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Waste water treatment in textile Industries - the concept and current removal technologies

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Abstract

The textile industry is one of the most promising industrial sectors that provide huge unskilled employment in the developing countries in Asia, particularly China, India and Bangladesh. Since textile industry is a very diverse sector in terms of raw materials, processes, products and equipment and has a very complicated industrial chain. The textile finishing covers the bleaching, dyeing, printing and stiffening of textile products in the various processing stages (fibre, yarn, fabric, knits, finished items). These units are being used in various chemicals and large amounts of water during the production processes and also generate a substantial quantity of effluents, which can cause various environmental problems, if disposed of without proper treatment. So the characterization of textile process effluents is very important to develop strategies for wastewater treatment and reuse. The paper describes the characteristic and composition of textile wastewater, some national standard of the textile effluents and reviews the currently available primary, secondary, tertiary and advanced pollutants removal technologies used in the textile industries.

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Introduction

The word textile comes from the Latin word '*texere*' which means to weave. Textiles can be woven by both hand and machines. The textile industries are classified on the basis of the types of textile fiber they use. The raw materials for textiles are natural and synthetic fibres (Elliott *et al.*, 1954). The textile raw materials can be classified into three main categories: cellulose fibres (cotton, rayon, linen etc), protein fibres (wool, silk etc) and synthetic fibres (polyester, nylon, acrylic etc). Cellulose fibers are obtained from plant sources such as cotton, rayon, linen, ramie, hemp and lyocell (Bledzki and Gassan, 1999). Protein fibers are obtained from animals and include wool, angora, mohair, cashmere and silk. Artificially synthesized fibres include polyester, nylon, spandex, acetate, acrylic, ingeo and polypropylene. However, the most of the textiles are produced from cotton liners, petrochemicals and wood pulp. China is the biggest exporter of almost all the textiles followed by European Union, India, USA and Korea as shown in Table 1 (*Ghaly et al.*, 2014). The production process of textiles industry involves three or four fragmented group of establishment that can be yarn formation, fabric formation, wet processing and textile fabrication. A flow diagram for various steps involved in processing textile in a cotton mill shown in figure 1.

Various manufacturing processes are carried out for different types of textiles. The major exporters of clothing are shown in Table 2 (Ghaly *et al.*, 2014). The production process of textiles can be broadly divided into two categories: the spinning process (the dry process) and the wet process (involves the usage of dyes). Production of cotton textiles involves the separation of cotton fibres from the cotton seeds which are then spun into cotton yarns (Sette *et al.*, 1996). These yarns are weaved successfully into cloths. The cloths then undergo various wet processes including singeing and scouring. This process uses a large amount of water. Dyeing is one of the most important steps in the wet process which involves changing the colour of the textile spun using dyes. Finishing is the final step in manufacturing and uses chemicals like HS-ULTRAPHIL, ECODESIZEPS- 10 and Amino silicone fluid to treat the cloths for obtaining a better quality (Wang *et al.*, 2002) So the different manufacturing steps, such as desizing, mercerization, bleaching, neutralization, dyeing, printing and finishing, in Textile industry consumes huge amount of dyes and chemicals as well as large amount of water and also produces large volumes of textile wastewater effluents. The textile effluents contains different type of dyes, organic acid and salts, inorganic acid and salts, bleaching agent, trace metals in variable concentration. These un- treated industrial effluents not only deteriorate surface water quality, ground water, soil and vegetation, but also cause many diseases like haemorrhage, ulceration of skin, nausea, severe irritation of skin and dermatitis (Nese *et al.*, 2007).

The characterization of the textile effluents is also needed to assess the pollution level for the protection of environment and natural resources. Such analysis report is important for the textile industries for selecting proper technologies to prevent environmental pollution. As the textile wastewater is harmful to the environment and people, some environmental protection agencies worldwide have imposed rules entrusted with the protection of human health and guarding the environment from pollution caused by the textile industry. These agencies imposed certain limits on the disposal of effluents into the environment. Some of the regulations imposed by several countries. However, due to the difference in the raw materials, products, dyes, technology and equipment, the standards of the wastewater emission have too much items. It is developed by the national environmental protection department according to the local conditions and environmental protection requirements which is not fixed. It varies according to the situation in different regions. Therefore, the purpose of this investigation is to characterize the effluents of the textile industries and review the current available technologies in textile industry.

Materials and methods

Characterization and Composition of textile wastewater

The different manufacturing steps in Textile industry, such as desizing, mercerization, bleaching, neutralization, dyeing, printing and finishing have been discharging the following

Colour.

A major contribution to colour in textile wastewater is usually the dyeing and the washing operation after dyeing which as much as 50% of the dye might be released into the effluents (Joshi *et al.*, 2004). Textile dyes are mainly cationic, anionic and non-ionic dyes. The chromophores in anionic and non-ionic dyes are mostly azo group or anthraquinone types. The reactive cleavage of azo linkage is responsible for the formation of toxic amines in the effluents. Presence of colour in the waste water is one of the main problems in textile industry. Anthraquinone based dyes are most resistance to degradation due to their fused aromatic structure and therefore remain coloured for long time in the textile wastewater. These colours are easily visible to human eyes even at very low concentration. Hence, colour from textile wastes carries significant aesthetic importance. Most of the dyes are stable and has no effect of light or oxidizing agents.

TDS and TSS

Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. TDS is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. TSS is solid materials, including organic and inorganic, that are suspended in the water. TDS are difficult to be treated with conventional treatment systems. Disposal of high TDS bearing effluents can lead to increase in TDS of ground water and surface water. TSS in effluent may also be harmful to vegetation and restrict its use for agricultural purpose.

Toxic Metals

Waste water of textiles is not free from metal contents. There are mainly two sources of metals. Firstly, the metals may come as impurity with the chemicals used during processing such as caustic soda, sodium carbonate and salts. Secondly, the source of metal could be dye stuffs like metalised mordent dyes.

The metal complex dyes are mostly based on chromium. A number of metals including cadmium, chromium, copper, iron, lead, mercury, nickel and zinc. Many metals, which are usually only available naturally in trace quantities in the environment, can be toxic to humans, plants, fish and other aquatic life.

Sulphur and Sulphide

Textile dyeing uses large quantities of sodium sulphate and some other sulphur containing chemicals. Textile wastewaters will therefore contain various sulphur compounds and once in the environment sulphate is easily converted to sulphide when oxygen has been removed by the BOD of the effluents

Oil and Grease

This includes all oils, fats and waxes, such as kerosene and lubricating oils. Oil and grease causes unpleasant films on open water bodies and negatively affect aquatic life. They can also interfere with biological treatment processes and cause maintenance problems as they coat the surfaces of components of ETPs.

Residual Chlorine

The use of chlorine compounds in textile processing, residual chlorine is found in the waste stream. The waste water (if disposed without treatment) depletes dissolved oxygen in the receiving water body and as such aquatic life gets affected. Residual chlorine may also react with other compounds in the waste water stream to form toxic substances.

pH

pH is a measure of the concentration of hydrogen ions in the wastewater and gives an indication of how acid or alkaline the wastewater is. This parameter is important because aquatic life such as most fish can only survive in a narrow pH range between roughly pH 6-9.

BOD and COD

Biochemical oxygen demand (BOD) is defined as the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature (20^{o}C) over a specific time period (5-day). BOD can be used as a gauge of the effectiveness of wastewater treatment plants. COD is a measure of the oxygen equivalent of the organic material chemically oxidised in the reaction and is determined by adding dichromate in an acid solution of the wastewater.

So the textile wastewater effluent contains high amounts of agents causing damage to the environment and human health including suspended and dissolved solids, biological oxygen demand (BOD), chemical oxygen demand (COD), chemicals, odour and colour. Most of the BOD/COD ratios are found to be around 1:4, indicating the presence of non-biodegradable Substances (Arya and Kohli, 2009). Typical characteristics of textile effluent are shown in Table 3.

National Standard for textile effluents

The characteristics of textile effluents vary and depend on the type of textile manufactured and the chemicals used. The textile effluents contain trace metals like Cr, As, Cu and Zn, which are capable of harming the environment (Eswaramoorthi *et al.*, 2008). Dyes in water give out a bad colour and can cause diseases like haemorrhage, ulceration of skin, nausea, severe irritation of skin and dermatitis (Nese *et al.*, 2007). They can block the penetration of sunlight from water surface preventing photosynthesis. Dyes also increase the biochemical oxygen demand of the receiving water and in turn reduce the reoxygenation process and hence hamper the growth of photoautotrophic organisms (Nese *et al.*, 2007). The suspended solid concentrations in the effluents play an important role in affecting the environment as they combine with oily scum and interfere with oxygen transfer mechanism in the air-water interface (Laxman, 2009). Inorganic substances in the textile effluents make the water unsuitable for use due to the presence of excess concentration of soluble salts. These substances even in a lower quantity are found to be toxic to aquatic life (Tholoana, 2007). Some of the inorganic chemicals like hydrochloric acid, sodium hypochlorite, sodium hydroxide, sodium sulphide and reactive dyes are poisonous to marine life (Blomqvist, 1996; Tholoana, 2007). The organic components are found to undergo chemical and biological changes that result in the removal of oxygen from water (Tholoana, 2007).

Human exposure to textile dyes have resulted in lung and skin irritations, headaches, congenital malformations and nausea (Lima *et al.*, 2007; Mathur *et al.*, 2005).) detected benzidine, a known carcinogen in a textile effluent which contained disperse orange 37, disperse blue 373 and disperse violet 93 dyes. Mathur *et al.* (2005) tested a total of seven dyes (cremazoles blue S1, cremazoles brown GR, cremazoles orange 3R, direct bordeaux, direct royal blue, direct congo red and direct violet) using AMES tests and witnessed the presence of mutagenic agents. It was noted that direct violet was the only dye with a mutagenicity ratio less than 2:0. They observed that the cremazoles dyes were so toxic to microorganisms. Morikawa *et al.* (1997), reported evidence of kidney, liver and urinary bladder cancers on workers after prolonged exposure to textile dyes. It was found that dermatitis, asthma, nasal problems and rhinitis were acquired by workers after prolonged exposure to reactive dyes (Nilsson *et al.*, 1993).

There are strict requirements for the discharge of the waste water as the wastewater is harmful to the environment and the human being by the textile industry. However, the raw materials, dyes and chemicals, products, technology and equipment used in textile industries are different; the standards of the discharged wastewater are also different. Generally it is developed by the national environmental protection department according to the local conditions and environmental protection requirements which is not fixed. The disposal limits are found to differ from country to country. Some of the regulations imposed by several countries are presented in Table-4.

Textile effluent treatment processes

Many pollutant removal technological processes have been developed in the past decades to treat the textile wastewater. The treatment processes is being chosen on the basis of composition, characteristics and concentration of material present in the effluents. These processes are pre-treatment or preliminary, primary or physicochemical, secondary, tertiary treatment or combined treatment processes depending on type, sequence and method of removal of the harmful and unacceptable constituents. Most commonly used processes are being discussed below:

Pre-treatment processes or preliminary treatment

Prior to textile Dyeing, the fabric must be clean & clear of all impurities. It should be free from dust particles and coloring materials. In order to obtain a white pure fabric, the fabric undergoes a series of cleaning steps covered in Pretreatment. The process of fabric treatment prior to dyeing or printing in order to achieve a clean fabric is known as pretreatment. The basic aim of the pretreatment is to prepare the fabric for dyeing and printing which gives the best result in respect to economy and quality. It is assumed that 70% dyeing & printing faults are coming from the pretreatment. Natural fibers and synthetic fibers contain primary impurities that are contained naturally, and secondary impurities that are added during spinning, knitting and weaving processes.

The most conventional treatment processes in textile wastewater treatment is the removal of suspended solids, excessive quantities of oil and grease and gritty materials (Eswaramoorthi *et al.*, 2008). The coarse suspended materials such as yarns, lint, pieces of fabrics, fibres and rags is being removed from the effluent by using bar and fine screens (Das, 2000). The screened effluent then undergoes settling for the removal of the suspended particles. The floating particles are removed by mechanical scraping systems. Neutralization is done to reduce the acidic contents of the effluents. Sulphuric acid and boiler flue gas are the most commonly used chemicals to alter the pH. A pH value of 5-9 is considered ideal for the treatment process (Babu *et al.*, 2007; Das, 2000; Eswaramoorthi *et al.*, 2008). The common primary treatment processes are shown as follows.

Equalization

Effluent treatment plants are usually designed to treat wastewater that has a more or less constant flow and a quality that only fluctuates within a narrow margin. The equalization tank overcomes this by collecting and storing the waste, allowing it to mix and become a regular quality before it pumped to the treatment units at a constant rate.

Floatation

The floatation produces a large number of micro-bubbles in order to form the three-phase substances of water, gas, and solid. Dissolved air under pressure may be added to cause the formation of tiny bubbles which will attach to particles. Under the effect of interfacial tension, buoyancy of bubble rising, hydrostatic pressure and variety of other forces, the microbubble adheres to the tiny fibers. Due to its low density, the mixtures float to the surface so that the oil particles are separated from the water. So, this method can effectively remove the fibers in wastewater.

Coagulation flocculation sedimentation

Coagulation flocculation sedimentation is a physical process which involves slow mixing of the effluent with paddles bringing the small particles together to form heavier particles that can be settled and removed as sludge (Heukelekian.,1941; Tripathy *et al*., 2006). Active on suspended matter, colloidal type of very small size, their electrical charge give repulsion and prevent their aggregation. Adding in water electrolytic products such as aluminum sulphate, ferric sulphate, ferric chloride, giving hydrolysable metallic ions or organic hydrolysable polymers (polyelectrolyte) can eliminate the surface electrical charges of the colloids. This effect is named coagulation. Normally the colloids bring negative charges so the coagulants are usually inorganic or organic cationic coagulants (with positive charge in water). The metallic hydroxides and the organic polymers, besides giving the coagulation, can help the particle aggregation into flocks, thereby increasing the sedimentation. The combined action of coagulation, flocculation and settling is named clariflocculation. Settling needs stillness and flow velocity, so these three processes need different reactions tanks. This processes use mechanical separation among heterogeneous matters, while the dissolved matter is not well removed (clariflocculation can eliminate a part of it by absorption into the flocks). The dissolved matter can be better removed by biological or by other physical chemical processes (Sheng *et al*., 1997). But additional chemical load on the effluent (which normally increases salt concentration) increases the sludge production and leads to the uncompleted dye removal.

Adsorption

The adsorption process is used to removes colour and other soluble organic pollutants from effluent. The process also removes toxic chemicals such as pesticides, phenols, cyanides and organic dyes that cannot be treated by conventional treatment methods. Dissolved organics are adsorbed on surface as waste water containing these is made to pass through adsorbent. Most commonly used adsorbent for treatment is activated carbon (Sultana *et al*., 2013). It is manufactured from carbonaceous material such as wood, coal, petroleum products etc. A char is made by burning the material in the absence of air. The char is then oxidized at higher temperatures to create a porous solid mass which has large surface area per unit mass. The pores need to be large enough for soluble organic compounds to diffuse in order to reach the abundant surface area.

The activated carbon once it is saturated needs replacement or regeneration. Regeneration can be done chemically or thermally. The chemical regeneration can be done in within the column itself either with acid or other oxidizing chemicals. This normally effects partial recovery of activity and necessitate frequent recharging of carbon. For thermal regeneration, the exhausted carbon is transported preferable in water slurry to regeneration unit where it is dewatered and fed to furnace and heated in a controlled conditions. This process volatilize and oxidize the impurities held in carbon. The hot reactivated carbon is then quenched with water and moved back to the site. This results in almost complete restoration of its adsorption. There are some other materials such as activated clay, silica, flyash, etc are also known to be promising adsorbents.

Secondary Treatment

The Secondary treatment process (Figure 2) is mainly carried out to reduce the BOD, phenol and oil contents in the wastewater and to control its colour. This can be biologically done with the help of microorganisms under aerobic or anaerobic conditions. Aerobic Bacteria use organic matter as a source of energy and nutrients. They oxidize dissolved organic matter to CO_2 and water and degrade nitrogenous organic matter into ammonia. Aerated lagoons, trickling filter and activated sludge systems are among the aerobic system used in the secondary treatment. Anaerobic treatment is mainly used to stabilize the generated sludge (Das, 2000).

Aerated lagoons are one of the commonly used biological treatment processes. This consists of a large holding tank lined with rubber or polythene and the effluent from the primary treatment is aerated for about 2-6 days and the formed sludge is removed.

The BOD removal efficiency is up to 99% and the phosphorous removal is 15-25% (Das, 2000). The nitrification of ammonia is also found to occur in aerated lagoons. Additional TSS removal can be achieved by the presence of algae in the lagoon (EPA, 2002). The major disadvantage of this technique is the large amount of space it occupies and the risk of bacterial contamination in the lagoons (Das, 2000; Lafond, 2008).

Trickling filters are another common method of secondary treatment that mostly operates under aerobic conditions. The effluent for the primary treatment is trickled or sprayed over the filter. The filter usually consists of a rectangular or circular bed of coal, gravel, Poly Vinyl Chloride (PVC), broken stones or synthetic resins (Etter *et al.*, 2011). A gelatinous film, made up of microorganisms, is formed on the surface of the filter medium. These organisms help in the oxidation of organic matter in the effluent to carbon dioxide and water (NODPR, 1995). Trickling filters do not require a huge space, hence making them advantageous compared to aerated lagoons. However, their disadvantage is the high capital cost and odour emission (Etter *et al.*, 2011).

Aerobic activated sludge processes are commonly used. It involves a regular aeration of the effluent inside a tank allowing the aerobic bacteria to metabolize the soluble and suspended organic matters. A part of the organic matter is oxidized into CO_2 and the rest are synthesized into new microbial cells (NESC, 2003). The effluent and the sludge generated from this process are separated using sedimentation; some of the sludge is returned to the tank as a source of microbes. A BOD removal efficiency of 90-95% can be achieved from this process, but is time consuming (Yasui *et al.*, 1996). Sludge's formed as a result of primary and secondary treatment processes pose a major disposal problem. They cause environmental problems when released untreated as they consist of microbes and organic substances (Wright, 2013). Treatment of sludge is carried out both, aerobically and anaerobically by bacteria. Aerobic treatment involves the presence of air and aerobic bacteria which convert the sludge into carbon dioxide biomass and water. Anaerobic treatment involves the absence of air and the presence of anaerobic bacteria, which degrade the sludge into biomass, methane and carbon dioxide (Mittal, 2011).

Tertiary Treatment or Advance methods treatment

Textile effluents may require tertiary or advance treatment methods to remove particular contaminant or to prepare the treated effluent for reuse. There are several technologies used in tertiary treatments including electrodialysis, reverse osmosis and ion exchange. Electrolytic precipitation of textile effluents is the process of passing electric current through the textile effluent using electrodes.

As a result of electro chemical reactions, the dissolved metal ions combine with finely dispersed particles in the solution, forming heavier metal ions that precipitate and can be removed later (Wright, 2013). One of the disadvantages is that a high contact time is required between the cathode and the effluent (Das, 2000).

Membrane separation process

Membrane separation process is the method that uses the membrane's microspores to filter and makes use of membrane's selective permeability to separate certain substances in wastewater. Currently, the membrane separation process is often used for treatment of dyeing wastewater mainly based on membrane pressure, such as reverse osmosis, ultrafiltration, nanofiltration and microfiltration. Membrane separation process is a new separation technology, with high separation efficiency, low energy consumption, easy operation, no pollution and so on. However, this technology is still not large-scale promoted because it has the limitation of requiring special equipment, and having high investment and the membrane fouling and so on (Ranganathan *et al.*,2007).

Reverse osmosis

Reverse osmosis is a well-known technique which makes use of membranes that have the ability to remove total dissolved solid contents along with ions and larger species from the effluents. A high efficiency of >90% has been reported (Babu *et al.*, 2007). Cotton dyeing processes use electrolytes such as NaCl in high concentrations. These high concentrations of salts can be treated using reverse osmosis membrane (Kannan *et al.*, 2006).

Reverse osmosis can be used as end-of-pipe treatment and recycling system for effluent. After primary, secondary and/or tertiary treatment, further purification by removal of organics and dissolved salts is possible by use of reverse osmosis. RO membranes are susceptible to fouling due to organics, colloids and microorganism. Scale causing constituents like hardness, carbonate, Silica, heavy metals, oil etc has to be removed from the feed. Reverse osmosis membranes have a retention rate of 90% or more for most types of ionic compounds and produce a high quality of permeate (Ghayeni *et al.*, 1998).

Reverse osmosis membranes are available in different configurations. In spiral wound system, membrane and supporting material are placed in alternate layers, rolled into a cylindrical shape and inhoused in tube of suitable martial. The support material is porous and serves as transport medium for permeate. Tubular systems are available in which the membrane and its support are wound to fit inside a containment tube. Permeate is withdrawn from the support medium, while reject passes through the core of the membrane. Hollow fiber membranes are extremely small tubes. These fibres can be suspended in the fluid without the use of support medium. The feed water is usually on outside of fibre, while the permeate is withdrawn through the centre. The disc module is relatively new in the reverse osmosis application. Unlike conventional membrane modules such as spiral wound, the design of disc module facilitates an open feed flow path over membrane element. The membrane is housed in hydraulic disc which works as membrane spacers.

Nanofiltration

Nanofiltration has been applied for the treatment of colored effluents from the textile industry. A combination of adsorption and nanofiltration can be adopted for the treatment of textile dye effluents. The adsorption step precedes nanofiltration, because this sequence decreases concentration polarization during the filtration process, which increases the process output (Chakraborty *et al.*, 2003). Nanofiltration membranes retain low molecular weight organic compounds, divalent ions, large monovalent ions, hydrolyzed reactive dyes, and dyeing auxiliaries. The treatment of dyeing wastewater by nanofiltration represents one of the rare applications possible for the treatment of solutions with highly concentrated and complex solutions (Freger *et al.*, 2000; Kelly and Kelly, 1995; Knauf *et al.*, 1998; Peuchot, 1997; Rossignol *et al.*, 2000).

A major problem is the accumulation of dissolved solids, which makes discharging the treated effluents into water streams impossible. Various research groups have tried to develop economically feasible technologies for effective treatment of dye effluents (Karim *et al.*, 2006).

Ultrafiltration

This process is similar to reverse osmosis. The difference between reverse osmosis and ultrafiltration is primarily the retention properties of the membranes. Reverse osmosis membranes retain all solutes including salts, while ultrafiltration membranes retain only macro molecules and suspended solids. Thus salts, solvents and low molecular weight organic solutes pass through ultrafiltration membrane with the permeate water. Since salts are not retained by the membrane, the osmotic pressure differences across ultrafiltration membrane are negligible. Flux rates through the membranes are fairly high, and hence lower pressures can be used. Ultrafiltration can only be used as a pretreatment for reverse osmosis or in combination with a biological reactor (Babu *et al.*, 2007).

Microfiltration

Microfiltration is suitable for treating dye baths containing pigment dyes (Al-Malack and Anderson., 1997), as well as for subsequent rinsing baths. The chemicals used in dye bath, which are not filtered by microfiltration, will remain in the bath. Microfiltration can also be used as a pretreatment for nanofiltration or reverse osmosis (Ghayeni *et al.*, 1998).

Electrodialysis

Electrodialysis is a membrane process in which ions are transported through *ion permeable membranes* from one solution to another under the influence of an electrical potential gradient. It has the ability to separate dissolved salts. The electricity used in electrodialysis influences the ions to get transported through a semi permeable membrane by passing an electrical potential across water (WTS, 2012). The membranes used are charge specific and anion-selective which allows negatively charged particles to pass through and traps positively charged particles and vice versa. Placing numerous membranes throughout the system hinders the flow of effluent and the effluent would reach a point at which the ions are trapped or settled down and the remaining ions are neutral in charge (Jurenka, 2010). Membrane fouling (the process where solutes or other particles get attached to the membrane or into the membrane pore) has to be prevented by removing suspended solids, colloids and turbidity prior to electrodialysis (Marcucci *et al.*, 2002).

Ion exchange process

Ion exchange process is normally used for the removal of inorganic salts and some specific organic anionic components such as phenol. All salts are composed of a positive ion of a base and a negative ion of an acid. Ion exchange materials are capable of exchanging soluble anions and cations with electrolyte solutions (Neumann *et al.*, 2009; WWS, 2013). For example, a cation exchanger in the sodium form when contacted with a solution of calcium chloride will scavenge the calcium ions from the solution and replace them with sodium ions. This provides a convenient method for removing the hardness from water or effluent. Ion exchange resins are available in several types starting from natural zeolite to synthetics which may be phenolic, sulphonic styrenes and other complex compounds. The divalent ions such as calcium and magnesium in general have high affinity for the ion exchange resins and as such can be removed with high efficiencies. In the ion exchange process the impurities from the effluent streams is transformed into another one of relatively more concentrated with increased quantity of impurities because of the addition of regeneration chemicals. The process cannot be used for removal of non-ionic compounds

Biological wastewater treatment method

The biological process removes dissolved matter in a way similar to the self-depuration but in a further and more efficient way than clariflocculation. The removal efficiency depends upon the ratio between organic load and the bio mass present in the oxidation tank, its temperature, and oxygen concentration. The bio mass concentration can increase, by aeration the suspension effect but it is important not to reach a mixing energy that can destroy the flocks, because it can inhibit the following settling. Normally, the biomass concentration ranges between 2500-4500 mg/l, oxygen about 2 mg/l. With aeration time till 24 hours the oxygen demand can be reduced till 99%. According to the different oxygen demand, biological treatment methods can be divided into aerobic and anaerobic treatment. Because of high efficiency and wide application of the aerobic biological treatment, it naturally becomes the mainstream of biological treatment.

Aerobic biological treatment

According to the oxygen requirements of the different bacteria, the bacteria can be divided into aerobic bacteria, anaerobic bacteria and facultative bacteria.

Aerobic biological treatment can purify the water with the help of aerobic bacteria and facultative bacteria in the aerobic environment. Aerobic biological treatment can be divided into two major categories: activated sludge process and biofilm process.

Anaerobic biological treatment

Anaerobic biological treatment process is a method that make use of the anaerobic bacteria decompose organic matter in anaerobic conditions. This method was first used for sludge digestion. In recent years it was gradually used in high concentration and low concentration organic wastewater treatment. In textile industry, there are many types of high concentration organic wastewater, such as wool washing sewage, textile printing and dyeing wastewater etc., which the organic matter content of it is as high as 1000 mg/L or more, the anaerobic wastewater treatment process can achieve good results. The anaerobicaerobic treatment process is usually adopted in actual project that is using anaerobic treatment to treat high concentration wastewater, and using aerobic treatment to treat low concentration wastewater. Currently, the hydrolysis acidification process is the main anaerobic treatment process, which can increases the biodegradability of the sewage to facilitate the following biological treatment process.

The hydrolysis acidification process is the first two stages of the anaerobic treatment. Through making use of the anaerobic bacteria and facultative bacteria, the macromolecule, heterocyclic organic matter and other difficult biodegradable organic matter would be decomposed into small molecular organic matter, thereby enhancing the biodegradability of the wastewater and destructing the colored groups of dye molecules to remove part of the color in wastewater. More importantly, due to the molecular structure of the organic matter and colored material or the chromophore has been changed by the anaerobic bacteria, it's easy to decompose and decolor under the aerobic conditions, which improve the decolorization effect of the sewage. Operating data shows that the pH value of the effluent from hydrolysis tank usually decrease 1.5 units. The organic acid which is produced in hydrolysis can effectively neutralize some of the alkalinity in wastewater, which can make the pH value of sewage drop to about 8 to provide a good neutral environment for following aerobic treatment. Currently, the anaerobic digestion process is a essential measure in the biological treatment of textile dyeing wastewater. In addition, there are many other processes used in textile dyeing wastewater treatment currently, such as upflow anaerobic sludge bed (UASB), upflow anaerobic fluidized bed (UABF), anaerobic baffled reactor (ABR) and anaerobic biological filter and so on.

Biochemical and physicochemical combination processes

In recent years a large number of difficult biodegradable organic matter such as PVA slurry, surface active agents and new additives enter into the dyeing wastewater, which result in the high concentration of the organic matter, complex and changeable composition and the obvious reduction of the biodegradability. The COD_{Cr} removal rate of the simple aerobic activated sludge process which was used to treat the textile dyeing wastewater has decreased from 70% to 50%, and the effluent cannot meet the discharge standards. More seriously, quite a number of sewage treatment facilities can't normally operate even stop running. Therefore, the biochemical and physicochemical combination processes has been gradually developed and its application is increasingly widespread (Sheng-Jie *et al.*, 2008). The types of the combination process are various, and the main adoptions currently are as following:

Hydrolytic acidification-contact oxidation-air floatation process

This combination process is a typical treatment process of the textile dyeing wastewater, which is widely used (Fig. 10). The wastewater firstly flows through the bar screen, in order to remove a part of the larger fibers and particles, and then flows into the regulating tank. After well-distributed through a certain amount of time, the sewage flows into the hydrolysis acidification tank to carry out the anaerobic hydrolysis reaction. The reaction mechanism is making use of the anaerobic hydrolysis and acidification reaction of the anaerobic fermentation to degrade the insoluble organic matter into the soluble organic matter by controlling the hydraulic retention time. At the same time, through cooperating with the acid bacteria, the macromolecules and difficult biodegradable organic matter would be turned into biodegradable small molecules, which provide a good condition for the subsequent biological treatment. Next, the sewage enters into the biological contact oxidation tank. After the biochemical treatment, the wastewater directly enters into the flotation tank for flotation treatment, which is adopted the pressurized full dissolved air flotation process. The polymer flocculants added in flotation tank react with the hazardous substances, which can condense the hazardous substances into tiny particles. Meanwhile, sufficient air is dissolved in the wastewater. And then the pressure suddenly is released to produce uniformly fine bubbles, which would adhere to the small particles. The density of the formation is less than 1kg/m^3, which can make the formation float and achieve the separation of the solid and liquid.

The anaerobic hydrolysis acidification tank equipped with semi-soft padding and the biological contact oxidation tank equipped with the new SNP-based filler. The following physicochemical treatment uses the dosing flotation tank, which has four characteristics. Firstly, the deciduous biofilm and suspended solids removal rate can reach 80% to 90%. Secondly, the color removal rate can reach 95%. Thirdly, the hydraulic retention time in the flotation tank is short, which is only about 30 min, while the precipitation tank is about 1.15 h to 2 h, so the volume and area of the flotation tank is small. Finally, the sludge moisture content is low, only about 97% to 98%, which can be directly dewatered. But the flotation treatment need an additional air compressor, pressure dissolved gas cylinders, pumps and other auxiliary system. The operation and management is also relatively complicated. After the treatment of this process, the COD_{Cr} removal rate can be up to 95% or more. The actual effluent quality is about: pH=6~9, color<100times, SS<100mg/L, BOD5<50mg/L, COD_{Cr}<150mg/L (Honglian Li, 2006).

Anaerobic-aerobic-biological carbon contacts

The treatment process is a mature and widely used process in wastewater treatment in recent years (Fig. 11). The anaerobic treatment here is not the traditional anaerobic nitrification, but the hydrolysis and acidification. The purpose is aiming at degrading some poorly biodegradable polymer materials and insoluble material in textile dyeing wastewater to small molecules and soluble substances by hydrolysis and acidification, meanwhile, improving the biodegradability and BOD5/COD_{Cr} value of the wastewater in order to create a good condition for the subsequent aerobic biological treatment. At the same time, all sludge generated in the aerobic biological treatment return into the anaerobic biological stage through the sedimentation tank. Because of the sludge in the anaerobic biochemical stage has sufficient hydraulic retention time (8h~10h) to carry out anaerobic digest thoroughly; the whole system would not discharge sludge that is the sludge achieves its own balance. Anaerobic tank and aerobic tank are both installed media, which is a biofilm process. Biological carbon tank is filled with activated carbon and provided oxygen, which has the characteristics both of suspended growth method and fixation growth method. The function of pulse water is mixing in the anaerobic tank. The hydraulic retention time of various parts is about: Regulating tank: 8h~12h; anaerobic biochemical tank: 8h~10h Aerobic biochemical tank: 6 ~8h; biological carbon tank: 1h~2h Pulse generator interval: 5min~10min. According to the textile dyeing wastewater standard (COD_{Cr} ≤1000 mg/L), the effluent can achieve the national emission standards, which can be reused through further advanced treatment. For the five years operation project, the results show that the operation is normal, the treatment effect is steady, there is no efflux of sludge and the sludge was not found excessive growth in the anaerobic biochemical tank.

Coagulation-ABR-oxidation ditch process

The treatment has been adopted widely in the textile dyeing wastewater treatment plants (Fig. 6). The characteristics of the textile dyeing plant effluent are the variation in water, the higher of the alkaline, color and organic matter concentration , and the difficulty of the degradation ($BOD5/COD_{Cr}$ value is about 0.25). The workshop wastewater enter into the regulating tank by pipe network to balance the quantity and quality, after wiping off the large debris by the bar screen before the regulating tank. The adjusted wastewater flow into the coagulation reaction tank, at the same time, the $FeSO_4$ solution was added into it to carry out chemical reaction. Finally, the effluent flows into the primary sedimentation tank for spate separation, meanwhile enhancing the $BOD5/COD_{Cr}$ ratio. The effluent of primary sedimentation tank flows into the anaerobic baffled reactor (ABR) by gravity. After the anaerobic hydrolysis reaction, it enters into the integrated oxidation ditch for aerobic treatment, and then goes into the secondary sedimentation tank for spate separation. The upper liquid was discharged after meeting the standards, but the settled sludge was returned to the return sludge tank, most of which was returned to ABR anaerobic tank by pump. The remaining sludge was pumped to the sludge thickening tank for concentration.

UASB-aerobic-physicochemical treatment process

For the high pH value dyeing wastewater treatment systems should adjust the pH value to the range from 6 to 9 before entering the treatment system. The "UASB-aerobic-physicochemical method" treatment process is shown in Fig. 7.

At present, the treatment process has been applied in a number of textile dyeing factories which sewage component is complex. Before the sewage enters into the regulating tank, the suspended particles in which must be removed by bar screen, at the same time, an appropriate amount of acid was added to adjust the pH value of the sewage. Then adjusting the water quantity and quality to make it uniformed. After pre-treatment, the textile dyeing wastewater carries out anaerobic reaction firstly in UASB reactor to improve the biodegradability of wastewater and the decolourization rate, and then flows into the aerobic tank. In the aerobic tank, the organic matter in sewage is removed. Finally, in order to ensure the effective removal of the suspended particles particular the activated sludge, some flocculants was added in the sedimentation tank to improve its effect. Through this sewage treatment process, the removal rate of pollutants is shown in table 5 (Zhang, 2007).

Cutting edge advanced oxidation processes (AOP)

AOP uses a powerful and effective combination of ozone, UV and hydrogen peroxide to decompose unwanted chemical and organic compounds, TOC, COD and BOD. Unlike physical and biological treatment methods, AOP doesn't produce additional by-products and sludge, eliminating the need for further handling. Furthermore, physical and biological treatment methods fall short of meeting the new environmental standards. AOP is a proven, more efficient and effective means of treating waste streams that meets and exceeds industry requirements.

AOP systems can be adapted to suit specific applications and are fully automated, reducing capital and operating costs. These processes are ideal for:

- Reclaim, recycle and reuse of process and waste water
- Waste water treatment
- Gas effluent treatment
- Treatment for ultra-pure water

Advanced Oxidation Processes (AOPs)

AOPs were defined by Glaze and *et al.* (1987) as near ambient temperature and pressure water treatment processes which involve the generation of highly reactive radicals (specially hydroxyl radicals) in sufficient quantity to effect water purification. These treatment processes are considered as very promising methods for the remediation of contaminated ground, surface, and wastewaters containing non-biodegradable organic pollutants. Hydroxyl radicals are extraordinarily reactive species that attack most of the organic molecules. The advanced oxidation processes (AOPs) are: UV/O3 process, UV/H_2O_2, O_3/H_2O_2, Fe^{3+}/ UV-vis process, UV/TiO_2 (Heterogeneous photocatalysis), H_2O_2 / Fe^{2+} (known as Fenton's reagent).

Among various AOPs, the Fenton reagent (H_2O_2/ Fe^{2+}) is one of the most effective methods of organic pollutant oxidation. The Fenton reagent has been found to be effective in treating various industrial wastewater components including aromatic amines, a wide variety of dyes as well as many other substances, e.g. pesticides and surfactants (Rodríguez, 2003). Therefore, the Fenton reagent has been applied to treat a variety of wastes such as those associated with the textile and chemical industries.
The advantage of the Fenton reagent is that no energy input is necessary to activate hydrogen peroxide (Rodríguez, 2003). Therefore, this method offers a cost-effective source of hydroxyl radicals, using easy-to-handle reagents. However, disadvantages in using the Fenton reagent include the production of a substantial amount of $Fe(OH)^3$ precipitate and additional water pollution caused by the homogeneous catalyst that added as an iron salt, cannot be retained in the process (Rodríguez, 2003). To solve these problems, the application of alternative iron sources as catalysts in oxidizing organic contaminants has been studied extensively. A number of researchers have investigated the application of iron oxides such as hematite, ferrihydrite, semicrystalline iron oxide and crystalline goethite (Rodríguez, 2003). They generally have observed a greatly accelerated decomposition of hydrogen peroxide but variable amounts of contaminant were lost.

The Fenton reaction was discovered by H.J.Fenton in 1894 (Fenton, 1894). Forty years later the Haber-Weiss. (1934) mechanism was postulated, which revealed that the effective oxidative agent in the Fenton reaction was the hydroxyl radical.

The Fenton reaction can be outlined as follows:

$Mn^{+}+H_2O_2\_M(n+1)^{+}+HO^{-} + HO\bullet$ (1)

where M is a transition metal as Fe or Cu.
The HO• radical mentioned above, once in solution attacks almost every organic compound. The metal regeneration can follow different paths. For Fe2+, the most accepted scheme is described in the following equations (Sychev and Isak, 1995)

$Fe^{3+}+H_2O_2\_Fe^{3+}+HO + HO\bullet$ (2)

$Fe^{3+}+H_2O_2\_Fe^{2+}+ HO_2\bullet + H+$ (3)

$Fe^{2+}+HO\bullet\_Fe^{3+}+HO\bullet-$ (4)

$HO\bullet+H_2O_2\_HO\bullet+H_2O$ (5)

$Fe^{3+}+HO\bullet\_Fe^{2+}+H^{+}+ O_2$ (6)

$Fe3++O2\bullet-\_Fe^{2+}+O_2$ (7)

$Fe^{2+}+HO_2\bullet\_Fe^{3+}+HO_2\bullet-$ (8)

Fenton reaction rates are strongly increased by irradiation with UV/visible light (Ruppert *et al.*, 1993).

Photochemical oxidation

Photochemical oxidation has many advantages of the mild reaction conditions (ambient temperature and pressure), powerful oxidation ability and fast speed, etc. It can be divided into four kinds, which are light decomposition, photoactivate oxidation, optical excitation oxidation and photocatalysis oxidation. Among them, the photocatalysis oxidation has been more researched and applied currently.

This technology can effectively destroy a lot of organic pollutants whose structure is stable and difficult to biologically degrade. Compared with the physical treatment in traditional wastewater treatment process, the most obvious advantages of this technology are significant energy efficiency, completely pollutants degradation and so on. Almost all of the organic matter can be completely oxidized to CO_2, H_2O and other simple inorganic substances under the light catalyst. However, towards high concentration wastewater, the effect of the photocatalysis oxidation process is not ideal. The research about photocatalysis oxidation degradation of dye mainly focused on the study of photocatalyst.

Electrochemical oxidation

The mechanism of the electrochemical process treating dyeing wastewater is making use of electrolytic oxidation, electrolytic reduction, electrocoagulation or electrolytic floating destruct the structure or the existence state to make it bleached. It has the advantages of small devices, small area covering, operation and management easily, higher COD_{Cr} removal rate and good bleaching effect, but the precipitation and the consumption of electrode material is great, and the operating cost is high. The traditional electrochemical methods can be divided into power flocculation, electrical float, electro-oxidation, micro-electrolysis and the electrolysis method. With the development of electrochemical technologies and the appearing of a variety of high efficiency reactor, the cost of treatment will decrease largely. Electro-catalytic advanced oxidation process (AEOP) is a new advanced oxidation technology developed recently. Because of its high efficiency, easy operation, and environmental friendliness, it has attracted the attention of researchers. Under normal temperature and pressure, it can produce hydroxyl radicals directly or indirectly through the reactions in the catalytic activity electrode, thus the degradation of the difficultly biodegradable pollutants is effective. It is one of the main directions in future research.

Ultrasonic technology

Using ultrasonic technology can degrade chemical pollutants, especially the refractory organic pollutants in water. It combines the characteristics of advanced oxidation technology, incineration, supercritical water oxidation and other wastewater treatment technologies. Besides the degradation conditions are mild, degradation speed is fast and application widely; it can also use individually or combined with other water treatment technologies. The principle of this method is that the sewage enters into the air vibration chamber after being added the selected flocculants in regulating tank. Under the intense oscillations in nominal oscillation frequency, a part of organic matter in wastewater is changed into small organic molecule by destructing its chemical bonds. The flocculants flocculation rapidly companied with the color, COD_{Cr} and the aniline concentration was fall under the accelerating thermal motion of water molecules, which play the role of reducing organic matter concentration in wastewater. At present, the ultrasonic technology in the research of water treatment has achieved great achievements, but most of them are still confined to laboratory research level.

High energy physical process

High energy physical process is a new wastewater treatment technology. When the high energy particle beam bombard aqueous solution, the water molecules would come up with excitation and ionization, produce ions, excited molecules, secondary electrons. Those products would interact with each other before spreading to the surrounding medium. It would produce highly reactive HO. radicals and H atoms, which would react with organic matter to degrade it. The advantages of using high-energy physics process treat dyeing wastewater are the small size of the equipment, high removal rate and simple operation. However, the device used to generate high energy particle is expensive, technically demanding is high, energy consumption is big, and the energy efficiency is low and so on. Therefore, it needs a lot of research work before put into actual project.

Results and discussion

Textiles and Garments is one of the oldest and largest industries in the world. The textile industries have great economic significance by virtue of its contribution to overall industrial output and employment generation in so many countries. The textile industry utilizes various dyes, chemicals and large amount of water during the production process. The waste water produced during this process contains large amount of dyes and chemicals containing trace metals such as Cr, As, Cu and Zn which are capable of harming the environment and human health. The textile waste water causes haemorrhage, ulceration of skin, nausea, skin irritation and dermatitis. The chemicals present in the water block the sunlight and increase the biological oxygen demand thereby inhibiting photosynthesis and reoxygenation process.

Table 1. Major Exporters of Textiles.

Country	Value ($ Billion)	Share (%)
China	94.4	32.1
European Union 27	76.6	26.1
India	15.0	5.1
United States of America	13.8	4.7
Korea Republic	12.4	4.2
Turkey	10.8	3.7
Pakistan	9.1	3.1
Indonesia	4.8	1.6
Vietnam	3.8	1.3
Bangladesh	1.5	0.5
Rest of the World	51.7	17.5
Total	294	99.9

Table 2. Major Exporters of Cloths.

Country	Value ($ Billion)	Share (%)
China	153.8	35.6
European Union 27	116.4	27.1
Bangladesh	19.9	4.6
India	14.4	3.3
Turkey	13.9	3.2
Vietnam	13.2	3.1
Indonesia	8.0	1.8
United States of America	5.2	1.2
Pakistan	4.6	1.1
Korea Republic	1.8	0.4
Rest of the World	79.8	18.5
Total	431	99.9

Table 3. Characteristics of typical untreated textile wastewater.

Parameter	Range
pH	6-10
Temperature (°C)	35-45
Total d solids (mg/L)	8,000-12,000
BOD (mg/L)	80-6,000
COD (mg/L	150-12,000
Total suspended solids (mg/L	15-8,000
Total dissolved solids (mg/L)	2,900-3,100
Chlorine (mg/L)	1,000-6,000
Free chlorine (mg/L)	<10
Sodium (mg/L)	70%
Trace metals (mg/L	
Fe	<10
Zn	<10
Cu	<10
AS	<10
Ni	<10
B	<10
F	<10
Mn	<10
V	<10
Hg	<10
PO_4	<10
Co	<10
Oil and Grease (mg/L)	10-30
TNK (mg/L	10-30
NO_3-N (mg/L	<15
Free Ammonia (mg/L	<10
Sulphate (mg/L	600-1000
Silica (mg/L	<15
Total Kjeldahl Nitrogen (mg/L	70-80
Color (Pt-Co)	50-2,500

Table 4. Some Textile waste water pollution regulations imposed by several countries.

Parameter	CCME	China	BIS	Hong Kong	FEPA	MEX	THA	PHI	INDO	BD	SL
pH	6.5-8.5	6-9	5.5-9	6-10	6-9	6-8.5	5-9	6-9	6-9	6.5-9	6-8.5
Temperature (°C)	30	-	50	43	40	-	-	40	-	40-45	40
Color (Pt-Co)	100	80	None	1 (Lovibond)	1 (Lovibond)	-	-	100-200	-	-	30
TDS (mg/L)	2000	-	2100	-	2000	-	2000-5000	1200	-	2100	2100
TSS (mg/L)	40	150	100	800	30	-	30-150	90	60	100	500
Sulphide (μg/L)	200	1000	2000	1000	200	-	-	-	-	1000	2000
Free Chlorine (μg/L)	1000	-	1000	-	1000	-	-	1000	-	-	-
COD (mg/L)	80	200	250	2000	80	<125	120-400	200-300	250	200	600
BOD (mg/L	50	60	30	800	50	<30	20-60	30-200	85	150	200
Oil and Grease (mg/L)	-	-	10	20	10	-	300	5-15	5	10	30
Dissolved Oxygen (μg/L)	6000	-	-	≥4000	-	-	-	1000-2000	-	4500-8000	-
Nitrate (μg/L)	13000	-	10000	-	20000	10000	-	-	-	10000	45000
Ammonia (μg/L)	0.1	-	-	500	0.2	-	-	-	-	5000	60
Phosphate (μg/L)	<4000	1000	5000	5000	5000	-	-	-	2000	-	2000
Calcium (μg/L)	-	-	-	-	20000	-	-	20000	-	-	24000
Magnesium (μg/L)	20000	-	-	-	20000	-	-	-	-	-	15000
Chromium (μg/L)	1	-	100	100	<100	50	500	50-500	500	2000	50
Aluminium (μg/L)	5	-	-	-	<1000	5000	-	-	-	-	-
Copper (μg/L)	<1000	2000	3000	1000	<1000	1000	1000	1000	2000	500	3000
Manganese (μg/L)	5	2000	2000	1000	5.0	200	5000	1000-5000	-	5000	500
Iron (μg/L)	300	-	3000	500	20000	1000	-	1000-20000	5000	2000	1000
Zinc (μg/L)	30	5000	5000	1500	<10000	10000	-	5000-10000	5000	5000	10000
Mercury (μg/L)	0.026	-	0.01	1	0.05	-	5	5	-	10	1

Note: CCME-Canadian Council of Ministers of the Environment, BIS-Bureau of Indian Standards, FEPA-Federal Environmental Protection Agency (USA), Mex-Mexico, Tha-Thailand, Phi-Philipines, Indo-Indonesia, Bd-Bangladesh SL-Srilanka

Table 5. The removal of the processing units.

Items	Raw Water (regulating tank)	Biochemical treatment system		Physiochemical treatment system	
		Effluent	Removal rate	Effluent	Removal rate
pH	8-12	7-8		6-9	
CODcr (mg/L)	1000-2000	100-200	90	≤100	50
BOD_5 (mg/L	300-600	15-30	95	≤30	
Color (times)	100-600	60	80	≤40	35

In the recent year, many consumers in the developed countries are demanding biodegradable and ecologically friendly textiles. Some countries have already strictly applied their ecological standards for water pollution in textile industries throughout processing from raw material selection to the final products. The main challenge for the textile industries today is to modify production methods, so they are more ecologically friendly by using safer dyes and chemicals and by reducing cost of effluent treatment. Waste minimization is of great importance in decreasing pollutions load and production costs.

Traditionally the effluent water discharged from the textile industries undergoes various physio-chemical processes such as flocculation, coagulation and ozonation followed by biological treatments for the removal of nitrogen, organics, phosphorous and metal. The whole treatment process involves three steps: primary treatment, secondary treatment and tertiary treatment. The primary treatment involves removal of suspended solids, most of the oil and grease and gritty materials. The secondary treatment is carried out using microorganisms under aerobic or anaerobic conditions and involves the reduction of BOD, phenol and remaining oil in the water and control of color.

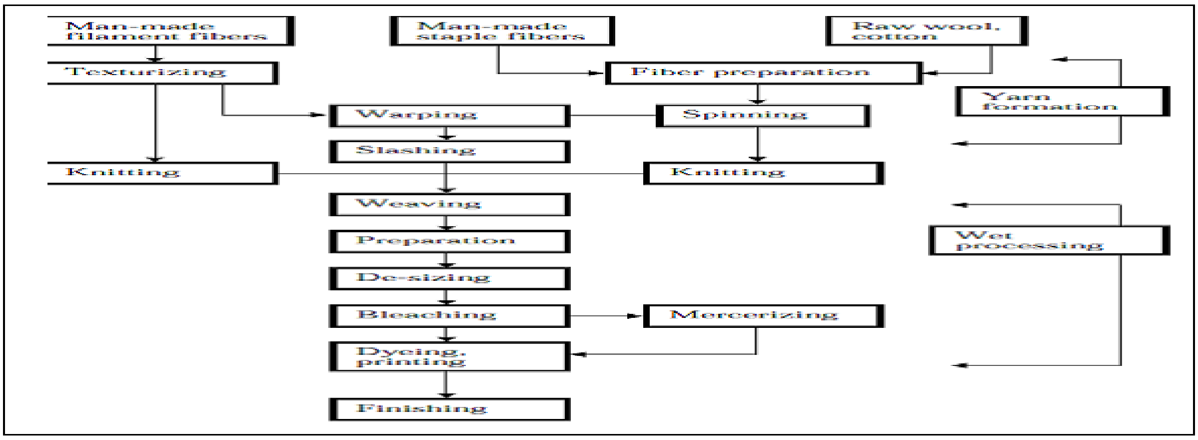

Fig. 1. A flow diagram for various steps involved in processing textile in a cotton mills.

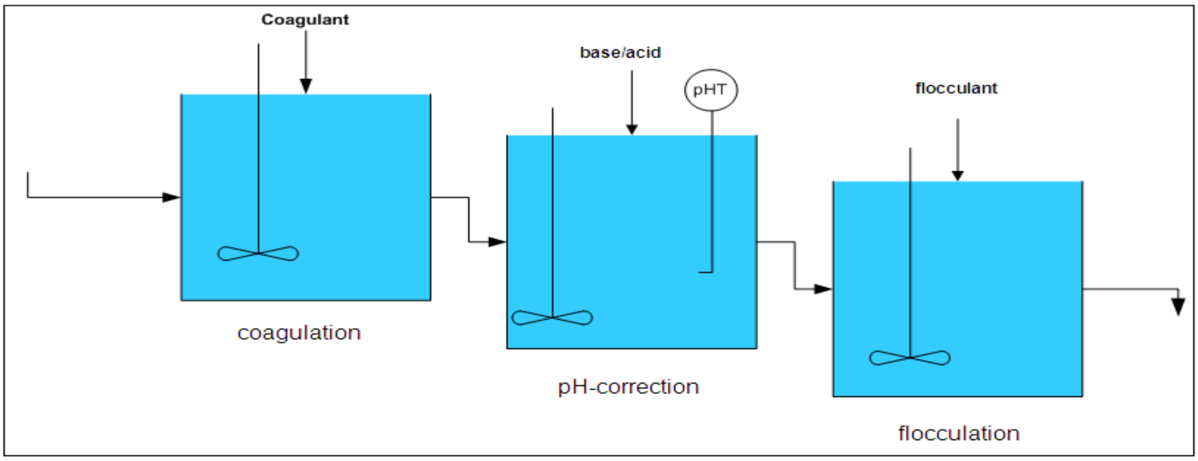

Fig. 2. Components of conventional physico-chemical treatment.

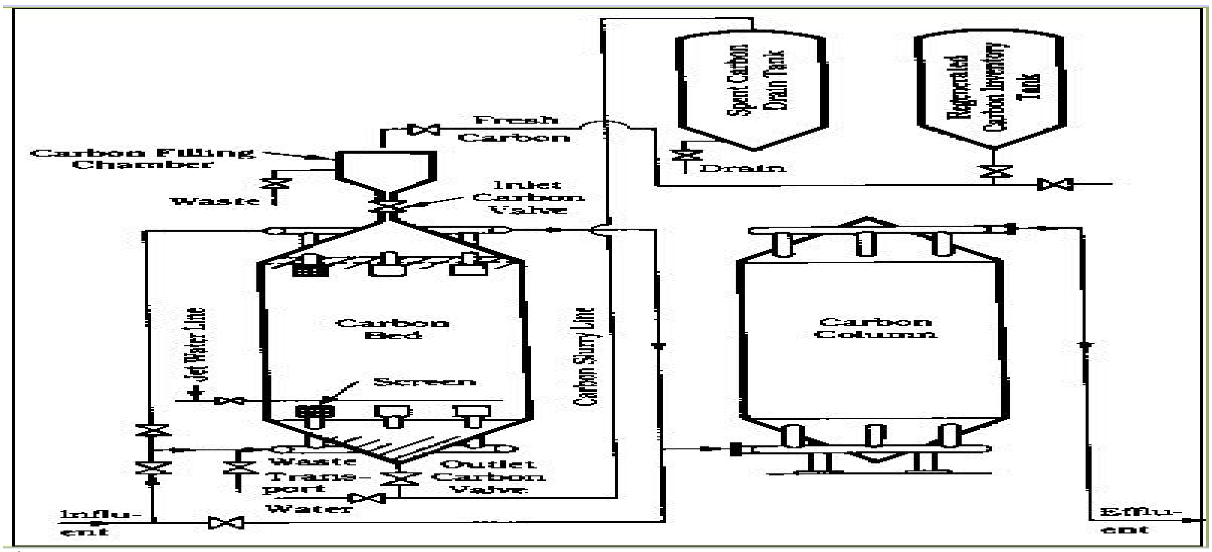

Fig. 3. Components of conventional physico-chemical treatment.

The tertiary treatment involves the use of electrodialysis, reverse osmosis and ion exchange to remove the final contaminants in the wastewater. The major disadvantages of using the biological process are that the presence of toxic metals in the effluent prevents efficient growth of microorganisms and the process requires a long retention time.

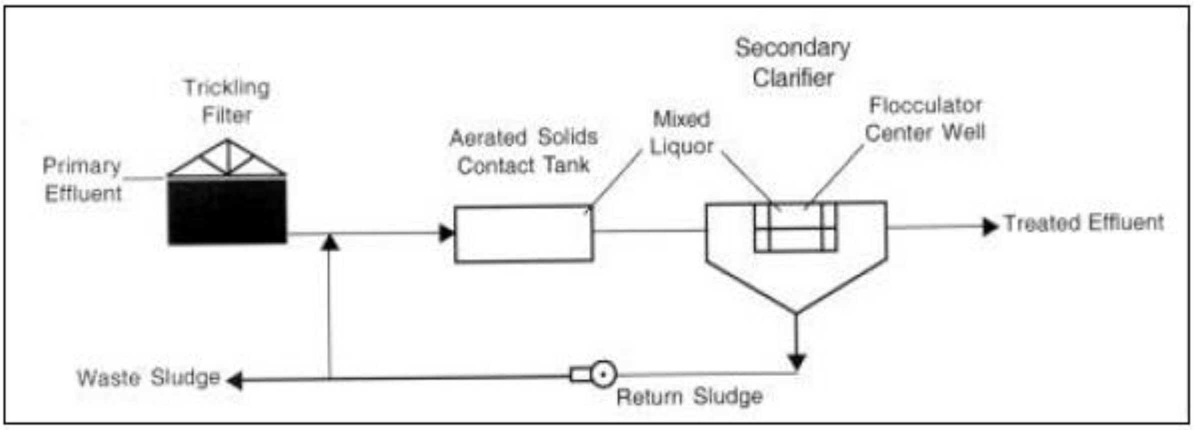

Fig. 4. Secondary treatment Processes.

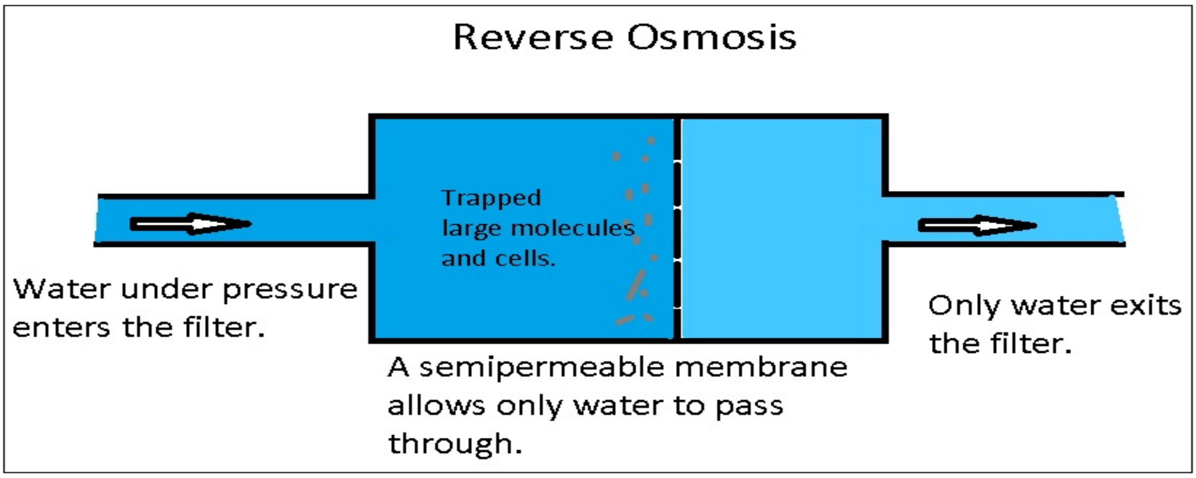

Fig. 5. Secondary treatment Processes.

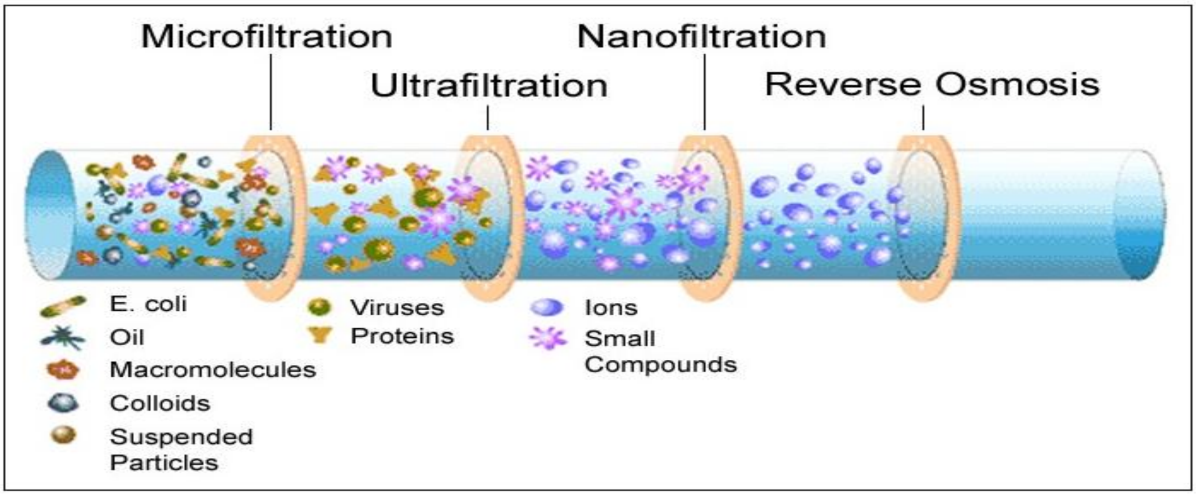

Fig. 6. Secondary treatment Processes.

The advanced oxidation processes is gaining attention in the recent days due to the ability to treat almost all the solid components in the textile effluents. The photo-oxidation of the effluents is carried out using H_2O_2, combination of H_2O_2 and UV and Combination of TiO_2 and UV.

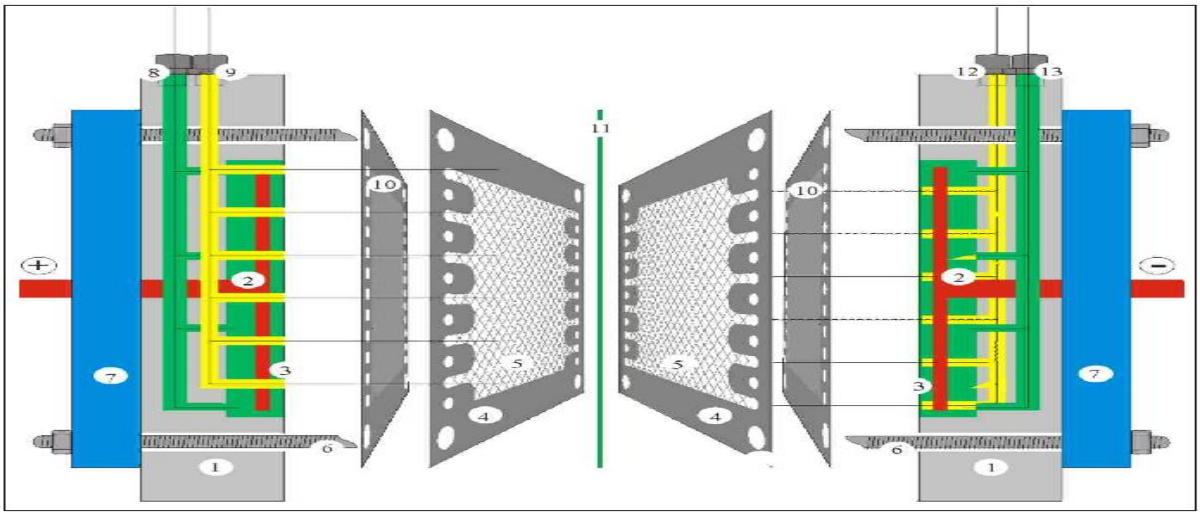

Fig. 7. A typical Electrodialysis (ED) flow diagram.

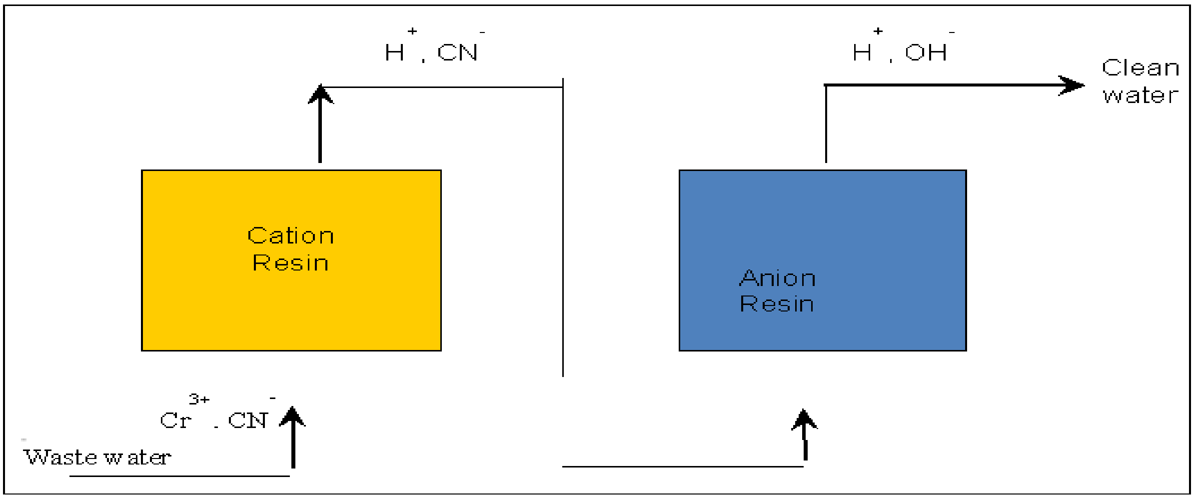

Fig. 8. A Flow diagram of Ion Exchanger.

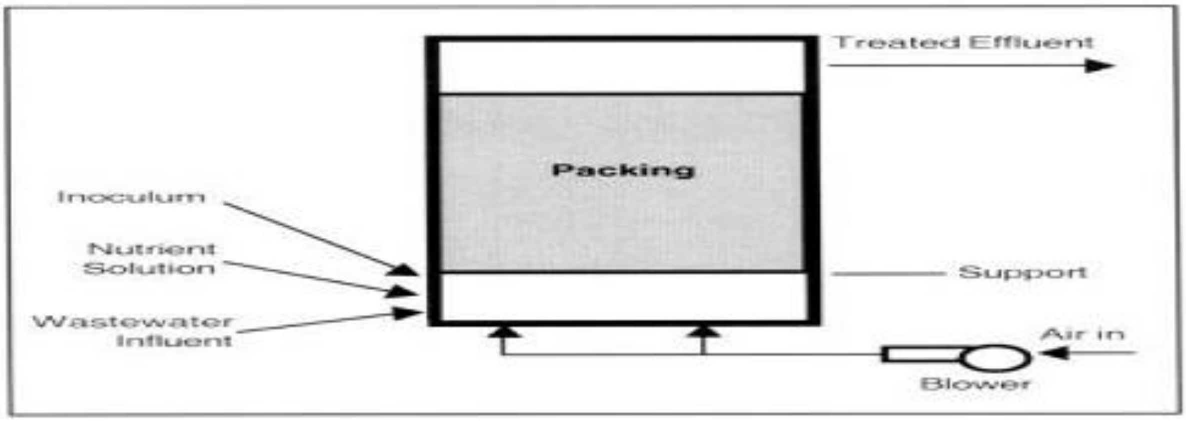

Fig. 9. Secondary treatment Processes.

Advanced oxidation process generates low waste and uses hydroxyl radicals (OH●) as their main oxidative power. The hydroxyl radicals (OH●) are produced by chemical, electrical, mechanical or radiation energy and therefore advanced oxidation processes are classified under chemical, photochemical, catalytic, photocatalytic, mechanical and electrical processes.

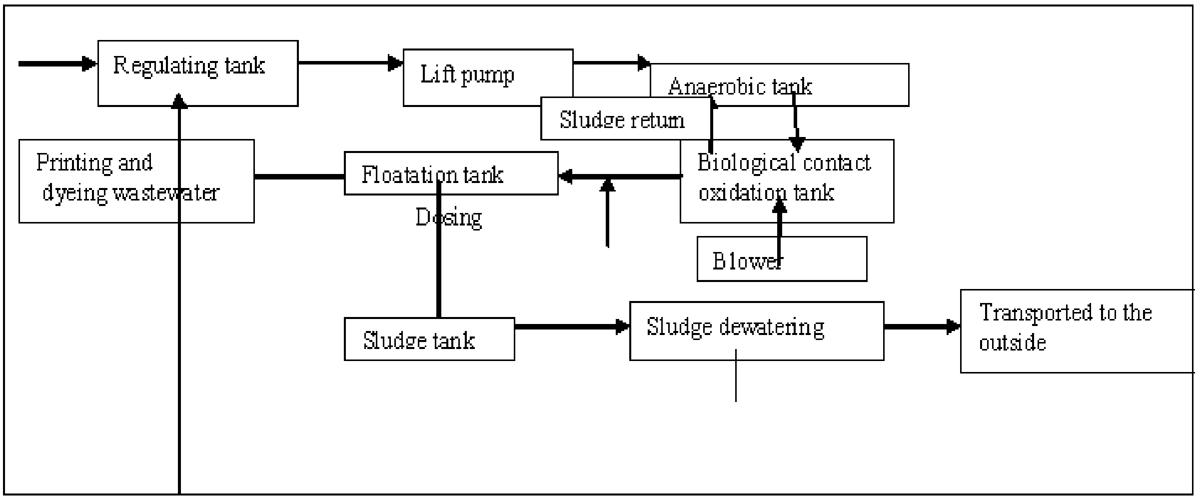

Fig. 10. Hydrolytic acidification-contact oxidation-air floatation process flow diagram.

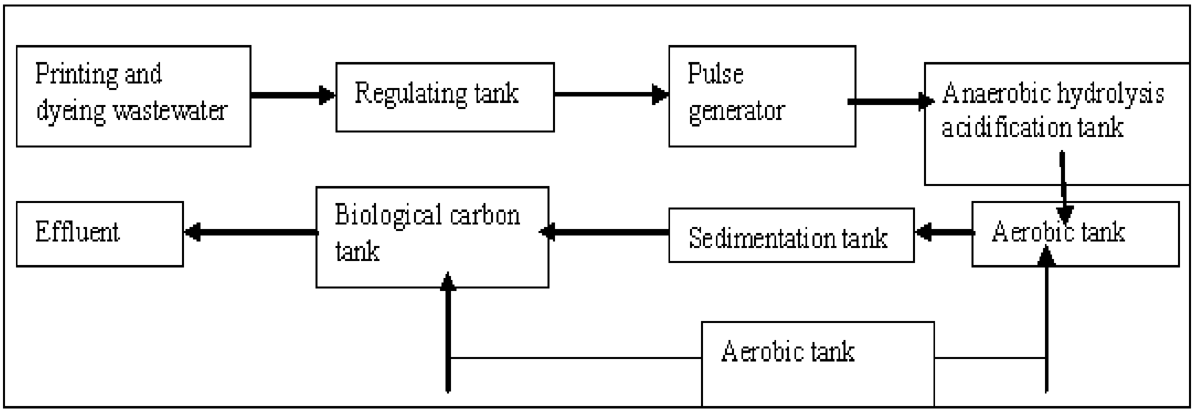

Fig. 11. Anaerobic-aerobic-biological carbon contacts process flow diagram.

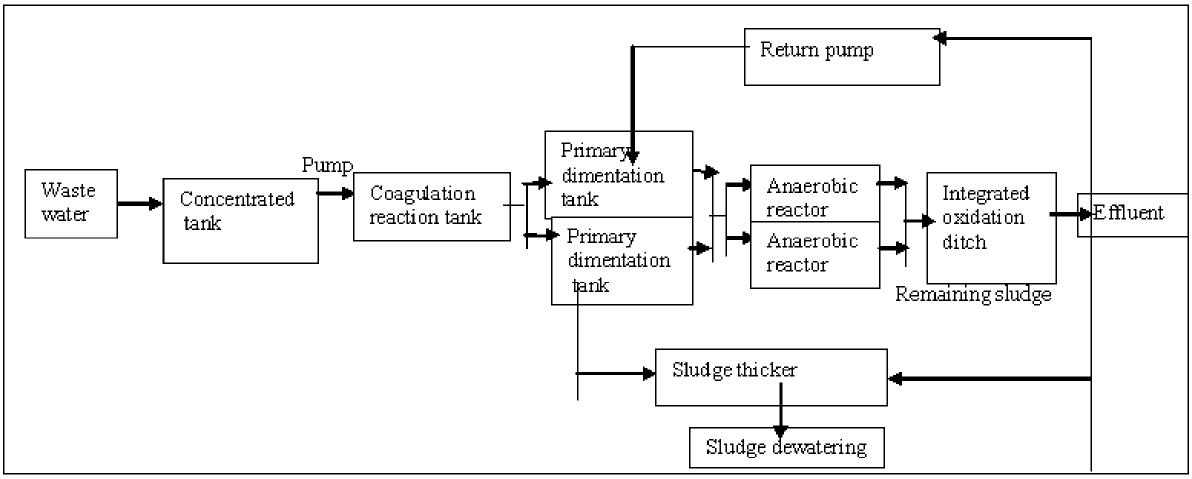

Fig. 12. Coagulation-ABR-oxidation ditch process flow diagram.

The effluents treated with advanced oxidation process were found to reduce 70-80% COD when compared to 30-45% reduction in biological treatment.

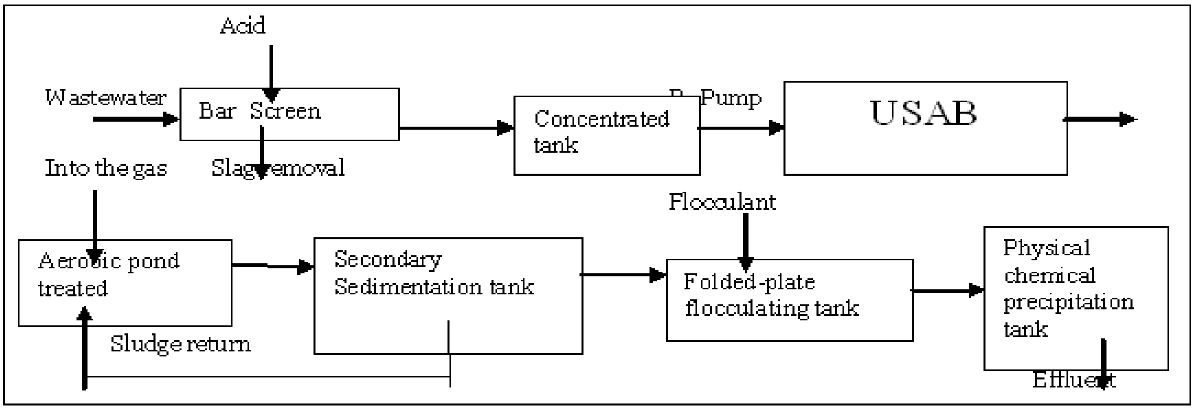

Fig. 13. UASB-aerobic-physicochemical treatment process flow diagram.

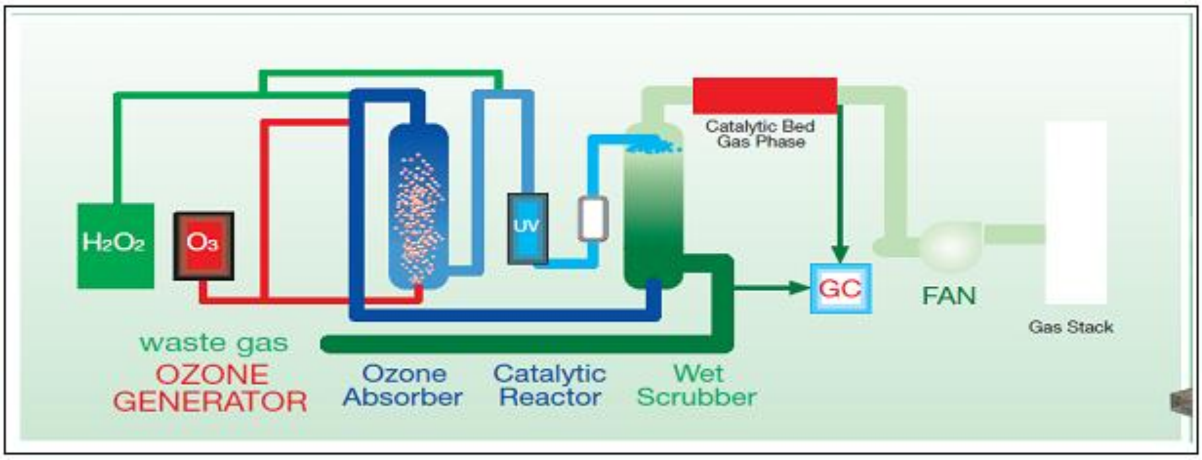

Fig. 14. Advanced Oxidation Processes (AOPs) flow diagram.

Conclusion

Proper selection and application of individual or combination the advance treatment methods in textile industry can effectively make recovery of water from the wastewater for their reuse in production processes. The advance methods can also be applied to meet stringent environmental or regulatory requirements by the reusing the water and chemicals. On the other hand, clean production is also an important research, which can shift the focus from end of the treatment to the prevention of pollution and conduct more in-depth research on the printing and dyeing production technology and process management. Moreover, the strategic, comprehensive, preventive measures and advanced production technology can be used to improve the material and energy utilization. Also, we can reduce and eliminate the generation and emissions of wastes as well as the production of excessive use of resources and the risks to humans and the environment. Prevention and treatment of dyeing wastewater pollution are complementary. We can both use preventive measures as well as a variety of methods to control the wastes and make use of treated water. This will not only reduce water consumption, but also effectively reduce the pollution of the printing and dyeing wastewater and achieve sustainable development of society.

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