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A REVIEW ON VARIOUS TREATMENT METHODS FOR TREATING PHARMACEUTICAL WASTEWATER

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Abstract-With the rapid increase in population, developmental works and industries, the environment is bound to get polluted, if timely steps are not taken for proper treatment of the pollutants. Sustainable development for a nation depends upon the economic, social and environmental growth. Pharmaceutical industries are one of fast growing industries in world and releasing complex and toxic industrial wastes. Like economic and social growth, environmental growth also plays an important role for the development of a nation. This paper reviews various treatment methods for the treatment of the pharmaceutical wastewater. Many researchers have tried to find out different treatments for pharmaceutical wastewater. This paper includes various types of processes like coagulation, fenton, physicochemical and up flow anaerobic sludge blanket reactor.

Keywords: Environment; population; physicochemical; pollution.

INTRODUCTION

The pharmaceutical industries are spreading globally because of the growing needs of its different products which are used for human and animal medications. The disposal of pharmaceuticals into the water bodies is creating environmental pollution. The wastewater containing pharmaceuticals compounds, antibiotics, anticonvulsants, antipyretics, cytostatic drugs, and drugs should be treated before discharging into the sewer networks and water bodies. Pharmaceutical waste can be of three states that is solid, liquid and gas. The liquid waste is known as pharmaceutical wastewater. The Level of wastewater pollution varies from industry to industry depending on the type of industry and the size of the industry. Waste water is generally considered in terms of temp, pH, Total suspended solid (TSS), BOD, COD, Oil & grease, chlorides and sulphates.

Treatment of pharmaceutical wastewater has always been troublesome to reach the desired effluent standards due to the wide variety of the products produced in the pharmaceutical industries. Conventional treatment methods are usually not being used these days because the substances synthesized in a pharmaceutical industry are complex organic chemical. Various treatment methods for wastewater found in the literature have contributed greatly to our knowledge regarding the fate of these compounds in different treatment systems. Advanced methods like Fenton-type processes, coagulation, treatment by ozone, up flow anaerobic sludge blanket reactor etc are used for the decomposition of waste.

LITERATURE REVIEWS

Ahmad Reza Yazdanbakhsh, Amir Sheikh Mohammadi, Mahdieh Sardar, Hatam Godini, Mohammad Almasian (2014) Study was about the COD removal from synthetic wastewater containing Azithromycin using combined coagulation and a fenton-like process. COD was selected as the main parameter to assess treatment efficacy in this study. First, the coagulation process was carried out on the synthetic wastewater and Poly Aluminum Chloride (PAX-18) having dosage of 100mg/L and pH of 7.0 was selected as coagulant. After coagulation, a Fenton-like oxidation process was performed on the effluent of the coagulation process. The optimum conditions were observed and calculated for the Fenton-like process: $[Fe^{2+}]$ = 0.36 mM/l, $[H_2O_2]$ = 0.38 mM/l and [pH] =7.0. Finally, in combined treatment (coagulation and the Fenton-like process together), the COD removal rose to 96.89% under optimum conditions. This study shows that when coagulation and Fenton-like process are combined together, the efficiency of the COD removal is high.

Gome A. and Upadhyay K. (2013)

Biodegradability Assessment of Pharmaceutical Wastewater Treated by Ozone, according to this study ozone treatment can improve biodegradability of pharmaceutical wastewater. BOD/COD, known as biodegradability, is determined, which is used to measure the degree of biodegradation in a wastewater sample. Wastewater sample was collected from one of the pharmaceutical industries in Dewas (M.P.), India. The collected sample was stored in a cold storage unit during the whole treatment period. For biodegradability improvement of pharmaceutical sample, it is recommended that treatment under acidic condition at highest ozone concentration of 32.73 mg/lit for a treatment time of 8 min and for alkaline medium

ozonation was observed more suitable at highest ozonator current of 0.5 ampere and 30 mg/lit O_3 concentration. Because higher treatment time favored the enhancement of biodegradability of samples, it can be said that due to low treatment time, no significant improvement could be reported. It can be concluded that biodegradability improved at alkaline pH of the sample.

Vanerkar A.P., Shanta Satyanarayan, Dharmadhikari D. M. (2013)

Full scale treatment of herbal pharmaceutical industrial wastewater, herbal pharmaceutical industries produce wastewater in huge amount in terms of COD, BOD, and SS. Physicochemical treatment studies were done using various conventional coagulants individually and in combination with six polyelectrolytes of three different charges. Among ten combinations, Alum 300 mg/L + Oxyfloc-FL-11 was found to be the best combination with respect to COD, BOD, and SS removals of 6266 mg/L (64.00%), 2867 mg/L (69.40%) and 637 mg/L (80.82%) respectively. Further this treated effluent was carried for secondary biological Activated Sludge Process (ASP) using optimal parameters like organic/ hydraulic loadings. Removals of organics in terms of absolute value of COD, BOD, and SS were found in the range with an absolute value of 896-944 mg/L, 156-174 mg/L and 66-74 mg/L respectively. Finally ASP treated effluent was subjected to tertiary Fenton's oxidation process where the removals of COD, BOD, SS, and TOC were found to be efficient with 138 mg/L (85.19%), 20 mg/L (88.10%), 21 mg/L (70.00%), and 98 mg/L (78.22%) respectively on optimum conditions, which is well below the prescribed standards. The tertiary Fenton's oxidation process is amenable to remove the non biodegradable organics and thus achieves the optimum removal of organics as promulgated by regulatory agency. As compared to radiation induced hydroxyl radical generation processes, the Fenton's oxidation has been found highly suitable to treat the herbal pharmaceutical wastewater.

Amir Mirzaei, Zhi Chen, Fariborz Haghighat, Laleh Yerushalmi (2017)

Removal of pharmaceuticals from water by homo/heterogonous Fenton-type processes, the presence of pharmaceuticals in natural water has raised threat to aquatic system. Advanced oxidation processes (AOPs) are able to oxidize organic pollutants whereas Fenton-based processes utilize nontoxic and common reagents and potentially can exploit solar energy, will considerably reduce the removal cost of recalcitrant contaminants. The homogeneous Fenton processes generates high amount of iron-containing sludge and limited operational range of PH. So due to that heterogeneous Fenton processes are preferred over homogeneous Fenton processes. The combination of Fenton-type processes with biological processes as the pre/post treatment stages in pilot-scale operations is considered.

Conventional wastewater treatment processes such as flocculation, filtration, coagulation and sedimentation, are not efficient in the removal of pharmaceuticals from water because of the contaminants. Advanced oxidation processes, hydroxyl radicals can be considered as an effective method to eliminate emerging contaminants from the environment. Fenton reactions with biological processes, it is possible to develop an advanced treatment process with higher efficiency and lower costs.

P. Bautista, A.F. Mohedano, M.A. Gilarranz, J.A. Casas, J.J. Rodriguez (2006) Application of Fenton oxidation to cosmetic wastewaters treatment. The removal of organic matter (TOC and COD) from a cosmetic wastewater by Fenton oxidation treatment has assessed. The operating conditions (temperature as well as ferrous ion and hydrogen peroxide dosage) have been developed. Working at an initial pH equal to 3.0, a Fe^{2+} concentration of 200 mg/L and a H_2O_2 concentration to COD initial weight ratio corresponding to the theoretical stoichiometric value (2.12), a TOC conversion higher than 45% at 25 °C and 60% at 50 °C was achieved. Fenton oxidation process allows to reach the COD regional limit for industrial wastewaters discharges to the municipal sewer system. Fenton oxidation is a feasible treatment for cosmetic wastewaters as a complement for coagulation/flocculation allowing to achieve a significant decrease of TOC and COD. The TOC conversion increases with temperature, although this effect becomes less significant as the Fe^{2+} dose increases, and even the opposite trend takes place when high Fe^{2+} loadings are used. The overall kinetics of the process was adjusted to a second-order kinetic equation with respect of TOC. This simple equation describes well the rate of TOC reduction in a wide range covering up to 80–90% of the maximum achievable TOC conversion. A value of 50.7 kJ/mol was obtained for the apparent activation energy.

M. GANDHIRAJAN, G. AMARNATH, P. KAVITHA AND RAKHEEBHAGAVATH (2008)

Characterisation and treatment of pharmaceutical R&D waste water, a study was carried out on characterisation and treatment of wastewater discharged from a pharmaceutical R&D unit. The wastewater samples were collected from laboratory scale and pilot plant (scale-up) operations and analysed. Besides, combined wastewater samples were also collected and analysed. There is wide variation in waste characteristics due to the varied manufacturing operation/reactions employed. The combined waste exerts high BOD/COD value of 1385 mg/L and 5716 mg/L, respectively. The wastewater is treated in a full-

fledged treatment plant comprising of equalisation, neutralisation, settling, extended aeration type biological treatment, pressure sand filtration and activated carbon filtration followed by a recycling plant with reverse osmosis and forced circulation mechanical evaporator. The wastewater samples were collected at various stages of treatment and results are presented.

The study on characterisation and treatment of pharmaceutical R&D waste reveals that the wastewater contains high suspended and dissolved solids and also exerts high BOD/COD. The physico chemical followed by biological treatment effects partial reduction of BOD/COD. However, the reverse osmosis system removes the pollutants and bring down total dissolved solids, BOD and COD and make fit the RO permeate for re-cycling.

Arshad Husain, Iram Javed and Nadeem Ahmad Khan (2014) Characterization and treatment of electroplating industry wastewater using Fenton's reagent, the electroplating of a metallic product is done to prevent it from corrosion and to provide a decorative and smooth finish. This paper deals with Characterization, quantification and treatment of electroplating Industry wastewater. The wastewater was treated with Fenton's reagent for the removal of heavy metals. The results indicated an increase in the percentage reduction of heavy metals with an increasing dose of Fenton's reagent. Hydrogen peroxide alone was not effective in the removal of heavy metals. However, hydrogen peroxide in combination with ferrous Sulphate (Fenton's reagent) was effective in the removal of heavy metals.

Hydrogen peroxide alone was not effective in the removal of heavy metals. However, hydrogen peroxide in combination with ferrous Sulphate (Fenton's reagent) was effective in the removal of heavy metals the removal efficiency increases with increase in hydrogen peroxide concentration. The removal efficiency of heavy metals increases by adjusting the pH of the solution to 4.0. The result reveals that about 60% of Cr, 60% Cu and 50% of Ni can be removed from an electroplating effluent by advanced oxidation process using Fenton's reagent at acidic pH of 4.0.

D. Puyola, V.M. Monsalvoa, A.F. Mohedanoa, J.L. Sanzb, J.J. Rodrigueza (2014)

Cosmetic wastewater treatment by upflow anaerobic sludge blanket reactor, anaerobic treatment of pre-settled cosmetic wastewater in batch and continuous experiments has been noticed. Biodegradability tests revealed high COD and solid removal efficiencies (about 70%), being the hydrolysis of solids the limiting step of the process. Continuous treatment was carried out in an upflow anaerobic sludge blanket reactor. High concentration of COD and TSS removal efficiencies (up to 95% and 85%, respectively) were achieved over a wide range of organic load rate (from 1.8 to 9.2 g TCODL−1 day−1). Methanogenesis inhibition was observed in batch assays, which can be forecast by means of a Haldanebased inhibition model. Both COD and solid removal were designed by Monod and pseudo-first order models, respectively.

The results indicate that pre-settled cosmetic wastewater can be satisfactorily biodegraded by anaerobic granular sludge in an upflow anaerobic sludge blanket reactor. These wastewaters show a low methanogenic potential. The observed inhibition of acetotrophic methanogenesis can be caused by the presence of an inhibitory fraction of the COD. Hydrogenotrophic methanogenesis inhibition is accurately predicted by a pseudo-first order with inhibition model. Biodegradation of cosmetic effluents can be described by pseudo-first order and Monod-based kinetic equations for hydrolysis and substrate consumption, respectively.

Huseyin Tekin, Okan Bilkay, Selale S. Ataberk, Tolga H. Balta, I. Haluk Ceribasi, F. Dilek Sanin, Filiz B. Dilek, Ulku Yetis (2016) Use of Fenton oxidation to improve the biodegradability of a pharmaceutical wastewater, the applicability of Fenton's oxidation to improve the biodegradability of a pharmaceutical wastewater to be treated biologicallywas investigated. The wastewater was originated from an industry producing a variety of pharmaceutical chemicals. Treatment studies were carried out under laboratory conditions with all chemicals (having COD varying from 900 to 7000 mg/L) produced in the industry in order to determine the operational conditions to utilize in the full-scale treatment plant. Optimum PH was observed as 3.5 and 7.0 for the first (oxidation) and second stage (coagulation) of the Fenton process, respectively. For all chemicals, COD removal efficiency was highest when the molar ratio of H_2O_2/Fe^{2+} was 150–250. The wastewater treatment plant that uses Fenton oxidation followed by aerobic degradation in sequencing batch reactors (SBR), built after these treatability studies provided an overall COD removal efficiency of 98%, and compliance with the discharge limits. The efficiency of the Fenton's oxidation was found to be 45–50% and the efficiency in the SBR system which has two reactors (each 8 m^3) and operated with a total cycle time of 1 day, was around 98%, regarding the COD removal.

Farshid Pajoum Shariati, Mohammad Reza Mehrnia, Bahreh Madadkhah Salmasi, Marc Heran, Christelle Wisniewski, Mohammad Hossein Sarrafzadeh (2014)

Membrane bioreactor for treatment of pharmaceutical wastewater containing acetaminophen, in this study, a pilot scale system including an external loop airlift membrane bioreactor (ELAMBR) was applied for treatment of a synthetic pharmaceutical wastewater. The performance of this system was evaluated in removal of acetaminophen as the main pollutant of a pharmaceutical wastewater. A conventional activated sludge (CAS process) laboratory system was used in parallel with this system to compare both systems in regard to their ability for acetaminophen removal. The performance of the ELAMBR system was monitored for approximately one month to investigate the long-term operational stability of the system and possible effects of solids retention time on the efficiency of removal of acetaminophen. The removal efficiency was significantly higher in the ELAMBR system than the CAS process. 100% of the acetaminophen was removed after 2 days in this system. The results also showed that initial concentration of acetaminophen, chemical oxygen demand (COD) and mixed liquid suspended solids (MLSS) are the most effective parameters in removal of a pollutant such as acetaminophen. This study demonstrates the usefulness of ELAMBR system for pharmaceutical wastewater treatment with the advantages such as: (i) simple operation and maintenance, (ii) efficient removal of pharmaceutical pollutant and COD and (iii) low-energy consumption. The result showed that the important parameters in removal of acetaminophen are: the primary concentration of acetaminophen, COD and MLSS. The result indicated that the removal of acetaminophen from model of pharmaceutical wastewater seems to be favoured in MBR unit.

Mohamed I. Badawy, Rifaat A. Wahaab, A.S. El-Kalliny (2009)

Fenton-biological treatment processes for the removal of some pharmaceuticals from industrial wastewater, treatability study of pharmaceutical wastewater from El-Nasr Pharmaceutical and Chemical Company, South-East of Cairo, was carried out. The company discharges both industrial (6000m^3/d) and municipal wastewater (128m^3/d) into a nearby evaporation pond without any treatment. The generated raw wastewater is characterized by high values of COD (4100–13,023), TSS (20–330 mL), and oil grease (17.4–600 mg/L). The presence of refractory compounds decreases i.e. BOD/COD ratio (0.25–0.30). Analysis of raw wastewater suggested that pre-treatment is required prior to discharge into public sewers to comply with the Egyptian Environmental laws and regulations. The obtained results reveals that the refractory compounds and their by-products cannot be readily removed by biological treatment and always remain in the treated effluent or adsorbed on the sludge flocs. The Fenton oxidation process used as a pre-treatment improved the removal of pharmaceuticals from wastewater and appears to be an affective solution.

Fenton as a pre-treatment process would increase the biodegradability and/or remove the toxicity of the wastewater, which represent physicochemical characteristics of the raw wastewater and their treated effluents by means of Fenton process followed by biological activated.

CONCLUSION

In today's world people are suffering from different types of diseases like cancer, thyroid and diabetes etc. So demand of the medicines is increasing day by day. The Pharmaceutical industry plays an important role to save the life of millions. Apart from this, during the process of manufacturing of drugs large amount of pollutants get generated. Therefore, an increasing number of pharmaceutical industries lead to environmental pollution, due to that water, air and land quality is getting affected. Due to the rapid decrease in the level of water resources and increasing demand of water for consumption in our daily life, it is necessary to reuse the wastewater by developing a treatment process to clean up contaminated wastewater. In this study, an attempt is made to gather information about the treatment methods of pharmaceutical wastewater.

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