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Designing of a Plant for Treatment of 500m^3 per Day Leather Tannery Effluent

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Abstract

With rising concerns of water scarcity and fast pace of industrialization of urban and rural land, it is immensely important to conserve, recycle and reuse water resources to manage the aqua demands of growing society. Chemical industry specifically textile industry is presumed to be one of the major contributors to the water pollution. Major pollutants which are of carcinogenic nature have been discussed in the chapter above. With time, advance research is being carried out in the field of water treatment. Some of the major techniques used in industry have been discussed briefly in the chapter. As Chemical engineers we aim to devise an economical and practical waste water treatment plant design to limit the hazardous effects caused by effluents of leather industry. We aim to bring the concentration of textile effluents under the bar set by WHO (World Health Organization) and UNEP (United Nations Environmental Pr; K\\; Kogram). Like many other industrial sectors a developing country like Pakistan need \= lot of research and progress in areas of water recycling, reuse and treatment technologies.

Keywords: Tanning; Leather; Inorganic salt; Hazardous

Introduction

Tanning is a commercial process of treating skins and hides of animals by using inorganic salt to produce leather. During this process, the protein structure of skin completely changes. Decomposition does not happen during this process. First of all, hair, grease and salt are removed from the skin and it is soaked into saline water for a period of 6 hrs to 2 days. Tannin (acidic chemical compound) and chromium solutions are used in this process. Pakistan tanners association (PTA) is regulatory body in Pakistan to manage the leather industries. In Pakistan, there are almost 800 leather units including 213 tanneries working on large scale. This industry currently employs 50,000 labour and it contributes 5% GDP and 5.4% of overall exports. Mostly tanneries donot treat their effluents and send their efluents as it is to the surroundings and environment. Chromium salt is required to be removed from the effluent of tanneries as most of the chromium salt remains unreacted after the process.

Figure 1: Export areas by courtesy of Pakistan tanners association.

Majority of pollutants in effluent are inorganic nature. Suspended and dissolved solids, chlorides, sulphides and alkalinity are important constituents of tannery effluents. Effluents from tannery units contain tanning agents which exert high oxygen demand. High amounts of proteins are also present due to dehairing processes; these proteins can be degraded biologically but exert high BOD. Chlorides, Chromium (III), ammonium salts, phosphorus etc. are in organic pollutants present in significant quantities. Known for its carcinogenic properties, hexavalent chromium is also a fertilization toxin. Direct or indirect exposure to hexavalent chromium includes side effects such as asthma, eye irritation, perforated ear drums, respiratory system complexities, hepatic and renal damage, pulmonary congestion and edema. The hazardous nature of chromium demands a safe way of handling, usage and storage so that its adverse effects can be minimized. At local level industry safety precautions are not taken seriously thus imposing serious environmental and health hazards to the labor at work and residential colonies near work site. Amphoteric exchangers also exist which have an ability to exchange cations and anions at the same time. This procedure of ion exchange has vast applications in food and beverage industry, nuclear waste treatment, hydrometallurgy, chemical, petrochemical, pharmaceutical industry and Industrial waste water treatment units. Most of the ions exchange units work on cycle basis. It also has essential applications in preparation for pure water for electricity production purposes, as the ions present in water may cause scaling in the boilers while steam generation process This facility of waste water treatment is based on activated sludge. This system comprises of numerous settling tanks with large surface areas. Biomass is grown as bio films and introduced in settling tanks with a residence time of 24 hours-7 days.

Research advancements are being made in continuous fed systems thus future is promising for this technology too. Anaerobic digestion involves microorganisms breaking down complex organic compounds in absence of oxygen. The process has wide applications at industrial and domestic level to treat, manage and reserve water. The process initiates with bacterial hydrolysis of the input materials. Trickling filter for waste water treatment has been used successfully for water

treatment at industrial scale. A bed of filter media is prepared to which micro-organisms attach and grow to form a layer known as Biofilm. It is also called fixed-film process. Generally a community of different microorganisms such as bacteria, fungi, yeast forms the biofilm. Desalination is used to remove dissolved solids and mineral content from water. Water from brackish, sea water, saline wells, lake and rivers may by desalinate for domestic and agricultural consumption. High energy consumption makes this process unsuitable for larger scale. Depletion of reserves is also a factor considered critically before expanding this process at industrial scale. 15,000-20,000 desalination plants in world produce more than 20000 m^3/day. A process by which suspended particles are made to floc together (bind together) by chemical action of flocculating agents. The flocs formed then can easily be separated by process of filtration. All flocs are in form of suspension so no cake is formed. This very procedure of waste water treatment utilizes semi-permeable membrane to eliminate ions, molecules and other suspended particles form the water mass. One of the major disadvantages of reverse osmosis process that makes it quite not a feasible option for industrial is scale is that it recovers only 75% of water that inters in form of feed as a finished product thus increase process cost. Due to the mesh size of membranes used, this process may also remove desirable minerals from water thus producing ultra-pure water which is not recommended in any case. The process of preparing waste water from (targeted sources) to be treated chemically in secondary treatment process. This comprises of removal of grit, debris, larger particles which are subjected to harm the equipment installed. If the waste water is deficient in minerals for treatment (Biological waste treatment), minerals shall be added at this particular stage. Biodegradable, dissolved and colloidal organic matter using aerobic biological treatment processes are exercised in this treatment segment. Aerobic biological treatment is carried out in the presence of oxygen by aerobic-microorganism (principally bacteria) that carry out the process of metabolization of organic matter in waste water, therefor it produces organic decomposers and inorganic end products usually termed as waste of organic compounds. With rising concerns of water scarcity and fast pace of industrialization of urban and rural land, it is immensely important to conserve, recycle and reuse water resources to manage the aqua demands of growing society.

Research Methodology

Feed from tanneries first pass through a screen. The size of the screen is 30 mm and it is used to retain coarse material. The materials that are usually retained are flesh, hair, globular protein or anything that has a diameter greater than 3 cm is retained while rest is passed along to the next equipment. This is a unit operation and does not involve any chemical reaction.

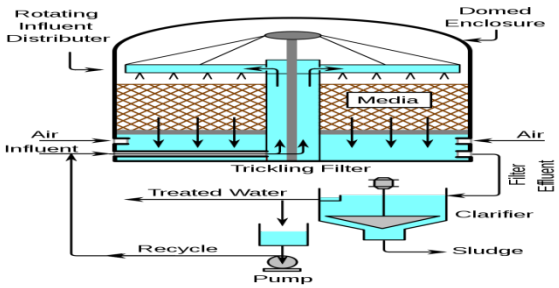

Figure 2: A typical complete tricking filter system for water treatment

This is also an elongated application of above mentioned procedures. An MBR (membrane bio reactor) is made up of micro filtration and ultrafiltration of biological waste treatment. One of the most worked upon drawback of this system is that efficiency of membrane declines with time due to reduced microbial activity. Intensive research has been carried out to minimize membrane fouling. Desalination is used to remove dissolved solids and mineral content from water. Water from brackish, sea water, saline wells, lake and rivers may by desalinated for domestic and agricultural consumption. High energy consumption makes this process unsuitable for larger scale. Depletion of reserves is also a factor considered critically before expanding this process at industrial scale. 15000-20,000 desalination plants in world produce more than 20000 m^3/day. This is a batch reactor in which doses of magnesium oxide is added along with the effluent. Chromium ion reacts with magnesium oxide in the presence of water to form chromium hydroxide which is insoluble and will precipitate and sink at the bottom. Since chromium is used in the tannery process it must be recovered so it can be reused. The chromium oxide collected from the chrome recovery unit is reacted with sulfuric acid to form chromium sulfate which is used extensively in the tannery process. The effluent is now under standard limit and is ready to be drained.

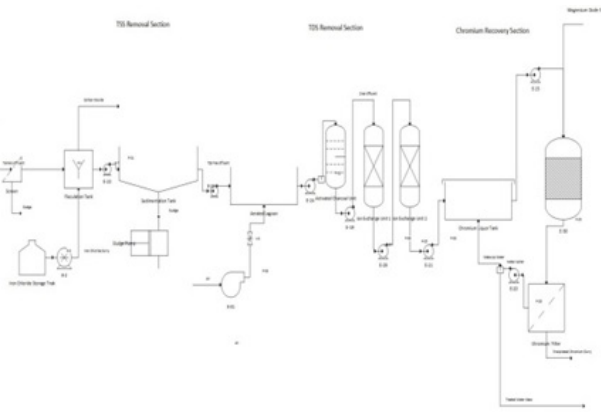

Figure 3: Flow sheet.

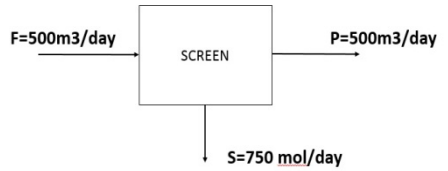

Figure 4: Material balance.

Results and Discussion

The basic material balance equation was employed in performing the calculations to find out the number of moles of various unknown quantities and the flow rate of the streams as well.

Equation is given as follows:

(In–Out)+(Generation–Consumption)=Accumulation

The equation was reduced to simple terms in respected equipment when performing the calculations. Material balance was done for specific equipment since the feed contained various compound and elements as well. Feed composition of water was taken from Environmental Pollution and Control in Chemical Process Industries by Bhatia at al. The treatment of feed resulted in a composition that was in accordance with the standards of World Health Organization. Calculations around some equipment have been shown below. The controller is the heart of control system and its job is to compare the process signal from the transmitter with the set point and to send an appropriate actuating signal to the control valve. The controller is usually located on a panel in the control room that is at some distance from the process equipment.

Electronic devices are used when the control room is located a long distance from the process equipment and when rapid transmission of signals is required. In pneumatic systems the transmitter is connected with controller and controller to the valve. This represents a dynamic lag in the control loop. Pneumatic systems are most widely used by chemical engineers due to their ease of usage.

Conclusion

Tanning of leather is carried out by using inorganic salt resulting in the finishing product called leather. The process involved change of protein structure of skin completely. This process stops the elimination of the odor and stops the decomposition. Before starting the process, Greace, hair and salts are removed from the skin and soaked the skin into saline water for 2 days. Chromium and acidic chemical compound (Tannim) are used for leather tanning. Pakistan tanners association is a body of all tanneries managements. Rest of the TSS are removed in the flocculator. Iron(III) chloride was employed as the flocculating agent. Stream composition is shown below. Amount of FeCl3 needed was calculated using the solubility of the compound in water. The Ion Exchange Unit removed the dissolved solids present in the form of ions. In the first unit, chlorides and sulfates are removed using a cationic resin bed.

Reactions occurring are as follows:

$Cl^- + ROH \rightarrow RCl + OH^-$

$(SO_4)^{2-} + 2ROH \rightarrow R2SO_4 + 2OH^-$

Moles of chloride ions entering=63380.38 moles

Moles of chloride ions leaving unit =(2x 617.25)/35.5=34.77 moles

Moles of sulfate ions entering=104.17 moles

Moles of sulfate ions leaving unit=(2x 617.25)/96=12.85 moles

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