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Review Paper

Study on the process and waste management of the edible oil industry

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Abstract

Augmented demand for edible oil in the world has resulted in the founding of many edible oil industries leading to the generation of enormous amounts of pollutions including waste, wastewater, and air. These pollutants if release into the environment leads to serious problems including human health. The wastes of this industry are mainly bleaching earth and soap stock. The wastewater flow is caused by several processes such as decolorization, cooling towers, and boilers and air pollutants including volatile organic compounds (VOCs). This study is pointed to describe diverse methods expended by edible oil industries to treat waste, wastewater, and air pollutions and their effectiveness for elimination them.

Keywords: Edible oil, industry pollutions, process, waste management.

Introduction

Edible oils are widely used for food production at different levels of household, commercial, and industrial applications. According to research conducted in 2018, the amount of edible vegetable oil production was 203.83 million tonsin the world, of which 197.33 million tons were consumed[1].

The raw materials for edible oil production include crude vegetable oil (as the main raw material), phosphoric acid, caustic soda, bleaching earth, water, beta-carotene, antioxidants, and essential oils. Crude oils extracted from oilseeds such as coconut, cotton, safflower, rapeseed, soybeans, peanuts, palm, sunflower, rice bran and sesame that have some insoluble suspended solids in the oil[2].

The purifying operation of raw edible oil comprises four processes: degumming, neutralization, bleaching, and deodorization[3]. The crude edible oil included undesirable materials. These materials change the taste and color of the oil and reduce its quality. The color of edible oil is due to the presence of pigments, such as chlorophyll-a and β-carotene[4,5]. The crude edible oil comprises remains free fatty acids, phosphatides, and metals at trace concentrations[6].

To produce edible oil, oilseeds must be treated. Many wastes are generated in this process, including inorganic remains, seeds and husks (organic solid waste) and wastewater[7]. Wastewater produced in the edible oil industry contains oils and greases, fats, phosphates and sulfates. Therefore, the study of total suspended solids (TSS), total dissolved solids (TDS), biological oxygen demand (BOD) and chemical oxygen demand (COD) in industrial wastewater is very important. Changes in the above can increase the organic and inorganic load of wastewater[8]. Direct release of edible oil wastewater into water sources is associated with rapid deoxygenation water, which causes damage to aquatic animals[9,10]. Oils and grease do not decompose easily and have an adverse impact on the environment. Oil industry wastewater can pollute water sources, soil and emit unpleasant odors[11,12]. Therefore, it is necessary that these effluents be treated in accordance with environmental standards and regulations.

Also, the oil residuals, if properly discharged into the wastewater treatment system, potentially can create some problems in the treatment system process, so reduce the efficiency and raise the operating costs[13]. These pollutants are difficult to treat after draining and entering the waters because the oil effluent has complex molecular structures that are difficult to decompose in nature[14]. These pollutants are categorized into three classifications: waste, wastewater, and air pollution.

This study aims to describe the process of refining and preparing edible oil as well as pollutants and how to manage it.

Oil refining steps

The goal of oil refinery is to achieve the best quality characteristics in terms of taste, color, odor, and durability, that during which unwanted impurities from the oil (with minimal damage to glycerides and minimal oil loss) are removed. The oil refining includes degumming, Alkali Refining, or neutralizing refining (including neutralization, washing, and drying), Bleaching, and Deodorization (Figure-1). Choosing the proper process depends on the type and quality of the raw oil[15].

Degumming: The first and specific stage of oil refining is the extraction of gums or phosphatides from crude vegetable oils,

which includes two steps of Degumming by water and Degumming by acid-water (phosphoric acid and citric acid) (Figure-2). Gums are used in the industrial processes, food industry and Livestock feed. The main types of gums (phospholipids) are phosphatidylcholine, phosphatidy-lethanolamine, and phosphatidylinositol. During the degumming operation, sufficient time should be provided for blending water, phosphoric acid, and oil with the help of suitable mixers, and then the hydrated phosphatides, which are heavier than the oil phase, should be split by separators that work with centrifugal mechanism[17].

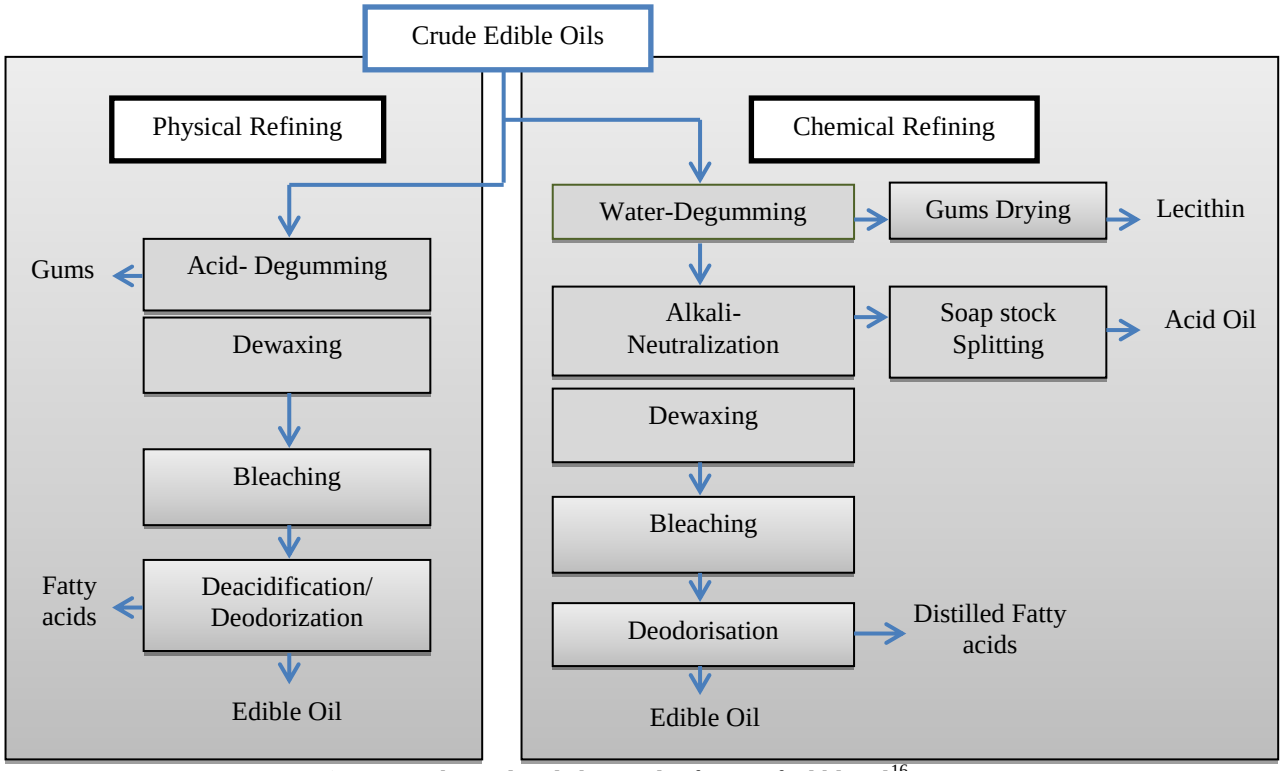

Figure-1: Physical and chemical refining of edible oil[16].

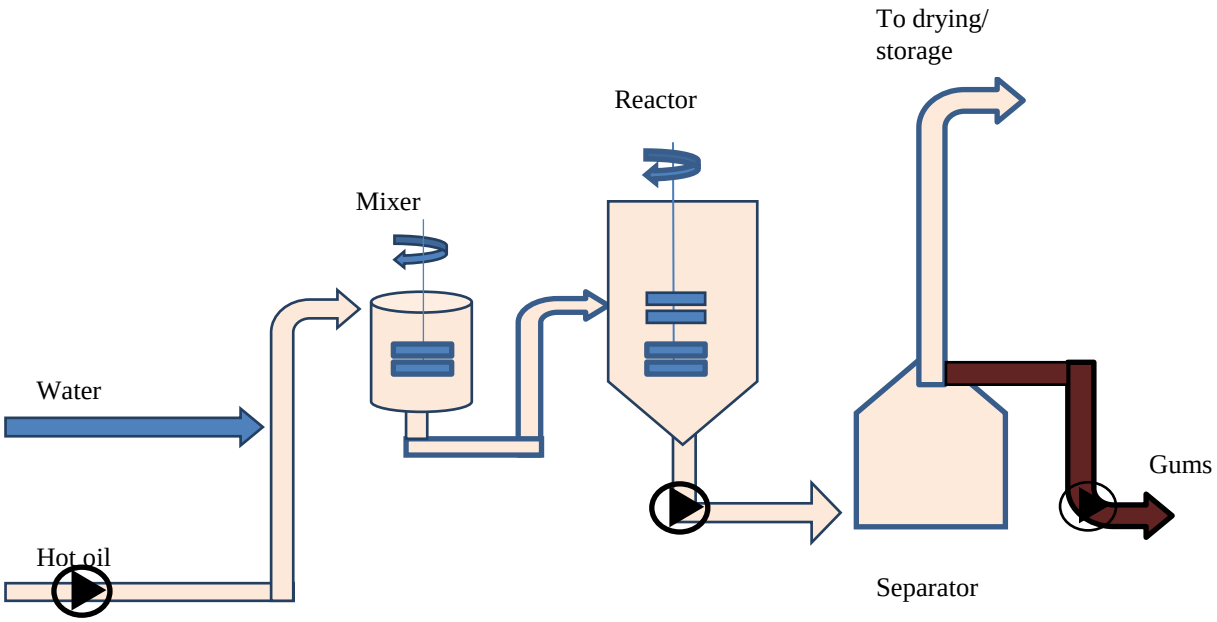

Figure-2: Degumming step of edible oil refinement.

Neutralization of free fatty acids of crude edible oil: During the storage period of oilseeds and fruits from the time of harvest to the oil extraction, due to the activities of enzymes as well as some microorganisms, the oils in the seeds or fruit has been hydrolyzed to free fatty acids and glycerol. During the refining process, it is necessary to separate the free fatty acids from crude oil. The process of removing free fatty acids from crude oil, known as neutralization[18]. The chemical neutralization process consists of three parts: adding an alkaline compound (such as caustic soda), rinsing the neutralized oil to remove soap residue, and drying the neutralized oil to remove moisture. If necessary, the neutralization operation is repeated to remove possible and residual impurities, and finally, after rinsing the oil with hot water and using the appropriate centrifuges, the aqueous phase containing the soap is separated from the oil. The oil is then dried under a vacuum and prepared for the next step.

Oil bleaching: The bleaching of oil edible is a process in which the color-forming compounds are separated from the oil along with some other impurities. This process is essentially a physical adsorption process in which pigments and other impurities are separated from the oil by adsorption on an adsorbent. Bleaching operations are performed using porous materials of clay with a powerful adsorption capability. These clays are called bleaching earth, which are activated by heating with strong acids. Most of them are bentonites[19] and kaolinites[20]. These clays contain generally aluminum silicates. This step plays an important role in refining and extracting oil impurities. The bleaching operation effectually removes some of the colors, trace metals, reduces the contents of chlorophyll, oxidation products, residual soap and gums and indirectly influences on deodorized oil color. After this step, the oil is prepared to remove odorous and volatile compounds.

This operation is usually performed in vacuum tanks equipped with a stirrer (Figure-3). The optimum temperature for this operation is 110-100˚C, and preferably between 15 and 20 minutes, there should be an opportunity for contact and exchange between the bleaching earth and oil. At the end of the bleaching operation, the mixture of oil and pigments is filtered by filter press systems, and the dye is separated from the oil. During the bleaching process, the maximum amount of pigments (chlorophyll and carotenoids) should be removed from the oil[21].

Deodorization: The purpose of deodorization as a final step is to remove aromatic volatile impurities from the oil that have been imposed on the oil during various stages of refining, such as earth flavor, and to produce a tasteless, pure-odor product. The basis of deodorization operation is steam distillation at high temperatures and under vacuum. In the deodorization phase, happened by high-temperature procedure (240–270°C), all thermally degradable pigments (i.e., carotenes), unfavorable elements, or volatile compounds, such as ketones, alcohols and aldehydes are eliminated by vacuum distillation.[22]. The deodorization operation is performed with the help of three factors: vacuum, high temperature, and direct injection of steam to separate the unpleasant odor and taste from the oil[23].

Oil packaging: Different types of glass, metal, and polymer packaging are available for oils and greases. Insulation properties of packaging materials against oxygen, moisture and the action and interaction of food ingredients with packaging. have a decisive effect on the quality and durability of packaged foods. According to studies, the stability of vegetable oils in the polyethylene terephthalate (PET) and polyvinyl chloride (PVC) is more than polypropylene (PP) and polystyrene (PS) bottles. Oil is more stable in colored glass than the clear one[24].

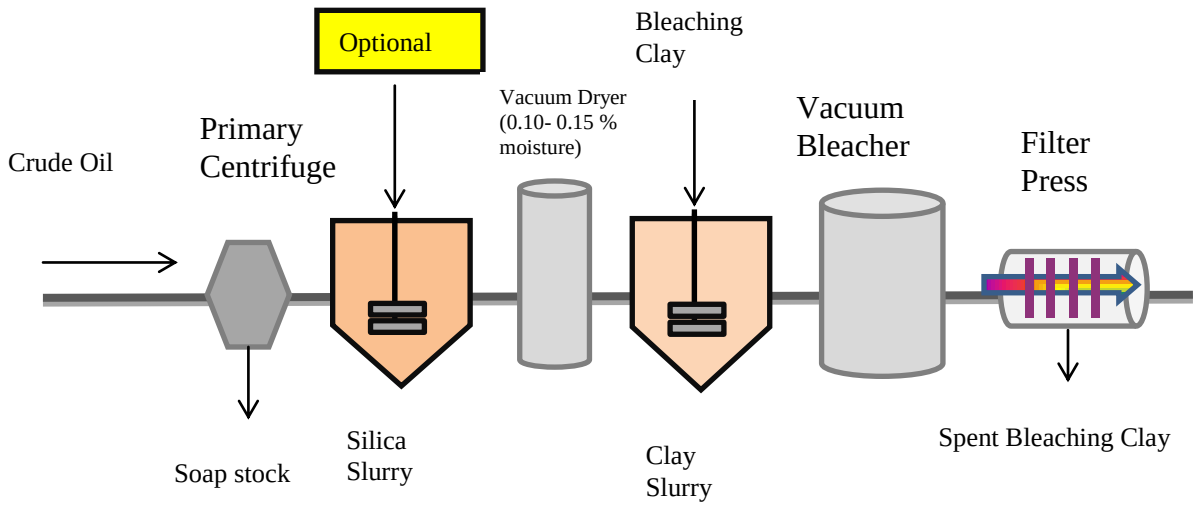

Figure-3: Bleaching operation.

Pollutions of the edible oil refining industry

As mentioned earlier, raw oils are refined to remove undesirable compounds by using several processes before being consumed, and these processes produce by-products as pollutants. These Pollutants are one of the most important environmental pollutants, which in some cases due to the complexity of the molecular structure of these compounds are difficult to treat. These pollutants are categorized into three classifications: waste, wastewater, and air pollution.

Waste: Edible oil refinement units produce solid waste and wastewater that were environmentally harmful and require proper treatment before discharge. Bleach earth is one of the wastes that generated on a relatively large scale (between 1.5-3 kg per ton of raw oil) that the amount is varied under various factors and conditions, including the amount of raw oil color. Various methods such as heat treatment and acid treatment are used to regenerate depleted bleach earth. Another waste generated as a by-product is soap stock that can be reused and recycled[17,25].

Wastewater: During the washing of oily bleach earth and boiler blow down is generated lot of wastewater. Specifically, in the neutralization phase, sodium salts of free fatty acids (soap stock) are produced which are separated using H_2SO_4. This stage creates very acidic and oily wastewater. The properties of wastewater usually depend on the type of oil and the method used.

In the past, wastewater was discharged directly into soil or groundwater after treatment. But now, with increasing environmental awareness, stricter requirements and standards are being applied to control pollution. Wastewater treatment is used to reduce the level of pollution before discharge to the environment to prevent the disturbance of the ecological balance. Notable key parameters include BOD5, COD, suspended solids, phosphates, pH, oil and grease (extractable by the solvent) and compounds such as sulfates, and chlorides[18,26].

In oily wastewater, there are oil and grease in thefree form, dispersed, and emulsified. The effective steps in removing free oil are overflow and sweeping. In recent decades, aerobic treatment has been applied to eliminate biodegradable organic pollutants from industrial process wastewater. For wastewater treatment by conventional methods (e.g. aerobic or anaerobic digestion), the BOD to COD ratio must be 0.6. Whereas, the edible oil industry effluents usually have a BOD to COD ratio of about 0.2, which can destroy useful microorganisms for biodegradation[27].

In general, physical and chemical operations are gone along with biological processes for wastewater treatment. Physical and chemical processes comprise flotation, oil sweeping, flocculation, and coagulation for colloidal contaminations followed by biological operation for the removal of organic compounds. The flotation unit is employed to separate solid or liquid particles from a liquid phase. Dissolved air flotation (DAF) is used to eliminate emulsified oils from oily wastewater. Flotation with soluble air clarifies based on the removal of various suspended pollutants such as oil, lipid, grease and colloidal particles cause to treat effluent and wastewater. The operation of removing pollutants and colloidal particles in this method is based on the infusion of compacted air in the wastewater. As a result, the finely released bubbles adhere to the suspended particles (oil) in the wastewater, causing the particles to float to the DAF surface, where they are assembled by a skimmer and discharged into a sludge storage tank. In general, due to the emphasis on environmental pollution control, new laws and regulations, the factories must be equipped with biological and physicochemical wastewater treatment systems. The flow diagram of the process with drained wastewater sources for the treatment unit of edible oil (soybean) is presented in Figure-4.

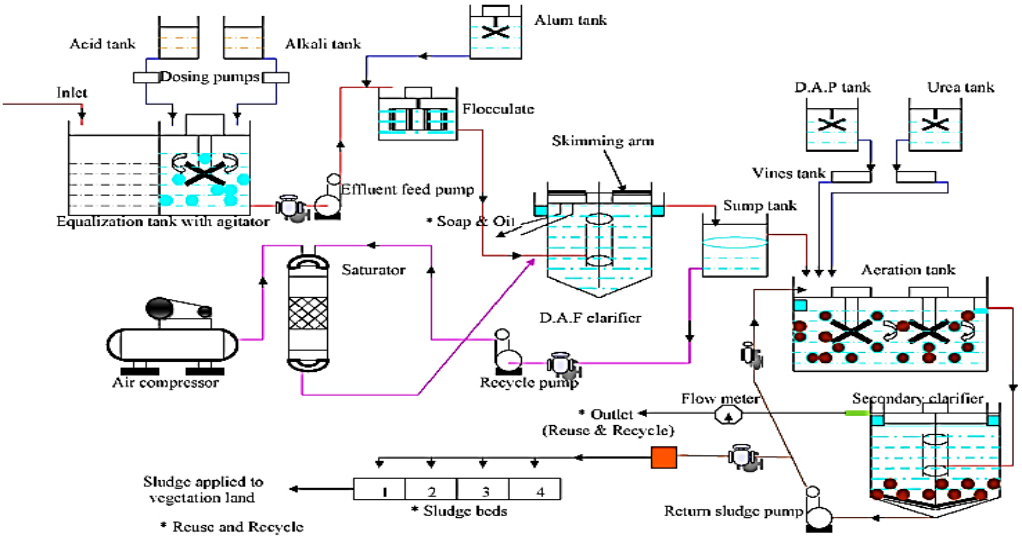

Figure-4: Schematic diagram of the treatment system for wastewater of edible oil plant[28].

Air pollution: Release of volatile organic compounds (VOCs) during the oil cooking phase is one of the air pollutants in the edible oil refinery. The other pollutants in the various stages of refining as a gas form include smoke, particulate matter, sulfuric acid or sulfur trioxide dust, hydrogen sulfide, nitric acid or nitrogen oxides, and carbon monoxide. Exhaust vapor must be collected (by scrubber), compressed, and condensed and treated in a treatment plant to remove odor[29].

Conclusion

In an edible oil refining industry, different processes are applied based on the type of raw oil. Typically, edible oil refinement involves the steps of degumming, Neutralization of free fatty acids of raw edible oil, oil bleaching, deodorization, and packing the oil. The wastes of this industry are mainly bleach earth and soap stock. Various methods such as heat treatment and acid treatment are used to regenerate used bleach earth. Soap stock can also be reused and recycled. The flotation unit is used to sequester solid or liquid particles from a liquid phase. DAF is used to remove emulsified oils from oily wastewater. The main air pollutants of oil refinement are VOCs in which the exhaust fumes from the deodorization process must be collected (by a scrubber), compressed and condensed, and treated in a treatment plant to remove odors.

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