A Review of Tannery Effluent Treatment

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ABSTRACT
In the recent time, there have been several new improvements in the tannery effluents treatment. The pressure from environmental bodies to adopt cleaner technologies of tannery effluents treatments and hazardous nature of the effluents has become imperative. These effluents normally contained components such as organic, inorganic, (i.e. nitrogenous compounds, sulphide, and chromium), large quantities of solid waste, dissolve solid, and suspended solid. Discoveries of advanced methods of the effluent treatments have become an area of concern worldwide as individuals, communities, industries and nations are trying to find most viable and economical treatment/methods available and appropriate to be used. This paper reviews the development of trends of treatment methods and technological advancement for pollution control from effluents discharge from tannery. Thus; the paper covers various advanced methods of effluent treatments from physical, chemical, to biological or combination of these methods. From this review it shows that the combination methods give satisfactory results compared to other types of effluent treatment processes.

Key words: *Tannery, Effluent, Treatments, Physical, Biological and Chemical.*

INTRODUCTION

Tanning is one of the oldest industries in the world. During ancient times, tanning activities were organized to meet local demands of leather foot wears, and musical instruments (Durai and Rajasimman, 2011). Tanning is the chemical process that converts animal hides and skin into stable and imputrescible products called leather (Hayelom and Adhena 2014 and Giusy *et al.*, 2013). The transformation of hides into leather is usually done by means of tanning agents and the process generates highly turbid, colored and foul smelling effluent (Hayelom and Adhena 2014 and Buljan and Kral. 2011). Two adopted methods for tanning of raw hide/skin are; vegetable tanning and chrome tanning. The production processes in a tannery categorize into four namely; Beam house operations, Tanyard operations, Post tanning operations and finishing operations (Durai and Rajasimman, 2011).

The release of effluents directly from tanneries into bodies of water has become a growing environmental challenge as it is one of the major sources of pollution (Bosnic *et al*., 2000). Many health problems are associated with the contaminated air, soil and water polluted by effluents from the tanneries (WHO, 2002). Most of these effluents are complex mixtures containing inorganic compounds (Fu *et al*., 1994) comprises of metals (either in free form in the effluents or adsorbed in the suspended solids) such as Cr, Fe^{2+}, Zn^{2+}, Cu^{2+t}, Ca^{+}, Na^{+}, etc., anion such as SO_4^{2-}, NO_{3-}, PO_4^{3-}; organic parameters such as Dissolved Oxygen (DO), Total Dissolved Solid (TDS) (Bosnic *et al*., 2000), and these pollutants have been found to be carcinogenic and poisonous not only to humans but also to aquatic life (Tamburlini *et al*., 2002, WHO, 2002), and also result in food contamination (Novick, 1999). While other chemicals present in the effluent are poisonous depending on the dose and exposure duration (Kupechella and Hyland, 1989, Akan et al., 2007).

Tannery effluent treatment is a multi-stage process to purify wastewater before it is discharge into the body of natural water, to the land, or it is reused (Buljan *et al*., 2011). The aim is to reduce or remove organic matter, solids, nutrients, Chromium and other pollutants since each receiving body of water can only receive certain amounts of pollutants without suffering degradation as regulated by many regulatory bodies like WHO. The standard of the effluent to be discharge to the environment is shown in the table 1 below. Therefore, each effluent treatment plant must adhere to discharge standards –limits usually promulgated by the relevant environmental authority (Buljan *et al*., 2011). This work attempted to review many publications on the tannery treatment as the method of treatment depends on the materials and chemical used.

METHODS

Internet browsing from Google Scholar data base, Jstor.org and Sciencedirect.com was used to identify and download abstracts and research papers related to tannery effluent treatment using suitable keyword (Tannery+Effluent+Treatments+Physical+Biological+Chemical) between the month of march and April 2016. The basis for the selection of articles focused on General procedures in the treatment of tannery effluent, Description of procedures, equipment and method adopted as well as new trends in tannery effluent treatment. Many publications were identified and reviewed for this work.

CHARACTERIZATION OF TANNERY EFFLUENT GENERATION OF COMPOSITE CHROME TANNERY WASTEWATER

The characteristics of tannery effluent vary considerably from tannery to tannery depending upon the size of the tannery, chemicals used for a specific process, amount of water used and type of final product produced by a tannery effluent from a typical tannery. The pollution of tannery effluent can be characterized by parameters such as Chemical oxygen demand (COD), Biochemical oxygen demand (BOD), Suspended solids(SS), Chromium, sulfide etc (Buljan *et al.*, 2011).

In general composite tannery effluent is alkaline in nature with pH above 7.5, high content of organic substances mainly slowly biodegradable substances , high suspended solids, considerable amount of nitrates and total chromium. In addition, tannery effluent contains high amount of sulfide/sulphate, chlorides and other metals. Several problems are already encountered during the biological treatment of tannery wastewater because of high toxic interferences of chromium, sulphide, chloride etc. As a result, undesirable effluent quality is attained in terms of chromium, sulphide etc .Obviously disposal of such effluent into water bodies may cause adverse environmental effects (Buljan *et al*., 2011).

There are three main categories of tannery effluent, each one have very distinctive characteristics, these are:

•Effluents emanating from the beam-house – liming, deliming/bating, water from fleshing and splitting machines; they contain sulphides, their pH is high, but they are chrome-free.

•Effluents emanating from the tanyard (tanning and re-tanning, sammying) – high Cr content, acidic.

•Soaking and other general effluents, mainly from post-tanning operations (fat-liquoring, dyeing) – low Cr content. (Buljan *et al*., 2011).

METHODS OF TANNERY EFFLUENT TREATMENT

Effluent treatment methods are classified into three (3); physical, chemical and biological processes (Metcalf and Eddy, 1979). Various treatment for tannery effluent like physico-chemical methods such as sedimentation (Song *et al*.,2000), Electro floatation (Murugananthan *et al*.,2004), Filtration (Cassano *et al*.,1999; Tiglyene *et al*.,2008) and Membrane filtration (Justina *et al*., 2009), Precipitation (Kabdasli et al.,2003; Esmaeili *et al*.,2005) and Coagulation (Jing-Wei *et al*.,2007; Haydar *et al*.,2009; Zhi *et al*.,2009; Espinoza-Quinones *et al*., 2009; Sengil *et al*.,2009), Adsorption (Santosa *et al*., 2008; Covarrubias *et al*.,2008), Ion exchange (Tiravanti et al.,1997; Kabir and Ogbeide, 2008) and Biological methods such as aerobic, anaerobic, and wetlands and ponds (Martinez et al.,2003; Farabegoli *et al*.,2004; Murat et al.,2006; Lefebvre et al.,2006; Banu and Kaliappan, 2007; Munz *et al*.,2008; Zupancic and Jemec, 2010). It was suggested that many organic compounds contained in effluent are resistant to conventional chemical and/or biological treatment, (Schrank *et al*., 2004), (Rameshraja, and Suresh, 2010).

However, the choice of effluent treatment process depends on several factors like efficiency, cost and environmental capability (Costa and Olivi, 2009). Also, the wastewater characteristics should also be considered when choosing the best process (Costa and Olivi, 2009). Many authors have previously reviewed the various techniques for treatment of tannery effluent (Cassano *et al*., 2001; Aravindhan *et al*., 2004). Thus; the Tannery effluent is treated in many different ways. There are situations in which a tannery applies all the aforementioned effluent treatment steps on site. In an individual tannery may apply only pre-treatment or a part pre-treatment or no treatment at all, sending the effluent to a centralist effluent treatment plant (Hayelom and Adhena 2014). Below is the description of methods for the treatment of tannery effluents.

CHEMICAL TREATMENT

Chemical tannery effluent treatment is an individual process that is employed to removesubstance that are harmful in the tannery effluent, so that it can be recycled or released into natural water sources. Several chemicals are used in different phase of the filtration process to separate out solids, harmful microorganisms' and remove dangerous toxins. Chemical compounds such as alum, ozone, peroxide and lime help to treat tannery effluent . (Hayelom and Adhena 2014).

The important chemical effluent treatment technique involves neutralizing the acid content of the water. Pure water is demand natural on the pH scale, which a measure of seven. Acidic effluent typically has a pH value lower than seven. And most be made more basic through chemical processes. Vary specific amount of basic chemicals are added to acidic tanks in order to naturalize the contents. Lime is the most commonly used base, as it is easy for specialists to measure (Hayelom and Adhena 2014).

CHEMICAL OXIDATION METHOD

Chemical oxidation technology is one of these newer technologies which use chemical oxidant (H_2O_2, O_3, ClO_2, $KMnO_4$, K_2FeO_4 and so on) oxide pollutant to slightly toxic, harmless substances or transform it into manageable form. However, Chemical oxidation technologies constitute the use of oxidizing agents such as ozone and hydrogen peroxide, exhibit lower rates of degradation. In general, Chemical oxidation allows complete elimination of the principal organic pollutants but complete removal of total organic carbon is more difficult. (Gao *et al.*, 2010, Sadeddin *et al.*, 2011, Rodrigo *et al.*, 2010, and Kılıç *et al.*, 2009). Mostly, the sulphides are removed using H_2O_2 and Electro oxidation process (Valeika *et al.*,2006; Anglada *et al.*,2009). Oxidation of sulfide by air using activated carbon as catalyst gained importance for its removal of COD, BOD and TOC in addition to elimination of sulfide in wastewater (Sekaran *et al.*, 1996). Ozone is a gas at normal pressure and temperature. Its solubility in water is function of its partial pressure and temperature. Ozone is generated by high voltage discharge in air and oxygen. Ozone is unstable and tends to react to form (Hayelom and Adhena 2014)

$$O_3 + H^+ + e^- \longrightarrow O_2 + H_2O$$

Ozone is a very strong oxidizing agent and it is very effective as a decolouration agent and as oxidant of organic material.

Advanced Oxidation Process

Advanced oxidation processes (AOPs) with the capability of exploiting the high reactivity of hydroxyl radicals in driving oxidation have emerged a promising technology for the treatment of tannery effluent containing refractory organic compounds. Several technologies like Fenton, photo-Fenton, wet oxidation, ozonation, photocatalysis, etc. are included in the AOPs and their main difference is the source of radicals. (Badawy and Ali, 2006). Among the AOPs, the most widely used technique is solar Fenton process are the most promising technologies for the treatment of tannery effluent. However, optimizing the total cost of the treatment is a challenge, as AOPs are much more expensive than biological processes alone. Therefore, an appropriate design should not only consider the ability of this coupling to reduce the concentration of organic pollutants, but also try to obtain the desired results in a cost effective process (Badawy and Ali, 2006).

COAGULATION AND FLOCCULATION

Coagulation-flocculation process is employed in separating suspended solids materials in tannery effluent (Ukiwe *et al*,. 2014). The process operate in steps which break down forces, which stabilize charged particles present in the tannery effluent allowing inter-particle collision to occur, hence, generating flocs (Haydar and Aziz, 2009). Suspended solids possess negative charge in water. Since their surface charge is the same, they tend to stabilize and repel one another when they interact with each other. The aim of coagulation/flocculation process is to destabilize the charged particles of suspended solids. Addition of coagulants with charges opposite those of the suspended destabilizes the particles charge (Jing-wei *et al*., 2007). Coagulants are added to tannery effluent to neutralize the negative charge of suspended particles. Upon neutralization, the suspended particles stick together to form slightly larger particles. For tannery effluent coagulation, rapid mixing of the coagulant is needed to achieve effective collision; this process is followed by a flocculation process where gentle mixing increases the particle size from sub-microfloc to visible suspended solids. Particles are thus bound together to produce larger macroflocs. To prevent destabilizing of macroflocs an attention is given to the mixing velocity and energy (Ukiwe *et al*,. 2014).

ELECTROCHEMICAL TREATMENT

There is a great difficulty observed in handling of huge quantum of chemicals used and toxic sludge in the chemical coagulation/flocculation processes. Safe disposal of sludge materials in the environment has become a major problem particularly in the third world country such as India, Pakistan, Bangladesh or south Asian countries (Supriyo and Debabrata, 2014). Considering the challenges, a comprehensive advance chemical treatment technology was thought for tannery effluent treatment from the real life experiences. Under this circumstances Electrochemical treatment have been emerged as the new technology in the field of tannery effluent treatment (Min *et al*., 2004). The electrochemical treatment of tannery effluent has been investigate by many researchers (Costa, and Olivi., 2009, Costa *et al*., 2008, EspinozaQui˜nones *et al*., 2009. Kongjao *et al*., 2008, Min *et al*. 2004, Sundarapandiyan *et al*., 2010) in order to improve the performance of treatment by conventional coagulation and flocculation process. It is also fact that application of different electrode materials with different electrolytic properties can affect reactor treatment efficiency (Costa, & Olivi., 2009). The removal kinetics of organic pollutants as well as nutrients showed very faster removal than biological treatment (EspinozaQui˜nones *et al*., 2009). Although Nitrogen, Phosphorus, Chromium, Arsenic and other heavy toxic metals are successfully removed by electrochemical treatment, still there is a certain limitation of applying this technology in raw tannery effluent .However electrochemical technology can successfully be applied in post treatment or final finishing stage (Supriyo and Debabrata, 2014).

ELECTROCOAGULATION (EC)

Electrocoagulation (EC) is a new trend technology that combines the functions and advantages of conventional coagulation, flocculation, and electrochemistry in tannery effluent treatment. Electrocoagulation is based on dis-solution of the electrode material used as an anode (sacrificial anode) which produces metal ions that act as coagulant agents in the tannery effluent (Holt *et al*., 2005).

Electro-coagulation system consists of an anode and a cathode made of metal plates, both sub-merged in the tannery effluent being treated (Emamjomeh and Sivakumar, 2009). The electrodes are usually made of aluminum, iron, or stain-less steel (SS), because these metals are cheap, readily available, proven effective, and less toxic (Zodi *et al*., 2008). Thus they have been adopted as the main electrode materials used in EC systems (Kumar *et al*., 2004 and Chen *et al*., 2000). The configurations of EC systems vary. An EC system may contain either one or multiple anode-cathode pairs and may be connected in either a monopolar or a bipolar mode (Emamjomeh and Sivakumar, 2009). Electrocoagulation is efficient in removing suspended solids as well as oil and greases. It has been found particularly useful tannery effluent treatment (Secula *et al*., 2011).

Electrooxidation (EO)

Study on electrooxidation for wastewater treatment goes back to the 19th century, when electrochemical decomposition of cyanide was investigated (Malakootian *et al*., 2010). Extensive investigation of this technology commenced since the late 1970s. During the last two decades, research works have been focused on the efficiency in oxidizing various pollutants on different electrodes, improvement of the electrocatalytic activity and electrochemical stability of electrode materials, investigation of factors affecting the process performance, and exploration of the mechanisms and kinetics of pollutant degradation (Ville *et al*., 2013).

The electrochemical oxidation can be achieved by the application of electricity both in direct and/or indirect form. Moreover its effectiveness strongly depends upon several factors i.e. the treatment condition, tannery effluent composition, the nature of the electrode materials used and mode of operation both in batch or continuous process .The presence of high concentrations of dissolved solids, mainly chlorides, from soak yard makes the tannery effluent particularly amenable for electrochemical treatment (Sundarapandiyan *et al*., 2010).

BIOLOGICAL TREATMENT

Biological processes are also employed as a secondary treatment option after primary treatment to remove the major portion of dissolve organics and nutrients from tannery effluent. The major types of biological processes includes aerobic, anaerobic and combine biological method which can be suitably adopted in various phases of tannery effluent treatment. The aerobic biological processes for tannery effluent treatment include activated sludge processes (ASP) Sequential batch reactor (SBR), Wetlands or stabilization pond. Out of various anaerobic processes, Anaerobic filter (AF), Anaerobic digester (AD) and Up flow anaerobic sludge blanket (UASB) are common (Lin, and Chuang 1994, Ahmed and Lan 2012).

Aerobic Biological Treatment

The principle of the aerobic biodegradation is a significant aspect of Biological treatment. This is the process where oxygen is needed by degradable organisms in their degradation at two metabolic sites, at the initial attack of the substrate and at the end of respiratory chain (Pedro and Walter, 2006). Oxygenases and peroxidases could be produced by the Bacteria and fungi which could help with the pollutant oxidization and get benefits from observing the energy, carbon and nutrient elements released during this process. In general, a huge number of bacteria and fungi possess the capability to release non-special oxidase and degrade organic pollutants (Pedro and Walter, 2006). There are two types of relationships between the microorganism and organic pollutants; that is the microorganisms use organic pollutant as sole source of carbon and energy, and the microorganisms use a growth substrate as carbon and energy source, while another organic compound in the organic substrate which could not provide carbon and energy resource is also degraded (co-metabolism). The classic aerobic biodegradation reactors include activated sludge reactor and membrane bioreactor (Lin, and Chuang 1994, Ahmed and Lan 2012).

Activated sludge reactor

Many researchers have investigated the Treatment of tannery effluent using activated sludge process (Jawahar *et al*., 1998; Murugesan and Elangoan, 1994; Eckenfelder, 2002; Tare *et al*., 2003). Activated sludge is a process for treating sewage and industrial effluent using air and a biological floc composed of bacteria and protozoans. This technique was invented at the beginning of last century by Ardern and Lockett and was considered as a technique for treatment of effluent and waste water for larger cities as it required a more sophisticated mode of operation (Wu *et al*., 2003). Oxygen or air is introduced into a mixture of primary treated or screened effluent combined with organisms to develop a biological floc which reduces the organic content of the sewage, which is largely composed of microorganisms such as saprotrophic bacteria, nitrobacteria and denitrifying bacteria. The organic pollutant could be degraded with this biological floc, and bio-transform the ammonia in the effluent. In general, the process contained two steps, viz; adsorption and biological oxidation. The technique could effectively remove the organic matters, nitrogeneous matters, phosphate in the effluent, when there is enough oxygen and hydraulic retention time. However, the effluent is always short of oxygen, which could cause sludge bulking. The oxygen concentration could be increased by including aeration devices in the system, but research need to be done to find out the optimal value since aeration would cause an increase of the costs of the wastewater treatment plants. Also, the excess activated sludge, and the by-product of this process need to be dealt with by researchers, with a relatively less expensive (Lin and Chuang 1994).

Membrane bioreactor

Membrane bioreactor (MBR) is the combination of a membrane process like microfiltration or ultra filtration with a suspended growth bioreactor, and is now widely used for municipal and tannery effluent treatment (Chung *et al*., 2004). The Principle of this technique is nearly the same as activated sludge process, except that instead of separation the water and sludge through settlement, the MBR method uses the membrane which is more efficient and less dependent on oxygen concentration of the water. The MBR has a higher organic pollutant and ammonia removal efficiency in comparison with the activated sludge process. Besides, the MBR processes is capable to treat effluent with higher suspended solids (SS) concentrations compared to activated sludge process, thus reducing the reactor volume to achieve the same loading rate (Munz *et al*. 2007). Frequent membrane cleaning and replacement is therefore necessary, but it significantly increases the operating cost (Ahmed and Lan 2012).

Anaerobic Biological Treatment

The treatment of tannery effluent anaerobically, is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen. The principle of the anaerobic treatment is as follow; the insoluble organic pollutant breaks down the insoluble substances, making them available for other bacteria, the acidogenic bacteria convert the sugars and amino acid into carbon dioxide, hydrogen, ammonia and organic acid; and then the organic acids convert into acetic acid, ammonia, hydrogen and carbon dioxide; and finally the methanogens convert the acetic acid into hydrogen, carbon dioxide and methane, a kind of gaseous fuel (Pedro and Walter, 2006).

The process of anaerobic degradation has a limitation of being slow and inefficient compared to aerobic degradation. However, the anaerobic degradation not only decreases the COD and BOD in the effluent, but also produces renewable energy. Furthermore, anaerobic processes could treat the effluent with high loads of easy-to-degrade organic materials (effluent from the sugar industry, slaughter houses, food industry, paper industry, and tanning industry) efficiently and costly. These advantages make investigation and application of anaerobic microbial mineralization in tannery effluent important. Anaerobic reactor could be divided into anaerobic activated sludge process and anaerobic biological membrane process. The anaerobic activated sludge process includes conventional stirred anaerobic reactor, up flow anaerobic sludge blanket reactor, and anaerobic contact tank. The anaerobic biological membrane process includes fluidized bed reactor, anaerobic rotating biological contactor, anaerobic filter reactor. Up flow anaerobic sludge blanket reactor and anaerobic filter reactor are selected as the representative of the two kinds of reactors mentioned above.

Up flow anaerobic sludge blanket reactor (UASB)

The UASB system was developed in 1970s. No carrier is used in the UASB system, and effluent moves upward through a thick blanket of anaerobic granular sludge suspended in the system. Mixing of sludge and effluent is achieved by the generation of methane within the blanket as well as by hydraulic flow. And the triphase separator (gas, liquid, sludge biomass) could prevent the biomass loss of the sludge through the gas emission and water discharge. The advantage of this system are that 1) it contains a high concentration of naturally immobilized bacteria with excellent settling properties, and could remove the organic pollutants from tannery effluent efficiently; 2) a high concentrations of biomass can be achieved without support materials which reduces the cost of construction. These advantages would increase the efficient and stable performance of this system (Leitinga and Hulshoff, 1991).

Anaerobic bio-filter

Anaerobic biofilter, is a kind of high efficient anaerobic treatment equipment developed in1960s. These reactors use inert support materials to provide a surface for the growth of anaerobic bacteria and to reduce turbulence to allow unattached populations to be retained in the system

The advantages of this system are as follow:

1). the filler provides a large surface area for the growth of the microorganisms, and the filler also increases hydraulic retention time of the effluent;

2). the system provides a large surface area for the interaction between the wastewater and film;

3). the fact that microorganisms grow on the filler reduces the run of the degraders. These advantages could increase the efficiency of this treatment of the tannery effluent.

The limitation of this system is that the system could be blocked when dealing with high concentration organic water, especially in the water inlet parts (Kassab *et al*., 2010).

Combination of the Aerobic and Anaerobic Biological Treatment

Compared with the single anaerobic and aerobic reactors, the combination of the anaerobic and aerobic reactor is more efficient in tannery effluent treatment. The advantages of the combined system are as follow: 1) the anaerobic process could get rid of the organic matters and suspended solid from the tannery effluent, reduce the organic load of the aerobic degradation as well as the production of aerobic sludge, and finally reduce the volume of the reactors; 2) Tannery effluent pre-treated by anaerobic technology is more stable, indicating that anaerobic process could reduce the load fluctuation of the effluent, and therefore decrease the oxygen requirement of the aerobic degradation; 3) the anaerobic process could modify the biochemical property of the tannery effluent, making the following aerobic process more efficient. Investigation showed that the tannery effluent from aerobic-anaerobic combined reactor are more stable and ready for degradation, indicating that this technical have a huge potential for application. The classic aerobic-anaerobic reactors include A/O reactor, A2/O reactor, oxidation ditch, constructed wetland. Two classic aerobic biodegradation reactors, oxidation ditch and constructed wetland are introduced (Kassab *et al*., 2010).

Oxidation ditch

The oxidation ditch is a circular basin through which the effluent flows. Activated sludge is added to the oxidation ditch so that the microorganisms will digest the organic pollutants in the effluent. This mixture of raw effluent and returned sludge is known as mixed liquor. The rotating biological contactors could add oxygen into the flowing mixed liquor, and they could also increase surface area and create waves and movement within the ditches. Once the organic pollutant has been removed from the tannery effluent, the mixed liquor flows out of the oxidation ditch. Sludge is removed in the secondary settling tank, and part of the sludge is pumped to a sludge pumping room where the sludge is thickened with the help of aerator pumps (Peng *et al*., 2008). Some of the sludge is returned to the oxidation ditch while the rest of the sludge is sent to waste. The oxidation ditch is characterized by simple process, low maintain consumption, steady operation, and strong shock resistance. The effluent of the system has high water quality effluent with low concentration of organic pollutants, nitrogen and phosphorus. However, the problems of this reactor, such as sludge expansion, rising sludge and foam, are important factors which confines the development of this technique (Pery *et al*., 2008).

Constructed wetland

A constructed wetland is an artificial wetland which could act as a biofilter, removing sediments and pollutants such as heavy metals and organic pollutants from the tannery effluent. Constructed wetland is a combination of water, media, plants, microorganisms and other animals. Constructed wetlands are of two basic types: subsurface-flow and surface flow wetlands (Mook *et al*., 2012). Physical, chemical, and biological processes combine in wetlands to remove contaminants from tannery effluent. Besides absorbing heavy metals and organic pollutants on the filler of the constructed wetland, plants can supply carbon and other nutrients such as nitrogen through their roots to for the growth and reproduction of the microorganisms. Plants could also pump oxygen to form an aerobic and anaerobic area in the deep level of constructed wetland to assist the breaking down of organic materials. The major reactor in constructed wetland was supposed to be microorganisms, and microorganisms and natural chemical processes are responsible for approximately 90 percent of pollutant removal, while, the plants remove about 7-10 percent of pollutants (Calheiros *et al*., 2008).

As an economical, easy management and ecological friendly reactor, constructed wetland is supposed to be a promising technique to treat the effluent in developing country. However, this technique was not widely used up till now for the following reasons;

1) The plants couldn't adapt to heavy contaminated tannery effluent, which strikes its application scope;

2) The device of this technique demands large area of land;

3) The efficiency of this device relativity lower than other biological device such as activated sludge process and membrane bioreactor.

Thus, efforts should be made in plants selection, device structure modification and multiple devices combination to enhance the adaption and efficiency of this technique (Calheiros *et al*., 2008).

Physical Tannery Effluent treatment

A physical tannery effluent treatment process does not involve any chemical components or biological material to treat .The tannery effluent can be screened to filter out large object. It can also be treated by means of sedimentation, during which solids settle to the bottom under the effluence of gravity, then the water can be removed (Angkawisttpan and Manasri 2002). There methods of physical tannery effluent treatment are Mechanical treatment, Post-purification, and sedimentation a Sludge handling.

In order to carry out effluent treatment in the most effective manner, flow segregation is useful to allow preliminary treatment of concentrated wastewater streams, in particular for sulphide- and chrome-containing liquors. And although a reduction of water consumption does not reduce the load of many pollutants, concentrated effluents are often easier and more efficient to treat. Where segregation of flows is possible, thorough mixing of chrome-bearing effluents and other effluent streams improves the efficiency of the effluent treatment plant because the chromium tends to precipitate out with the protein during pretreatment (Jalandhar 2008).

Mechanical treatment

Usually the first treatment of the raw effluent is the mechanical treatment that Includes screening to remove coarse material. Up to 30-40% of gross suspended solids in the raw waste stream can be removed by properly designed screens. Mechanical treatment may also include skimming of fats, grease, oils and gravity settling (Frankfurt 2002).

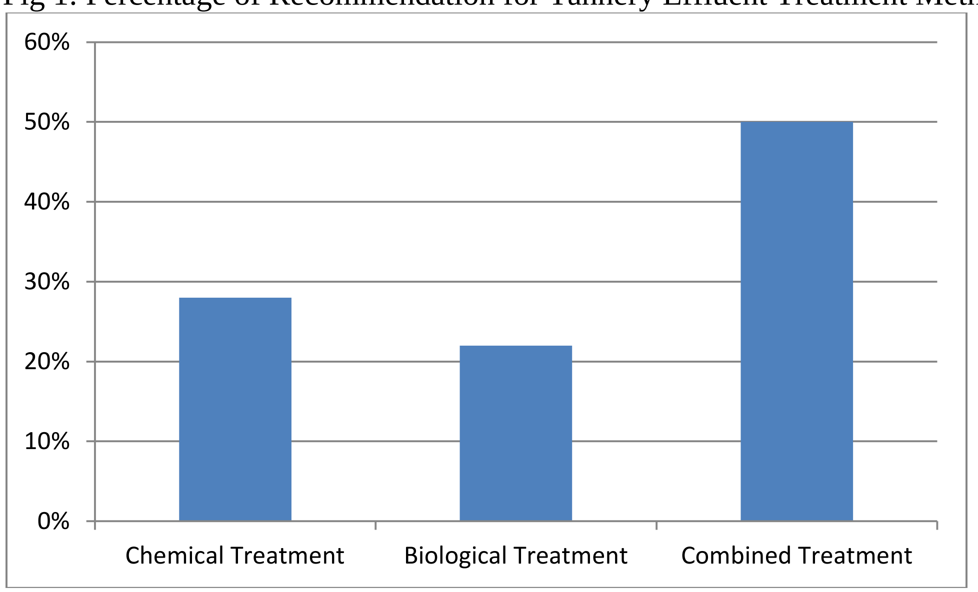
Post-purification, sedimentation and sludge handling

The main objective at this stage is the removal of suspended solids; however, various constituents such as fats, waxes, mineral oils, floating non-fatty materials, etc. ("grease"), not already removed in the grit-and oil chamber (usually positioned between screening and equalization), are also separated here (Buljan and Kral, 2011). Post-purification, Sedimentation and sludge handling are the last step in effluent from the water phase by gravity settlement. After dewatering this sludge by means of filter presses, a sludge cake with up to 40% dry solids can be achieved, whereas belt presses produce a sludge cake with up to 20-25% dry solids (Frankfurt, 2002., and Aravindhan, et al., 2004).

DISCUSSION

In addition to various methods related to tannery effluent treatment. It was our interest to see the percentage of recommendation of each method of a given number of articles reviewed. The result of the said recommendation percentage for the tannery effluent treatment methods is shown in figure 1 where the most recommended method is combined treatment method.

Fig 1: Percentage of Recommendation for Tannery Effluent Treatment Methods



CONCLUSION

This paper reviewed all of the above tannery effluent treatment processes. it is not possible to distinct which process is the best solution to tannery effluent treatments, among the few set of data found in this literature, however, much effort will gain more audience to increase data in the future. It is affairs that combine treatment options is the promising treatment option when compared with chemical or biological processes alone.

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