International Journal of Chemical Sciences and Applications
ISSN 0976-2590, Online ISSN 2278 – 6015
Vol 3, Issue 2, 2012, pp 264-268
http://www.bipublication.com

ADVANCES IN WASTEWATER TREATMENT- A REVIEW

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[Received-05/05/2012, Accepted-25/05/2012]

ABSTRACT:

The textile wastewater treatment is a big challenge to environmental chemist, engineers and the water authorities. Many dyestuffs used in textile dyeing and printing processes are non-biodegradable. Advanced treatment processes stand very high in providing true solution towards achieving destruction of such matter which cannot be destroyed by conventional treatment. We have made a sincere effort to take a review of the advanced treatment processes in this article.
Keywords: H_2O_2; O_3 / H_2O_2; O_3 /U.V.; O_3 / H_2O_2 / U.V. Textile Wastewater; Dyes; Advanced Oxidation. Processes

INTRODUCTION:

Effluent treatment involves science, engineering, business, and art. The treatment may include mechanical, physical, biological, and chemical methods. As with any technology, science is a foundation, and engineering makes sure that the technology works as designed. The appearance and application of water is an art.

Textiles are among the basic needs of the human being. The textile industry therefore has a great economic significance by virtue of its contribution to overall industrial output and employment generation. This sector has wide spectrum of industries ranging from small scale units that use traditional manufacturing processes, to large scale integrated mills using modern machineries and equipments. There are 2324 textile industries in the country including composite mills and process houses. Maharashtra state has 27 composite mills, 222 semi composite/ processing units and 249 in total. Textile industries transform yarn into fabrics or related products, and dye and finish these materials at various stages of production. During these operations lot of wastewater is generated.

Textile wastewater is a admixture of organic pollutants like carbohydrates, fats and oils, dyestuffs, phenols, detergents, & inorganic pollutants like acids, alkalis, metals, other salts, phosphates, nitrates, bleaches, sulphides, etc. the composition of textile wastewater is quite varied, its constituents ranging from organic solvents, oils suspended solids, to dissolved chemical compounds as mentioned above. Most of the chemicals are toxic and some are even carcinogenic and mutagenic. Such carcinogenic agents include[1,2] 4-aminodiphenyl, benzidine, 4-chloro-o-toludine, 2-naphthylamine, o-aminoazotoluidine, 2-amino-4- nitrptoluene, p-chlroaniline, 2,4-diamonoanisol,4,4-diaminodiphenylmethane, 3,3,-dichlorobenzidine, 3,3- dimethylbenzidine, 3,3,-dimethoxy benzidine, 3,3,-dimethyl-1-4-4-diiminodiphenylmethane, p-kresidine 4,4,-methyne-bis-(2-chloroaniline), 4,4,-oxydianiline, 4,4,-thiodianiline, o-toluidine, 2,4-toluylendiamine, 2,4,5,-trimethylaniline.the chemical composition of textile wastewater make the challenge to the environmental chemist and the textile industry as a whole[3]. variety of dyes, chemicals and auxiliaries come from the dyeing and finishing departments. As these are mostly organic in nature imposes high to very high B.O.D. and C.O.D. loads[4]. The colour of the wastewater is basically due to insoluble, non biodegradable dyes. Especially the reactive dyes, direct dyes, and vat dyes are of most concern to us. The use of advanced oxidation processes (AOPs) like Ozone (O_3) treatment, H2O2 and UV treatment have proved tobe very efficient and effective in removing colour and COD[5,6,7]. The textile industry uses 21-377 $m^3$of water per ton of textile produced[8]. Hence the large quantity of such a complex effluent is a real challenge. This paper reviews various advanced oxidation processes, application of zeolites based on cation exchange, adsorption and related molecular sieving, dehydration and rehydration, biological activity, catalytic activities, wet air oxidation, supercritical(water) oxidation, physical treatment processes like air-water to slid systems like activated carbon, activated alumina, organoclays, synthetic resins, and membrane boreactor.

CHARACTERISTICS OF TEXTILE WASTEWATER:

As the characteristics of textile waste water depends on the type of job undertaken, the parameters which are most important will be considered:

Table 1 : Typical Characteristics of Textile Wastewater

pH	6 – 10
Temperature	35 – 45 ^{0}C
BOD, (mg/L)	100 – 4000
COD, (mg/L)	150 – 10000
TSS, (mg/L)	100 – 5000
TDS, (mg/L)	1800 – 6000
Chlorides as Cl^-, (mg/L)	1000 – 6000
Total alkalinity, (mg/L)	500 – 800
Sodium as Na^+, (mg/L)	610 – 2175
Total Kje/dhl Nitrogen, (mg/L)	70 – 80
Colour (Pt – CO), Hazen units	50 – 2500

[Source : 9, 10, 11, 12, 13, 14, 15]

ADVANCED PROCESSES OF WASTER WATER TREATEMENT:

One of the useful methods of treatment is oxidation. In this hydroxyl free radial (OH) is generated, which is highly reactive, non-selective oxidant (E_H = 2.8 V), which can destroy even the recalcitrant pollutants. Hydroxyl free radial generation is highly accelerated by combining ozone (O_3), hydrogen peroxide (H_2O_2), Titanium dioxide (TiO_2), heterogeneous photo-catalysis, UV radiation or high electron beam radiation. The oxidant systems include Ozone/H_2O_2, Ozone/UV/H_2O_2, Ozone/TiO_2/H_2O_2, Ozone/TiO_2/electron beam irradiation, H_2O_2/UV, H_2O_2/Fe++, H_2O_2/UV/Fe++, Ozone/UV[16].

Ozone is prepared by the action of silent electric discharge upon oxygen in a Siemen's Oroniser, Brodie's Oroniser, Siemen-Halske Ozoniser (Manufacturing process), Corena discharge tube ozoniser, UV Ozone generators, Vacuum Ultraviolet (VUV) ozone generators, plasma fire glass tube cold plasma ozone generator. Ozone is metastable under all conditions[17]. Its oxidation potential is –2.07 V. Ozone decomposes giving rise to HO_2 and OH free radicals. These react with metal salts, organic matter as well as micro organisms, hydrogen and hydroxide ions. HO_2 and OH free radicals are very good and fast germicides. Organic compounds containing aliphatic unsaturated functions (e.g. Olefin) are acted upon by zone by addition mechanism, by ozonide mechanism in which ozone can add across unsaturation forming ozonide in non aqueous solvents but in water ozone hydrolyses to other products and by the substitution mechanism in which one atom or functional group is replaced with another[18].

As a strong oxidising agent it removes colour and odour, trace toxic synthetic organic compounds and assists in coagulation[19].

Ozone increases biodegradability index of textile waste water, which depends on the type and concentration of dye[20] i.e. 1.6 time[11], 11 – 66 times in waste water containing are dyes and upto 80 times in water containing reactive yellow 84 dye[21]. Ozone treatment is sensible to COD, pH, temperature.

Peroxone (H_2O_2/O_3)

H_2O_2 catalyses and accelerates ozone decomposition and formation of OH^o free radial. H_2O_2 is stable in acidic medium as by nature H_2O_2 is acidic. Hence at low pH H_2O_2 reacts slowly with O_3 but at high pH the action is fast producing $HO0_2$ free redial which in turn initiates ozone decomposition more efficiently than OH^o [22].

H_2O_2 / UV

UV brings about photolytic decomposition of H_2O_2 to produce (2OH) free radicals, which react with organic contaiminants[20]. OH^o free radients have higher oxidation potential (2.8 V) than H_2O_2 (1.78 V). hence H_2O_2/UV system is capable of destroying totally chromophoric structure of the dye. No sludge generation, action under ambient conditions, utility of O_2 formed for aerobic biological decay are same of the advantages of this process.

Among the factors influencing, pH plays a major role in H_2O_2/UV system. In acidic medium it is more effective in decolouration[23]. Dose of H_2O_2 is another factor in decolouration process. With the increasing dose of H_2O_2 efficiency to decolourise increases. But after certain value, it actually starts decreasing. Contact time is another factor which is determined by the type of dyes. Initial dye concentration and H_2O_2/UV removal efficiency are inversely proportional. Increased dye concentration increases dye molecules and decreases UV permeability. As photolytic decomposition and production of OH^o free radicals depends of UV irradiation, the rate of removal dye decreases.

Fenton's Reagent (H_2O_2/Re^{2+})

Large number of OH^o free radicals are generated in this system with powerful oxidizing potential (2.8 V) which has very short life, but it is reactive and attacks dyes by either abstracting an H atom or adding itself to double bonds. Increased Ferrous Sulphate conc. increases the dye removal efficiency[23].

TiO_2/UV

OH^o free radicals are produced as above but TiO_2 is better due to its stability under different conditions, high potential to produce radicals, easy availability and low price[24]. TiO2 is used with the help of Thin Film Fixed Bed Reactor (TFFBR) or Aerated Cascade Photoreactor (APC). APC are 3–13 times more efficient than TFFBR.

Table 2 : Oxidising Agents and their Oxidation Potentials[24].

Oxidising Agent	Oxidation Potential (V*)
Hydroxyl radical	2.80
Singlet Oxygen	2.42
Ozone	2.07 (1.24)
H_2O_2	1.78
Permanganate	1.68 (0.60)
Chlorine dioxide	1.57 (1.15)
Hypochlorous acid	1.48 (0.41)
Chlorine	1.36

* Under acidic condition, values in parenthesis are the oxidation potential under alkaline conditions.

The other additional methods for treatment are:[25]

Adsorption:

Colour and some soluble organic pollutants are removed from effluent. The other pollutants removal include toxic chemicals, pesticides, phenols, cyanides and organic dyes. Most used adsorbent is activated carbon.

Ion exchange:

This is used for the removal of inorganic salts and some specific organic anionic components like phenol. In this the impurities from the effluent are transformed into another which may be more concentrated. This does not remove non-ionic compounds.

Membrane filtration:

Reverse Osmosis

The textile effluent is passed through the membranes made of cellulose acetate or nylon at high pressure. The pressure overcome the osmatic pressure of stream and is sufficient to maintain flow of water through membrane. The membranes may be spiral wound, membrane and supporting material in placed alternate layers, rolled into a cylindrical shape and inhoused in tube of suitable material. Disc module, a new Reverse Osmosis application, facilitates an open feed flow path over membrane element.

Ultrafiltration, nanofiltration, microfiltration may help.

Table 3 : Filtration Scope of different Membranes

Process	Pore size (Micro)	Mol. wt.	Examples / Ose
Min	0.001 – 2.0	7,10,00,000	Bacteria,
Ultra	0.002 – 0.1	1000–2000000	Colloids, Virus, Protein etc
Nano	0.001 – 0.07	180 – 15000	Dyes, Pesticides, divalent ions, etc
R.O.	< 0.001	< 200	Salts & ions

Membrane fouling is the major problem associated with these techniques. Precipitation of calcium, silica, barium, strontilim and iron are the major cause of this fouling. Bacteria may preliferate in the membrane. Proper dosing can avoid this problem.

Multiple effect evaporation may also help to reduce effluent volume, increase in case of salts, making recovery more efficient.

Mechanical vapour compression, direct contact evaporation, crystallization may also help.

Proper selection and application of methods is a effective may to tackle the problem of effluent in textile industry. Advanced methods of treatment of textile effluent leads to multiple benefits to the textile industry, this enables recovery of water as well as salts.

The permeate from membrane techniques can readily be reused. This leads to direct economy. This reduces are of chemicals like requesting agents, this also helps to reduce no. of washing & fabric processing. Minimum hardness of permeate avoids treatment of water, corrosion, scale formation. This means less maintenance and less breakdown i.e. good economy.

The condensed water from evaporators is very good for even high or very high pressure besters. Most bester problems are thus avoided.

Nanofiltrate (brine) helps in dyeing as no salts are required. Recovery of salts can also be thought of by the Day of crystallization.

With few limitation like regular monitoring of the effluent quality for Reverse Osmosis, replacement or regeneration of activated carbon or other media, consistency in primary treatment system, frequent cleaning of evaporators to remove scales etc. these advance treatment processes are very useful.

CONCLUSION:

Ozonisation etc are used to maintain quality of effluent. Membranes methods are widely being used. Multiple effect evaporation with crystallizers is also being used Reverse Osmosis method is very good. The reuse is a need of the how in textile industry. The reuse or recycle in textile industry is a must and the technologies are available for this. This ultimately reduces effluent treatment cost by the way of water, chemical recovery, reduction in problems like scale formation, corrosion inhibition, etc.

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