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Current Technologies for Degradation of Distillery Wastewater - methods and techniques- A review

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Abstract: Large volumes of wastewater with a high organic content that are pigmented and acidic are produced by distilleries. Melanoidin, a class of high molecular weight organic molecules, is primarily responsible for the dark brown color of wastewater from distilleries. The release of wastewater into the environment carries a high risk of pollution It also lessens sunlight penetration in rivers and lakes, which in turn lowers photosynthetic activity and dissolved oxygen concentration. It follows that one of the most important environmental challenges is how to dispose of this liquid waste. Traditional methods of treating distillery wastewater - chemical, physical, and biological treatment have the drawbacks of being expensive, requiring a lot of energy and producing secondary pollution in the process. The highly reactive hydroxyl radicals produced by light-enhanced oxidation processes oxidize organic materials in solution and transform it entirely into harmless products like CO_2 and inorganic molecules. This study reviewed the use of TiO_2 as a photocatalyst in the photocatalytic degradation in aqueous solution under UV and solar light. Degradation is shown to be dependent on a number of factors, including pH, catalyst concentration, substrate concentration, and oxidants presence. Additional factors influencing the degradation are reaction temperature and light intensity

Keywords: Distillery effluent, Melanoidin, Pollution, Advance Oxidation Process,Wastewater treatment

I. INTRODUCTION

Around 80% of the raw material used in distilleries is released into the environment as spent wash, a massive amount of waste water . The kind of raw material used and the treatments applied before the effluent is released into the environment might affect the physico-chemical properties of distillery effluent. High levels of chemical and biological oxygen demand (BOD and COD), phenolic compounds, sulfates, heavy metals, intense brown color, low pH, unpleasant odor, high electrical conductivity (EC), and high levels of inorganic and organic salts are typically characteristics of distillery effluents. (Susheel et al.).Most often, local water and land bodies receive the wastewater from distilleries. Higher levels of foreign materials, such as heavy metals and hazardous metals, are introduced by effluent. Photocatalytic degradation performance is highly related to optimized operating parameters such as initial concentration, pH value, and catalyst dosage. In this study, the impact of various parameters on the photocatalytic degradation of anaerobically digested vinasse (AnVE) has been determined through decolourization and chemical oxygen demand (COD) reduction efficiency using zinc oxide (ZnO) photocatalyst [1]

II. POLLUTION REDUCTION AT SOURCE

The initial phase, or the first procedure if we can stop waste water from being produced or reduce pollution at the source itself, is prevention or reduction of the pollutant at the source. This decrease applies to both the amount of waste water produced and the pollution load. Therefore, we are saving a lot of water or a lot of contaminated water from being produced if we can reduce the amount of wastewater we are producing, say, from 100 units to 20 or 30 units. Reducing the pollutant load will allow for the recovery of usable byproducts once the contaminants are removed from the wastewater streams, which is the real treatment stage. Wastewater can then be used for reuse or recycling.

III. CHARACTERISTICS OF DISTILLERY WASTEWATER

Organic wastewater with a medium to high strength is what distillery effluent is described as. The effluents from distilleries that use molasses, also known as spent wash, stillage, slop, or vinasse, are typically acidic and contain a significant amount of wastewater with a dark brown color.

The raw material utilized determines the effluent's characteristics; also, 88% of the components of molasses are thought to be wasted. Furthermore, low molecular weight substances such lactic acid, glycerol, ethanol, and acetic acid are present in cane molasses effluent. Distillery effluents are typically brown in color, acidic, and include a high concentration of organic materials, which vary according on the raw material distilled. Because of their high organic content and acidic nature, distillery wastewaters can seriously pollute the environment.Wastewater from wine distilleries has a low pH of 3.5 to 5.0, which is harmful to aquatic life. Distillery spent wash has high temperature,dark brown color and high chemical and biochemical oxygen demands (80,000–100,000 mg/Land 40,000–50,000 mg/L, respectively). [2] In addition to contaminating the water, the distillery's foul-smelling effluent reaches several kilometers in all directions. If untreated or inadequately treated sewage is released into land, it renders the area unusable. Environmental concerns are now one of the key elements limiting the expansion of the distillery sector.[3]Melanoidins' potential to induce glycation processes which are linked to the development of a number of disorders, including Alzheimer's disease, diabetes mellitus, and cardiovascular problems, has been studied in relation to potential health risks.

IV. CHEMICAL METHODS FOR DISTILLERY INDUSTRY EFFLUENT TREATMENT

ELECTROCHEMICAL TECHNOLOGY

An appealing and practical method of treating industrial wastewater is electrochemical technology. This technology's key advantages over other traditional methods are its affordability, versatility, simplicity in automation, compatibility with the environment, energy efficiency, selectivity, and low maintenance costs. Wastewater and industrial effluent can be treated economically with electrochemical methods. The use of electrochemistry to remediate environmental pollution has been studied recently, with several studies looking into how well electrochemical devices can destroy organic compounds found in wastewater. A variety of electrochemical methods, including electrocoagulation, electrooxidation, electrodeposition, electro flotation, electrodialysis, electro flocculation, electrophoresis, and electroreduction, are taken into consideration for the treatment of industrial effluent. One type of AOP is electrochemical oxidation, which is the oxidation of organic molecules via the action of energy carried by electron flow. Organic substances undergo oxidation at the anode and reduction at the cathode of an electrolytic cell when an external current is applied [4-5]..

CHEMICAL PRECIPITATION

Ionic components are removed from water by chemical precipitation, which involves the addition of coagulants such lime, alum, iron salts, and other organic polymers to decrease the solubility. It is mostly used to remove metallic anions and cations, such as phosphate, cyanide and fluoride. This process eliminates organic compounds like phenols and aromatic amines. The biggest disadvantage is that the procedure produces a lot of sludge that contains hazardous chemicals.

CHEMICAL COAGULATION

Coagulation is the use of chemicals to cause pollutants to agglomerate and subsequently settle out during sedimentation. All surface water sources and industrial effluent contain perceptible turbidity. The plain sedimentation is not a very preferred method for the removal of smaller suspended particles. Efficient removal of particles less than 50 m in diameter cannot be expected. However, small colloidal particles can be removed by agglomeration of particle into groups, which increase the size, and are able to settle down . The colloids are separated from each other by zeta potential between colloids having negative charges. When coagulants are added, it reduces the zeta potential which causes of colloids and form large particles (flocks). The pollutants are also entrapped

ELECTRO COAGULATION

Electro-coagulation involves consumption of metal from the anode with simultaneous formation of hydroxyl ions and hydrogen gas occurring at the cathode . This process has been proposed since 100 year back for wastewater treatment It is capable to remove a large range of pollutants under a variety of conditions ranging from suspended solids and heavy metals . In Third Australian Environmental Engineering Research Conference discussion had taken place on application of electro-coagulation technique for castle maine, petroleum products, colour from dye-containing solution; aquatic humus and defluorination of water treatment. In the process pH, pollutant type and concentration, bubble size, position of electrode, floc and agglomerate size all influence the operation of electro-coagulation unit

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ION EXCHANGE

Here metal ions of dilute solutions get exchanged with ions held through electrostatic forces on exchange resin. Using this method, copper is transferred onto a cation resin by passing the wastewater via an ion exchange column. Similar to adsorption, the wastewater must be settled or filtered to remove suspended particles and organics before proceeding with ion exchange. It could be necessary to lower the pH in order to extract the copper from the organics before filtering, as any copper that is linked to them will gather in the sludge.The resin is renewed with acid when the ion exchange capability is depleted. The regeneration effluent can then be used to electrolyze the copper out of it by passing it through a plating cell. The benefit of this procedure is that solid copper, a marketable byproduct, is produced. Both the regenerated effluent following the plating cell and the effluent from the ion exchange column during the service run will have low pH levels and need to be adjusted before being released. Many distilleries have successfully implemented ion exchange systems.[6]

V. PHYSICAL METHODS FOR DISTILLERY INDUSTRY EFFLUENT TREATMENT

ADSORPTION

Adsorption is widely employed for the removal of colour and specific organic pollutants due to its extended surface area, microporous structure, high adsorption capacity and high degree of surface reactivity. In Distillery Waste Water treatment, the interface is between the liquid and solid surface that are artificially provided. The material removed from the liquid phase is called the adsorbate and the material providing the solid surface is called the adsorbent. Adsorption process is generally considered better in water treatment because of convenience, ease of operation and simplicity of design. Further this process can remove/minimize different types of organic and inorganic pollutants from the water or waste water and thus it has a wider applicability in water pollution control. This process has been also found successful in removing harmful parameter like COD and color from Distillery Wastewater. To remove the air pollutant for air adsorption process is also applicable. The effect of powdered activated carbon (PAC) on the operation of a membrane bioreactor (MBR) for the treatment of Distillery Waste Water has been also reported

MEMBRANES TECHNOLOGY

This process improves the efficiency of anaerobic process because various inhibiting substance are removed during membrane treatment Sometimes reverse osmosis is also employed for treatment of distillery wastewater. After anaerobic process reverse osmosis is employed for removal effiency of color and COD. Microfiltration is a pressure driven membrane process. For removing heavy metals this process use porous membranes . In this process filtration of a colloidal suspension or other fine particles of dimension roughly 0.02 µm to 10 µm is done. In ultra filtration the only difference is in particle size which lies in the range of 0.15 µm to $5x10^{-2}$ µm . The main drawback of both the processes are generation of sludge. Nanomembranes, also known as nanofiltration membranes, are water filtration and contamination resistant membranes created using nanofabrication technology . It can be divided into two categories based on structure: mixed matrix membranes and thin-film nanocomposite membranes . In order to improve the permeability potential, catalytic reduction, and suppression of membrane fouling, nanoparticles were primarily used in the synthesis of the membranes. It was beneficial in a number of respects, including simple production, inexpensive manufacturing, low energy consumption, minimal space requirements, effective remediation, and higher rejection rates to organic low molecular weight compounds and multivalent ions [7-8].

VI. ADVANCED OXIDATION PROCESSES IN HYBRID FORM

The use of advanced oxidation processes (AOPs) to handle materials with low biodegradability and high chemical stbility has shown great promise. When chemicals in industrial effluents are treated with AOPs, inorganic compounds, water, and CO2 can be produced. Furthermore, biodegradable intermediates may arise as a result of a biodegradable organic pollutant partially degrading.

AOPs can be produced in two different ways: either by oxygen oxidation or by using high-energy oxidants like O3 and H2O2, which help produce •OH radicals. Free •OH interacts with organic molecules in solution as a strong nonselective chemical oxidant. Usually, AOP is run at pressures and temperatures that are similar to ambient. Photocatalysis (TiO_2/UV; photo-Fenton reactions), chemical oxidation (O_3, O_3/H_2O_2, and H_2O_2/Fe^{2+} and photochemical degradation processes (UV/O_3; UV/H_2O_2) are examples of AOPs utilizing various reagent systems.[9]

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CLASSIFICATION OF ADVANCED OXIDATION PROCESSES (AOPS)

Figure 1 describes various types of AOPs. AOP also can be generally classified into two categories, namely, homogeneous and heterogeneous processes.

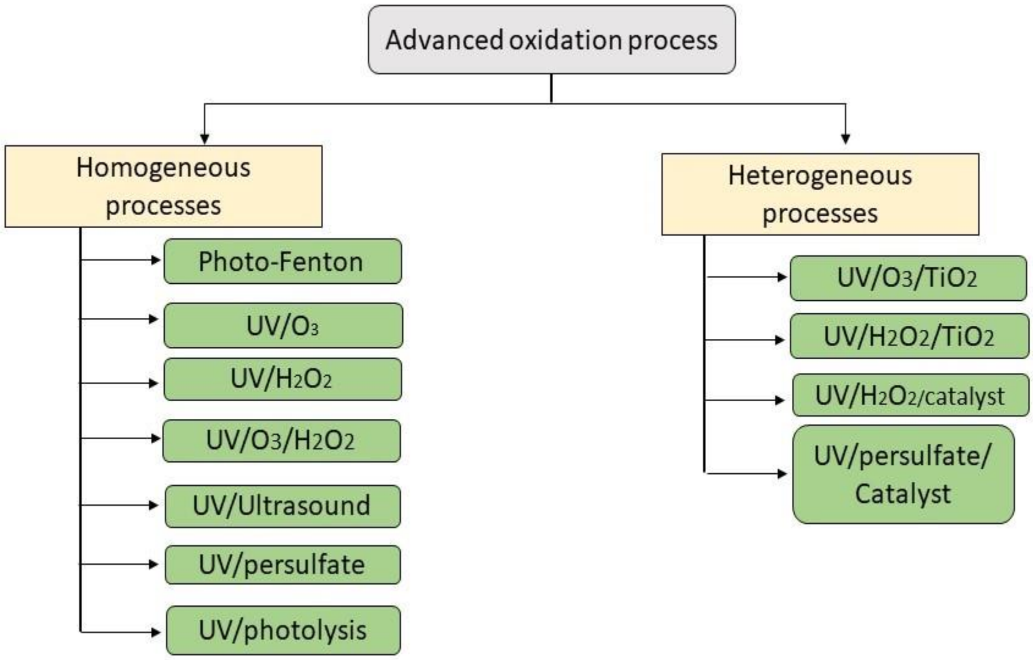

Figure 1. Classification of Advanced Oxidation Processes (AOPs).

HOMOGENEOUS AOP

Energy from light is used by homogeneous processes. Some of the most popular techniques for degrading pollutants are microwave radiation, electrical energy, ultrasonic sonolysis, and ultraviolet radiation. The homogeneous AOPs make up the majority of all AOPs. Because of the Fe^{+3}/Fe^{+2} cycle, homogeneous AOPs include the well-known (photo)Fenton, as well as electrochemical oxidation, photolysis, and the utilization of H_2O_2/UV and O_3/UV. When utilizing organic molecules as photocatalysts (also known as photosensitizers), homogeneous photocatalysis is another documented homogeneous AOP. These materials' primary benefit still lies in their capacity to absorb UV-visible light, making use of solar radiation. These materials might be present in greywater naturally and could hasten the organic matter's deterioration. Humic fulvic acids and organic dyes , such as riboflavin or triphenilpyrilium salts , are a few examples of homogeneous photocatalysts/photosensitizers. These substances have the potential to produce reactive oxygen species, including singlet oxygen, but they can also encourage photo-induced electron transfer, which takes an electron out of the pollutants and produces oxidized radicals made of the contaminants (photoredox process). These radicals might then carry on breaking down until they approach mineralization.

HETEROGENEOUS AOP

Heterogeneous photocatalysis, on the other hand, is seen to be a promising, practical, affordable, and environmentally acceptable method of addressing the issues related to the removal of hazardous substances from the environment. Based on the creation of redox species, photocatalytic technologies were developed to improve the breakdown of persistent pollutants. The photocatalytic reaction process is based on the absorption of incoming photons by a photocatalyst and the subsequent production of electrons and holes in the conduction and valence bands. It is postulated that more electrons were driven from the valence band (VB) to the conduction band (CB) when TiO_2 NPs were exposed to UV irradiation, which led to the creation of more positively charged holes (by h^+) on the surface. Excitons e^- and h^+ pairs are produced when electrons migrate to the conduction band (CB) and leave vacancies in the valence band. Super-oxide anions are produced when the activated electrons are taken up by the oxygen molecules that have been adsorbed on the surface Hydroxyl-radicals (OH) are created concurrently by the holes created by the process of oxidizing H_2O and OH molecules on the surface of the photocatalyst. With extremely high standard potentials (E^o (OH /H_2O) = 2.80 V), OH radicals are remarkable oxidizing agents that may oxidize any organic pollutants.

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VII. BIOLOGICAL TREATMENT

The biological treatment of distillery wastewater, such as the use of microalgae, demonstrates the technology's potential for promoting environmental greenness and its applicability for use in environmentally friendly technical approaches. Among the most productive creatures on the planet are microalgae. As a food source, the cellular organism known as microalgae has several benefits over higher plants, not to mention a very high potential commercial value. In addition, CO_2 sequestration and waste treatment by biochemical oxidation offer further benefits. [10]

VIII. CONCLUSION

Based on the current study, it can be inferred that distillery waste wash has a significant concentration of contaminants. The effluent exhibited a dark brown color, was turbid, and smelled strongly of alcohol. It also had a low concentration of dissolved oxygen and high levels of BOD, COD, electrical conductivity, total dissolved solids, and severely acidic pH. There are reports of physical and chemical characteristics that are greater than the irrigation-permissible limits. To reduce its impact on wildlife and vegetation, distillery spent wash generally needs to be cleaned before being released into water or land.

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