Cost Effective and Eco-Sustainable Treatment Options for Waste Water Effluents from Pharmaceutical Companies

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Abstract— There is the concern about the occurrence of active pharmaceutical ingredients, solvents, intermediate and raw materials that may be present in water and sanitation, including wastewater, growing interest in the pharmaceutical industry. Traditional methods of water treatment, such as activated sludge, are not sufficient for a complete removal of active pharmaceutical ingredients and other ingredients of sewage water. As a result, they often use complementary therapies such as membrane filtration, reverse osmosis and activated carbon along with traditional methods to treat industrial wastewater. Most of the writings were published so far in the municipal wastewater treatment. However, there is a growing body of research that looks at the proliferation of active pharmaceutical ingredients in the industrial wastewater and liquid waste treatment and removal rates. This article examines the treatments including both traditional methods and advanced oxidation processes. The paper concludes that the problem of waste water treatment can not be easily solved and there is the necessity of removal of critical chemicals from waste water of pharmaceutical industry.

Key words: Pharmaceutical Ingredients, Sewage Water, Critical Chemicals, Nanofiltration

I. INTRODUCTION

Availability of drugs and personal care products in surface wastewater was first detected in the United States and Europe, the 1960s. Concerns about their potential risk was raised in 1999 with the theme attracts great interest for the presence of pharmaceuticals in river water was feminization of fish surviving connected behind Effluent. An additional member between a non-steroidal anti-inflammatory agents, Diclofenac and renal failure vultures Post > 95% decline in population in the Indian Subcontinent since the 1990s has been to raise awareness reported. A study showed that the organic wastewater Contaminants including PPCPs was present in 80% U.S. 139 from the streams. Although the levels of PPCPs found Environment at trace levels, the chemical Perseverance, antibiotic resistance and synergistic Effects still unknown which is a cause for concern. In addition, the negative produces low levels. Effects on aquatic organism's life. Pharmaceuticals into the environment from a plurality of dispersed points. The main sources of Contamination, the pharmaceutical manufacturing Plants, sewage treatment plants, hospitals, landfills and even Cemeteries. The best-studied way in which Medicines for the environment, it is from municipal wastewater treatment plants. Human excretion unchanged or slightly tilted Active Pharmaceutical Ingredients (API), conjugated with polar molecules, such as Glucuronide in the sewage plant where these conjugates can then split the original document in API environment activated sludge. Sewage treatment has been particularly attention. A limited number of Studies also show drugs in drinking water and hospital wastewater. Monitoring release of APIs found in pharmaceutical production is not routine and importance of such releases are not established. Furthermore, pharmaceutical industry effluents containing organic solvents, catalysts, reactants, Intermediate goods, raw materials and APIs that are difficult to treat them. The presence of toxic substances or recalcitrant such Emissions taxes lead to lower chemical oxygen demand (COD) efficiencies. It Remove it was estimated that up to half of the pharmaceutical Wastewater produced in the world without released one treatment. While some Attention focused on endocrine disruptors chemicals (EDC) removal by other specific APIs largely ignored. Biological purification of waste water the most common and economical wastewater treatment method. However biological, Processes must be sufficient to remove all potentially hazardous components in wastewater. Recently, membrane bioreactor (MBR) technology, Ozonation and advanced oxidation processes (AOP) have demonstrated varying degrees of effectiveness for treating pharmaceutical wastewater.

II. CONVENTIONAL TREATMENT METHODS

Biological treatment methods have traditionally been used for the management of pharmaceutical wastewater (Suman Raj and Anjaneyulu, 2005). They may be subdivided into aerobic and anaerobic processes.

A. Aerobic Applications

Activated sludge, membrane batch reactors and sequence batch reactors (LaPara *et al*., 2002; Suman Raj and Anjaneyulu, 2005; Noble, 2006; Chang *et al*., 2008 and Chen *et al*., 2008). Anaerobic methods include anaerobic sludge reactors, anaerobic film reactors and anaerobic filters (Gangagni *et al*., 2005; Enright *et al*., 2005; Chelliapan *et al*., 2006; Oktem *et al*., 2007; Sreekanth *et al*., 2009). Activated sludge (AS) treatment is unsuitable for the treatment of wastewater where the COD levels are greater than 4000 mg/L (Suman Raj and Anjaneyulu, 2005). high energy consumption, the production of large amounts of sludge (Sreekanth *et al*., 2009) and operational problems including color, foaming and bulking in secondary clarifiers are associated with activated sludge plants (Oz *et al*., 2004). The impact of pharmaceuticals on the AS process appears to be negligible under normal operating conditions (Stamatelatou *et al*., 2003). However at higher concentrations, which may be expected in the wastewater of pharmaceutical manufacturing facilities, they may become inhibitory.

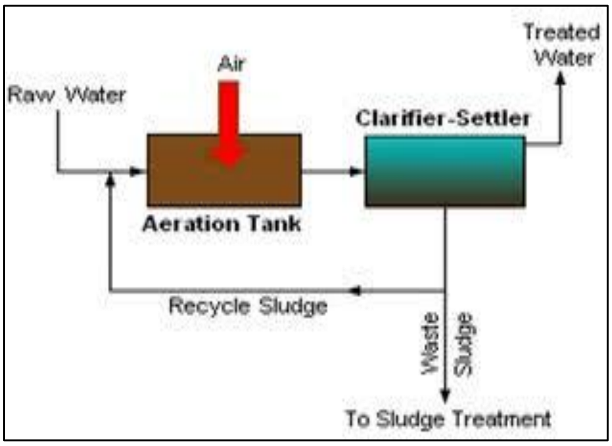

Fig. 1: Schemetic diagram showing the process Activated sludge process.

Ibuprofen, naproxen, bezafibrate and estrogens (estrone, estradiol and ethinylestradiol) showed a high degree of removal while sulfamethoxazole, carbamezapine and diclofenac showed limited removal (Clara *et al*., 2005; Joss *et al*., 2005; Xu *et al*., 2008). The advantages of anaerobic treatment over aerobic processes is its ability to deal with high strength wastewater, with lower energy inputs, sludge yield, nutrient requirements, operating cost, space requirement and improved biogas recovery.

B. *Anaerobic Treatment*

The advantages of anaerobic treatment over aerobic processes is its ability to deal with high strength wastewater, with lower energy inputs, sludge yield, nutrient requirements, operating cost, space requirement and improved biogas recovery. One way around this is to use anaerobic microorganisms such as methanogenic archaea, which can adapt to levels many times those that inhibit unadapted methanogens (Fountoulakis *et al*., 2008) as well as incorporating different configurations including bio-membrane reactors, stirred tank reactors, up-flow anaerobic filters and fluidized bed reactors (Gangagni Rao *et al*., 2005; Chelliapan *et al*., 2006; Oktem *et al*., 2007). Up-flow anaerobic stage reactors (UASRs) used as a pre-treatment to activated sludge for industrial effluent have been shown to be efficient for the removal of pharmaceuticals even at high concentrations (Chelliapan *et al*., 2006; Oktem *et al*., 2007). A UASR fed with real pharmaceutical wastewater containing the antibiotics tylosin and avilamycin showed a high degree of COD and drug removal (Chelliapan *et al*., 2006).

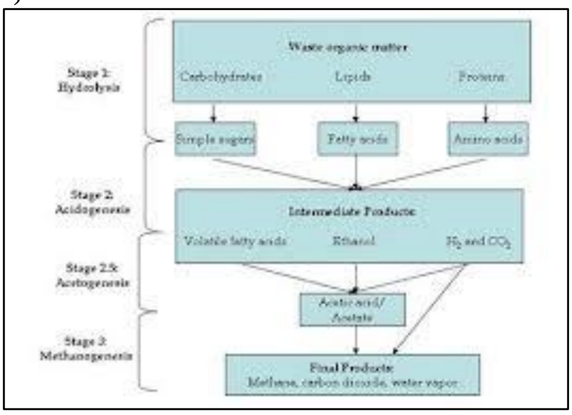

Fig. 2: Anaerobic treatment methods for waste water treatment.

C. *Membrane Processes*

Several membrane types and applications were evaluated for the removal of APIs at pilot and full-scale, including microfiltration, ultra filtration, nanofiltration, reverse osmosis, electro dialysis reversal, membrane bioreactors and combinations of membranes in series (Bellona and Drewes, 2007; Snyder *et al*., 2007). Microfiltration and ultra filtration are generally not fully effective in removing organic contaminants as pore sizes vary from 100-1000 times larger than the micro pollutants which can slip through the membranes. The pressure-driven membrane processes Nanofiltration (NF) and Reverse osmosis (RO) have been the focus of attention of many researchers for the treatment of drinking water (Watkinson *et al*., 2007). However, the studies on the use of RO/NF for pharmaceutical removal is limited and most of the studies employed NF and RO membranes for tertiary treatment in wastewater recycling plant or for treating saline groundwater. (Nghiem *et al*., 2005; Yoon *et al*., 2006; Snyder *et al*., 2007). RO in different configurations showed efficient removal of thirty-six personal care products and endocrine disrupting chemicals including antibiotics, lipid regulators, hormones and oral contraceptives, antiepileptic and analgesics (Snyder *et al*., 2007; Watkinson *et al*., 2007).

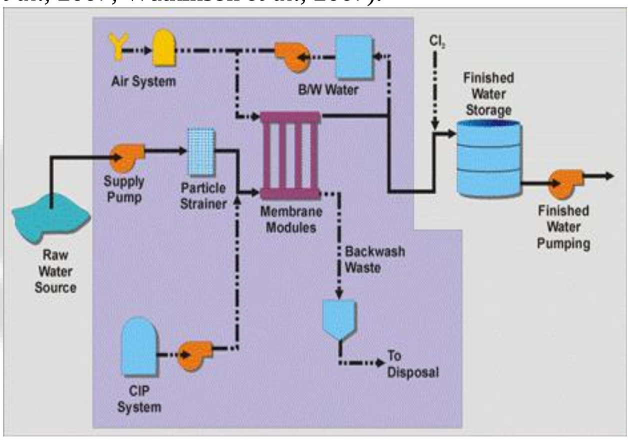

Fig. 3: Membrane process for waste treatment.

III. SOME COST-EFFECTIVE METHODS

A. *Chlorination*

Chlorination has been shown to be effective for the removal of pharmaceuticals including 17α-ethinylestradiol and 17 β-estradiol (Alum *et al*., 2004) and sulfonamides (Qiang *et al*., 2006). Chlorine dioxide is also effective for the removal of sulfamethoxazole, roxithromycin, 17α-ethinylestradiol and diclofenac (Khetan and Collins, 2007). Chlorination and ozonation when compared for the removal of bisphenol A, 17β- estradiol, and 17α-ethinylestradiol and byproduct estrogenicity from distilled water showed comparable results with ozonation resulting in 75-99 % removal (Alum *et al*., 2004). Residual chlorine and ozone was found to be low with > 99 % loss of the parent compound (Gharbani *et al.*, 2010).

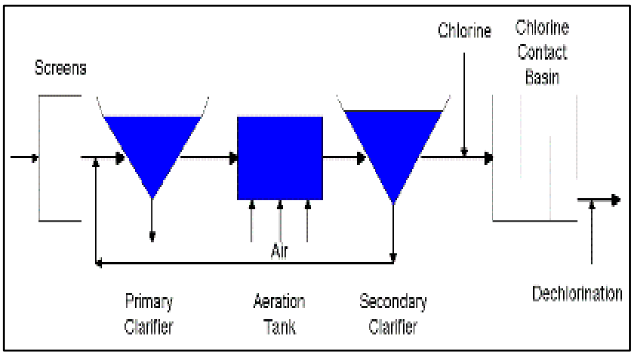

Fig. 4: A chlorination (cost-effective) method for waste treatment.

B. Oxidation Reactions

The biological and physiochemical treatment methods described previously have shown limited success for the treatment of pharmaceutical wastewater. However, the development of oxidation processes is showing higher removal rates. Oxidation reactions have primarily been used to supplement rather than replace conventional systems and to enhance the treatment of refractory organic pollutants (Balcioglu and Otker, 2003). This technology has been successfully applied to the treatment of pharmaceuticals (Khetan and Collins, 2007). A chemical agent such as hydrogen peroxide, ozone, transition metals and metal oxides are required for AOPs. In addition, an energy source such as ultraviolet-visible radiation, electric current, gamma-radiation and ultrasound is required (Ikehata *et al*., 2006).

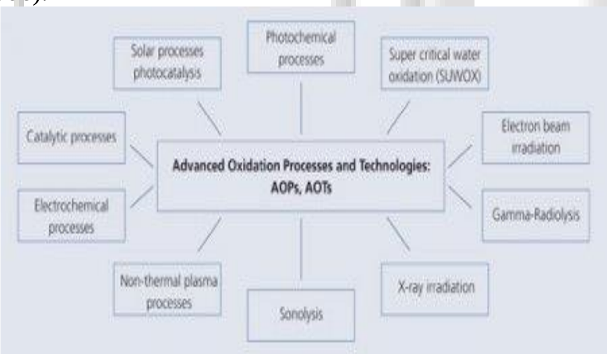

Fig. 5: Oxidation process.

C. Photocatalytic Reactors and Reaction Kinetics

In the development of photo catalytic reactors, many factors need to be considered including mass transfer, reaction kinetics, mixer, catalyst installation and catalyst illumination. Based on the arrangement of the light source, reactor configurations can be categorised as: 1) immersion type where lamps are inserted into the reactor, and 2) external type where lamps are put outside the reactor (Ray, 1998). One of the major impediments to the commercialization of photo catalytic water treatment is the high cost of generating artificial radiation. Therefore, solar photo catalytic reactors have received considerable interest. To ensure efficient conversion of the incident solar radiation to charge carriers, the design of the solar reactor is extremely important. There are four frequently used reactor configurations: Parabolic trough reactor (PTR), Thin film fixed bed reactor (TFFBR), Compound parabolic collector (CPC) and Double skin sheet reactor (DSSR) (Bahnemann, 2004).

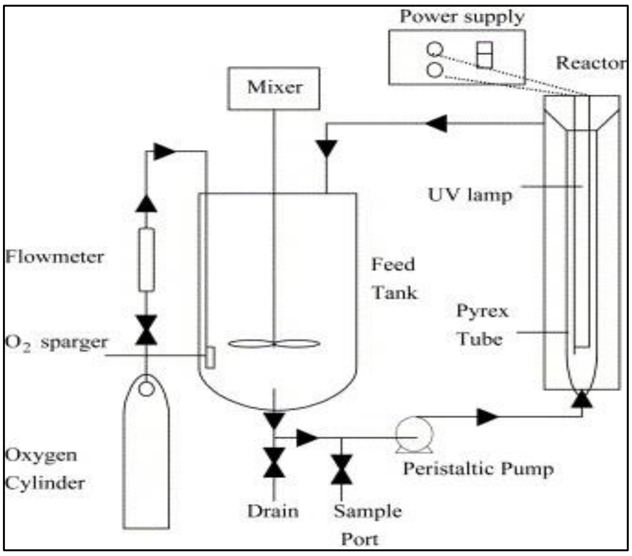

Fig. 6: Photocatalytic reactors and reaction kinetics.

IV. Conclusion

Various treatment methods for pharmaceuticals in water and wastewater found in the literature have contributed greatly to our knowledge regarding the fate of these compounds in different treatment systems. Generalizing compound behavior in these systems would allow further characterization of the fate and risk associated with pharmaceuticals in the environment, yet this description of trends is hindered by the wide variation in removal efficiencies across therapeutic classes, treatment processes, and even among separate studies for the same individual compounds. The majority of studies summarized used "removal" to describe the elimination of parent pharmaceuticals. The mere disappearance of the parent compound cannot be considered synonymous with complete removal. If adequate controls for physical and chemical removal mechanisms are in place, the loss of the parent compound indicates biotransformation of an unknown degree and not necessarily mineralization.

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