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Review Paper

Advanced Oxidation Processes for Wastewater and Effluent Treatment - An Insightful and Far-reaching Overview

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ABSTRACT

The vision of water treatment technologies is moving towards a new generation of science and technology. Wastewater and effluent treatment has undergone innovative and drastic changes over the years. Traditional wastewater treatment has yielded to modern and ground -breaking procedures which are more ever reaching and effective. The world of difficulties and hurdles has opened up new avenues to highly feasible effluent treatment procedures. So the vigorous and urgent importance of advanced oxidation procedures. This review will delineate and describe the increasing importance of various advanced oxidation processes including ozonation of textile wastewater. It will open up wide avenues for increasing visionary importance. Advanced oxidation processes (AOP's), which involve and includes the *in-situ* generation of highly potent chemical oxidants such as the hydroxyl radical, have emerged as an important avenue of technologies to accelerate the non-selective oxidation and thus the destruction of a wide range of non-degradable organic contaminants in wastewater which cannot be eliminated biologically. This review will delineate the difficulties and hurdles of advanced oxidation processes of wastewater particularly textile industry wastewater. Actually, recently, an increasing application of various AOP's for textile wastewater has been observed in contrast to traditional treatment methods. So our urge and conscience to investigate this domain of knowledge. A holistic and summarized view of the advanced oxidation processes is deliberated and delivered with scientific rigour.

INTRODUCTION

The increasing shortage of water resources around the world and in our society increases the demand on the use of secondary sources, such as wastewater effluent. In this perspective water recycling and re-use of treated effluent in high water consuming industrial sectors seem to be a viable alternative to save valuable resources. Advanced wastewater and effluent treatment by ozone and other oxidation technologies has a number of advantages compared to other technologies (Palit 2012a, Palit 2012b, Pesoutova et al. 2011).

Although some oxidation processes like use of ozone for disinfection of drinking water have been known since the 19th century, the rapid development and application of advanced oxidation processes (AOP's) is a matter of serious concern and an inevitable development in the last decade. AOP's found application mainly in the oxidation of complex organic compounds which are impossible to degrade into simpler organic compounds by biological treatment, and primary and secondary treatment. AOP's are based on generation and use of powerful but relatively non-selective highly reactive oxidizing species, primarily the hydroxyl radical OH having high oxidation potential and low selectivity (Ramesh Babu et al. 2007, Pesoutova et al. 2011). These radicals are able to oxidize compounds that are not degradable by conventional oxidizing agents as oxygen (O_2), ozone (O_3) or chlorine (Cl_2). The important and vital fact that the OH radical attack is characterized by low selectivity which is an important factor for a wide and broad application of advanced oxidation processes (Torabion et al. 2007, Pesoutova et al. 2011). The vision of this paper is to give an in-depth and insightful overview of the recent use of ozone and selected AOP in textile wastewater.

TEXTILE INDUSTRY AND ITS VISION

The important fact of the textile industry is that it is water intensive. Water is used through the whole textile production from cleaning of raw material to many washing processes through textile production or as a principal medium in various processes. Processes in the textile industry can be divided into mechanical and finishing operations. During the ongoing mechanical operations fabrics are manufactured from fibres by spinning, weaving and knitting. Sizing is one of the technological steps of weaving of cotton and its blends. In terms of water intake and consumption, mechanical operations are not very demanding. The second process is finishing (wet processing) providing the textiles with the main functional characteristics (appearance, feel, absorbency, softness, water repellence, crease resistance). During finishing a significant amount of water is consumed and also a significant amount of water and pollution are produced. According to the material composition these processes are desizing, scouring, bleaching, mercerization, carbonizing, fulling, washing, dyeing, finishing, etc. (Fersi & Dhahbi 2008, Pesoutova et al. 2011).

WASTEWATER MANAGEMENT AND CHALLENGES IN TEXTILE INDUSTRY

The main environmental issues arising from textile manufacturing regard primarily emissions to water and air and energy consumption. However, the major environmental concern, challenge and vision in textile industry is the amount of water being discharged as well as its chemical content and load. Water is the principal medium for removing impurities, applying dyes and finishing agents and for steam generation. The primary water consumption reaches 80-100 m^3/ton of finished textile and wastewater discharge 115-175 kg of COD/ton of finished textile. A large range of organic chemicals, low biodegradability, colour and salinity in discharged water are also of environmental concern (Palit 2010, Pesoutova et al. 2011).

VISION OF WASTEWATER MANAGEMENT WITH RESPECT TO ADVANCED OXIDATION PROCESS AND OZONATION PROCESS

Wastewater management is a concerning and disturbing issue of our society and the scientific community as a whole. Advanced oxidation process has a vision which is powerful and path breaking. The human society's benefit is scientists' primary goal. In that respect advanced oxidation process is surpassing one frontier over another. Wastewater management is a mind-boggling issue for the environmental scientists anticipating an inevitable breakthrough in the scientific domain and scientific research in environmental engineering. The world of unknown is surely unfolding into an invigorating and innovative vision (Palit 2009, Pesoutova et al. 2011).

The vision of the effectiveness of advanced oxidation process is scientifically justified and proved by the continuous research hardship. The stepping stones of success is not far. It is being justified with increasing intensity with every moment of research struggles.

USE OF THE OZONE AND OTHER ADVANCED OXIDATION PROCESSES FOR TEXTILE INDUSTRY EFFLUENT TREATMENT

Textile industry produces large quantities of highly coloured effluent, which is highly toxic and resistant to destruction by conventional treatment methods. Low biodegradability of many fibre acid, direct and reactive dyes allows them to pass untreated through the sewerage works due to their high water solubility and relatively low molecular weight. Important advantage of using AOP and their combinations is the destructive character of AOP to conventional processes such as activated carbon adsorption, coagulation, flocculation or precipitation.

Ozonation is relatively effective in decreasing colourisation of various dye origins and also reducing toxic effects of textile effluents which is the main environmental concern related to textile wastewater effluent discharge. Ozone dissolved in water reacts with many organic compounds in two different ways: by direct oxidation as molecular ozone or by indirect reaction through formation of secondary oxidant like hydroxyl radical. Use of ozone for wastewater treatment in textile industry to remove colouration and lower toxicity has been documented in several studies; however, sufficient effect on BOD/TOC removal was not detailed or confirmed (Pesoutova et al. 2011).

DYES AND THEIR COMPOSITION

Commercial dyes used in textile industry can be classified according to their chemical nature and composition (azo, anthrachinone, sulphur, triphenylmethane, indigoid, phthalocynanine, etc), or according to their application class (acid, direct, disperse, metal complex, chrome, reactive, etc). Azo dyes are the most commercially used dyes and comprise of nitrogen double bond (-N=N-) and when attached to molecules they become monoazo, diazo or polyazo dyes. Azo dyes, with the exception of few simply structured dyes, resist biodegradation under aerobic conditions (Pesoutova et al. 2011).

On the other side, azo bond is vulnerable to reductive cleavage and its degradation products include colourless aromatic amines which are known to be toxic and potentially carcinogenic.

VISION OF OZONATION PROCESS

The main factors affecting ozonation performance are pH, the nature and concentration of oxidisable organics, applied ozone dose, competition between the target compound and biodegradable by-products, the presence of oxidant scavengers and the efficiency of ozone mass transfer. Although increased ozone doses have a positive effect on decolourisation of acid dye solution effluents and the efficiency of the treatment increases with higher pH (pH range 5-9), an adverse effect on buffered solutions was reported. Increase of the mass transfer rate of ozone and enhancement of efficiency of the ozonation process was achieved by using a microbubble generator that enabled high intensity microbubble solution, utilization of almost all input ozone and faster decolourisation and organic reduction (Pesoutova et al. 2011).

Innovation will pave the way to success and will surely open up new areas of innovation. The subtle facts in scientific and engineering research will be more innovative in the years to come. Innovation in this area of environmental engineering science will be more productive and visionary in future. Hurdles will be won and overcoming thus chartering a new vision of environmental engineering science.

UTILITY OF OZONE AND HYDROGEN PEROXIDE FOR TEXTILE INDUSTRY WASTEWATER TREATMENT

Hydrogen peroxide is comparatively inexpensive, readily available chemical oxidant that accelerates decomposition of ozone and enhances formation of hydroxyl radical. The addition of both hydrogen peroxide and ozone to wastewater accelerates decomposition of ozone and enhances production of hydroxyl radical.

H_2O_2 acts as a catalyst and accelerates the decomposition of ozone to hydroxyl radical. Rapid and total decolourisation of textile industry effluent can be achieved, however, this combination like use of ozone alone is not able to bring complete mineralization either (Pesoutova et al. 2011).

OZONE AND ULTRASOUND (US)

Sonochemical reactions are induced upon high-intensity acoustic irradiation of liquids at frequencies that produce cavitation (typically in the range 20-1000KHz). Cavitation refers to formation, growth and implosive collapse of gas or vapour-filled cavities (bubbles) in a liquid matrix.

OZONE WITH ULTRA VIOLET (UV) LIGHT

UV-based advanced oxidation processes are based on formation of hydroxyl radicals OH through the direct ozonation and photolysis reactions and hydroxyl radical oxidation. Ozone combined with UV light demonstrated the effective means for textile wastewater treatment.

VISION OF ADVANCED OXIDATION PROCESS AS AN EFFECTIVE DYE DEGRADATION PROCESS

Advanced oxidation process as well as ozonation is one of the most path-breaking ventures of environmental engineering science. Innovation and intuition are the hallmarks of scientific and engineering research pursuits. Research endeavours in this domain of engineering science is vast and versatile. The world of unknown in this domain of engineering is slowly unfolding. It has been proved scientifically that dye wastewater removal and degradation is effective with the application of advanced oxidation process and ozone as a catalyst. Scientific rigours are opening up new avenues of innovation and success. The vision of this area of science is immense and groundbreaking (Pesoutova et al. 2011). Man's vision is wide, unparalleled and struggling. Vast areas of research hardship in the avenue of learning is opening up new windows of learning. The greatness is already reached and not an illusion. Advanced oxidation process will dominate the environmental engineering scenario in the years to come.

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REFERENCES

Fersi, C. and Dhahbi, M. 2008. Treatment of textile plant effluent by ultrafiltration and/or nanofiltration for water reuse. Desalination, 222: 263-271.

Palit, Sukanchan 2009. Ozonation of Direct Red-23 dye in a fixed bed batch bubble column reactor. Indian Journal of Science and Technology, 2(10).

Palit, Sukanchan 2010. Studies on ozone-oxidation of dye in a bubble column reactor at different pH and different oxidation-reduction potential. International Journal of Environmental Science and Development, 1(4).

Palit, Sukanchan 2011. Ozonation associated with nanofiltration as an effective procedure in treating dye effluents from textile industries with the help of a bubble column: A review. International Journal of Chemistry and Chemical Engineering, 1(1): 53-60.

Palit, Sukanchan 2012a. Ozone treatment as an effective advanced oxidation process for the degradation of textile dye-effluents. International Journal of Chemical and Analytical Science, 3(1): 1293-1295.

Palit, Sukanchan 2012b. Progress in membrane separation processes, ozonation and other advanced oxidation processes - A review. International Journal of Chemical and Analytical Science, 3(1): 1290-1292.

Pesoutova, R., Hlavinek, P. and Matysikova, J. 2011. Use of advanced oidation processes for textile wastewater treatment-A review, Food and Environment Safety. Journal of Faculty of Food Engineering, Stefan cel Mare University, Suceava 10(3).

Ramesh Babu, B., Parande, A.K., Raghu, S. and Premkumar, T. 2007. Cotton textile processing: Waste generation and effluent treatment. The Journal of Cotton Science, 11: 141-153.

Torabion, A., Nabi Bidendi, G.R., Nabi, Ranjbar P. and Zanganeh, Razmkhah N. 2007. Efficiency evaluation of textile basic dye removal from water by nanofiltration. Iran Journal Environ. Health, Sci. Engg., 4(3): 177-180.