_20_2 system makes the process more efficient and economical. The preset experiment work was performed with $1m^3$ of waste water for 45 mins of treatment at 28 C. The inlet pressure was 4 bar. Ozonator was run at a capacity of 10gm/hr. During the experiment samples were withdrawn before and after treatment to analyze the process of treatment.

e) Analysis Method

Initial and final samples were taken and analyzed for BOD and COD. Chemical Oxygen Demand (COD) measurement were analyzed using a COD digester (Hanna Instruments, model no: HI 839800) with standard vials and a digital photometer.

Results: *COD and BOD reduction*

The treatment effects in quantitative terms of COD and BOD reduction. The initial COD of 1200 mg/L with sewage was reduced to 200 mg/L after 45 mins of treatment. The BOD was also reduced from 10 mg/L to 4 mg/L. The hydroxyl radicals generated due to high temperature dissociation of water vapour inside cavities, degrade the organic contaminants present in the sewage by oxidizing them. The secondary radicals are also generated in the bulk water, which further enhances the degradation of pollutants.

Sewage of All India Shri Shivaji Memorial society's College of Engineering, Pune was efficiently treated using hydrodynamic cavitation and ozone. The foul smell emanating from the water was removed after 45 mins of treatment. These effects were sufficient for removal of color, bacteria [15] as well as organic contaminants present in the sewage. In scientific terms major reduction of COD (83.33%) and BOD (60%) was observed. The present work has enabled us to conclusively establish the efficacy of hydrodynamic cavitation reactors as compared to conventional sewage treatment methods. It can be said that hydrodynamic cavitation reactors offer immediate and realistic potential for scale up sewage treatment application.

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