Liquid Waste Treatment in the Vegetable Oil Processing Industry – European Practices

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ABSTRACT

The waste treatment methods that are currently used in the vegetable oil processing industry are reviewed with special attention to three points: a very careful study of the local conditions is necessary before selecting any treatment process; in any case, it will mean an expensive investment, and the running costs will be high; and, in the near future, new laws will leave no choice to plant owners–they will have to comply with legal requirements or close up shop.

INTRODUCTION

We shall try to review the problems connected with the treatment of polluted waters in vegetable oil processing plants and to give some details on the practical solutions adopted in the plants of the Lesieur Cy in France.

The reduction of water pollution in the vegetable oil industry is just a part of the general problem of environment protection with which the governments of industrial nations have to deal. In order to do so, these governments have enacted new laws to reduce the effects of the main types of pollution:

- Atmospheric pollution due to smoke (domestic heating, powerhouses) and industrial gases
- Noise due to industrial activities and road and air traffic
- Water pollution

We shall examine this last point in detail; there is the general consensus to consider that water pollution is a major danger for the future of mankind. Everybody knows that numerous streams and rivers the world over have turned to gutters. For instance, the Seine River downstream from Paris, the Rhine River, north of Mulhouse-Basel, and Lake Ontario all have reached a rate of pollution where both animal and plant life are threatened with complete destruction.

Under the pressure of public opinion, governments have been obliged to take drastic and costly measures to fight this danger. The sums involved are impressive. Let us quote:

- For West Germany, in a 5-year period–1.8% of the national income
- For Japan, in a 5-year period–11.4 billion U.S. dollars for investments only
- For the U.S. in a 10-year period (1971-1980)–investments and running costs will reach the fantastic sum of 287 billion U.S. dollars, that is to say, 2.2% of the national income.

These figures show the price that industrial nations will have to pay to provide a decent environment for future generations. The consequent taxes will have to be enforced by drastic legal methods.

The French government has already published a number of laws which, at the same time, have imposed obligations and offered citations to the owners of water-polluting plants. The national territory has been divided into six large geographical zones: Artois-Picardie, Seine-Normandie, Rhin-Meuse, Loire-Bretagne, Adour-Gard, and Rhone-Mediterranee-Corse. Each of these zones is under the control of a special branch of the administration called "Agence de Bassin." These six authorities are subsidized by the state and collect taxes from the local communities (departments, cities, villages) and from the polluting industries. For the latter, a complicated system of ratios has been established to fix taxes proportional to the gross production, number of workers, etc. Since the beginning of 1972, actual measurements have allowed a much more accurate method of taxation.

Let us consider, for instance, the Coudekerque plant of Lesieur Cy (in the neighborhood of Dunkerque, northern France). Taxes are based on the volume of discharged wastewaters in proportion to the tonnages of suspended solids, oxidizers, and inhibitive materials. The rates of taxation have increased with the years: for suspended solids, from 11 Frs/kg in 1973 to 22 Frs/kg in 1976; for oxidizers, from 17.50 to 34 Frs/kg during the same period. These high rates justify costly investments; and for the Coudekerque plant, the installation, which we shall describe further, with a cost of 1,100,000 Frs, allows a yearly tax cut amounting to 300,000 Frs.

Moreover, the "Agences de Bassin" provide financial assistance to the plant owners with a system of subventions and low interest loans up to 40% of the total investment cost.

PRACTICAL PROBLEMS OF WASTE TREATMENTS

Let us review the major sources of water pollution at each step of the process, from the storage of oilseeds to the final packaging of oil.

- Waters flowing out of heat exchangers or surface condensers: With the exception of unforeseen accidents, these waters are only changed by a rise in temperature.
- Barometric condenser effluents: For these waters, there is both an increase in temperature and addition of oil droplets.
- Effluents of various origins, such as gas scrubbers, cleaning of greasy soils, and stuffing box leakages.
- Process waters from the refining plant and soapstock-splitting effluents: These waters have been in contact with oils, especially during the washing that takes place after the neutralization process. The volumes involved are small, but the rate of pollution is very high.

IMPORTANCE OF EFFLUENT VOLUMES

The above enumeration of the main sources of water pollution shows that their impacts on the total pollution rate are very different. The cleaning of soils, and accidental leakages, are statistically negligible in comparison to the pollution produced by vacuum dryers, deodorizers, and other equipment, including barometric condensers, whose effluents will have a large volume with a low content of oily matters.

On the other hand, process waters (oil-washing and soapstock-splitting), with a low volume, are heavily polluted. It appears immediately that treatment methods will be different and adapted to the oil contents of various effluents.

We may indicate a few figures:

- For a 150 t/day semicontinuous deodorizer, operating under a 5 torrs vacuum, the water consumption amounts to ca. 300 m^3/hr.
- Should the deodorizer be equipped with a steam washer (a cumbersome and costly device), the oil contents of effluents would be reduced to 12 or 15 ppm; that is to say, 12-15 g/m^3, or 108 kg for 24 hr.
- If the same deodorizer is not equipped with a steam washer, the oil content of the effluents will be multiplied by at least 5, and it will mean a total of 550 kg of oily matters per day.
- On the contrary, for a refining line of the same capacity (150 t/day), the process waters (including soapstock-splitting effluents) will flow out at a rate of only 4 m^3/hr, but with an oil content of 1 g/liter, that is to say, 96 kg for every 24 hr period. Moreover, the pH can be as low as 2, and neutralization will be a must.

SOME PRACTICAL METHODS FOR REMOVAL OF OILY MATERIAL FROM WASTEWATERS

Many methods currently used for the removal of oils from waters involve gravity separation. The specific gravity of oily material (0.915) causes oils to rise during passage through a suitable tank. The oils having risen to the surface are eliminated by skimming, pumping, or simple overflow. The treatment equipment must be selected, after considering the oil content of the effluent, pH of the effluent, and nature of the water in which the oil droplets are in suspension.

The latter point is most important, and in two of our plants we have had to use completely different methods in spite of the fact that the problems looked identical. We had to purify the effluents of the barometric condensers on two batteries of semicontinuous Girdler deodorizers (capacity 150 t/day each). In the Coudekerque plant, water was pumped into our private canal; in Bordeaux, the water was pumped directly into the Garonne River. The deodorizers (three in Coudekerque; two in Bordeaux) were strictly identical and were all equipped with steam washers. However, experience revealed drastic differences in the possibilities of separating the oils from the waters.

In Coudekerque, the self-propelled barges, while moving along the canal, stirred clay and various organic matters, which stayed in suspension in the water. We discovered that, if we left the effluent in a 1 liter test tube, oil was adsorbed by the clay particles and settled. No trace of oil appeared at the top of the tube, even after 1 day of quiescence. On the contrary, a dark layer, 5-6 mm thick, settled at the bottom of the tube.

In Bordeaux, the same experience showed, as we expected, that all the droplets of oil rose to the top of the test tube after 15-45 sec. Repeated experiences always led to the same results, which were a subject of great perplexity for many experts.

In Coudekerque we tried every known auxiliary method, such as flocculation and air injection, without success. Therefore, we had to admit that gravity separation was impossible regardless of the dimensions of a tank or even of a lagoon for providing suitable quiescent conditions. Electroflotation was out of the question to treat 1,500 m^3/hr, and we were obliged to give up the canal water and to replace it with drinkable water from the city water supply. Disposabilities being difficult and price very high, we decided to recyle all condenser effluents in a circuit including atmospheric cooling towers. The problem was radically solved.

According to our experience, the following types of solutions might be considered for the treatment of oily wastewaters:

- When the oily materials rise easily (1 min or less) a rest tank equipped with a mechanical skimming device will give good results. To provide suitable quiescent conditions, the tank dimensions ought to be calculated on a basis of 0.3 m^2/m^3/hr. The effluents should flow successively through at least three separate compartments.
- If the oily matters rise slowly, the same device should be used but with addition of flocculents (followed by filtration) or compressed air injection.
- If the oily droplets do not rise to the surface but settle (as in Coudekerque), pure water has to be used, with complete recycling and cooling.
- In some exceptional cases, when the effluents are discharged directly to a river or a lake with a quality that meets the most severe official standards, more elaborate treatment becomes necessary. It will include preliminary neutralization, followed by concentration and steam evaporation. This method is very expensive (at least 70-80 Frs per ton of effluent). In spite of the cost, we have been obliged to use it for one of our plants in the neighborhood of Marseille in order to meet local requirements.

THE WASTEWATER TREATMENT INSTALLATION AT COUDEKERQUE

To recycle the effluents of the refining plant, we had to have the following equipment:

- A collector to receive the wastewaters flowing out of five barometric condensers (ca. 1,500 m^3/hr).
- A concrete tank to provide suitable quiescent conditions: surface 223 m^2; volume, 515 m^3. The tank is divided into four compartments by concrete walls. In one of these compartments are located the aspiration pipes of three centrifugal pumps. Each pump lifts 500 m^3/hr to the top of a cooling tower (Hamon type), through which air is blown upward. Under the three cooling towers, a 60 m^3 steel tank receives the effluents, which are sent back to the condenser tops through a 600 mm steel pipe. To improve the refrigeration and to take advantage of gravity, the three cooling towers are located on the terrace of a neighboring building, 27 m above ground, the condenser's tops being themselves at +16 m 30. A special siphon avoids all accidental introduction of air into the circuit.
- The installation also includes some auxiliary equipment such as a fourth standby 500 m^3/hr pump, an overflow pipe for emergency emptying of the 60 m^3 receiving tank, suitable automatic devices controlling the pumps to avoid overflow, alarms, and an electric control panel.

The following results have been obtained:

- Total flow of three pumps: 1,520 m^3/hr.
- With a dry air temperature of 13.1 C, the effluents at the bottom of the condensers emerge at a temperature of ca. 24 C.
- Under the cooling towers, the water temperature is reduced to 17.9-18.3 C, ΔT being equal to 5.6 C.
- After condensation of the stripping steam, experience has shown that evaporation and mechanical losses are compensated with a light overflow. No injection of fresh water is necessary.

The effluent's oil content increases during the first cycles, but, thanks to skimming of the rest tank surface and injection of sodium carbonate, it stabilizes itself around 7 mg/liter. Experience proves that this very high rate does not reduce the cooling tower's efficiency. After skimming, melting, and gravity separation, recovered oily material is sent back to the soapstock-splitting plant.

The rather elaborate installation we have just described was built in 1971-1972 for a total cost of 1,100,000 Frs. It has proved very satisfactory. We must mention that a similar setup was described in the April 1973 issue of *Fette und Seifen*. An additional improvement has been suggested in the case of malodorous effluents. It includes a battery of plate exchangers: on one side of each plate, the warm effluents are flowing and, on the other side, the cooling water. This device avoids all contact between the smelly effluents and outside atmosphere.

Power Requirements and Running Cost

For the Coudekerque unit, the energy consumption is 82 HP for each one of the three main pumps and 30 HP for each cooling tower ventilator. Including the efficiency factor, the required electric power amounts to 225 KWH. With an average price of 8 cents/KWH, the expense is 18 Frs/hr and, with 6,000 working hours per year, 108,000 Frs a year.

This cost compares with the money we previously spent to keep two larger units running, pumping water out of the canal. Expenses are about equal, and the additional cost is limited to the power required by the cooling tower ventilators. We estimate it to be 6 Frs/hr, or 36,000 Frs/yr, a relatively low running cost for a unit, allowing a 300,000 Frs cut on the plant pollution taxes.

SPECIAL TREATMENT FOR SOAPSTOCK-SPLITTING EFFLUENTS

As previously mentioned, these effluents have a high oil content and a low pH. The legal requirements for waste, subject to a secondary treatment in a public station (generally of the activated sludge type), impose the adjustment of pH.

A neutralization system must be installed to inject a 50% NaOH solution into the acid waste. The alkali demand will be controlled by an automatic pH meter, but in order to protect electrodes against greasy deposits it is at first necessary to separate oily material. To do so, plastic tanks receive the effluents, and their size is such as to provide for a 3 hr settling. Oily droplets rise to the surface and are eliminated by skimming or pumping.

OTHER WASTE TREATMENT METHODS

After having described in detail our own installations and having discussed the reasons for our choice, we might briefly review some improvements that are now in use for waste treatment in the vegetable oil industry.

Dissolved Air Flotation

This method is widely used in the U.S. under the name of the "Kumline-Sanderson" process.

The waste enters a flotation unit into which there is a continuous injection of air in intimate contact with an aqueous stream at high pressure (5 kg/cm^2). Through a back-pressure valve, the pressure on the liquid is reduced, thereby releasing millions of micro-size bubbles that sweep suspended oily particles to the surface of the unit. A continuous skimmer (Sandwik system) drains away floating greases.

These units (DAF) are built for different capacities, up to a surface of 35 m^2, with a depth of 1.50 m, allowing the treatment of 200 m^3/hr, the waste staying in the unit ca. 15 min.

Parallel Plate Interceptor (PPI) and Tilted Plate Separator (TPS) Systems

These have been mainly developed for the needs of oil refineries. They are based on the physical principle of "wall effect" (Effet de paroi).

Practically, wastewater enters a concrete separator bay and flows downward through a plate assembly consisting of 28-48 corrugated plates, arranged at an angle of 45° to the horizontal. Oil bubbles collect on the underside of the plates and rise to the surface where they are skimmed.

Solids settle into a sludge compartment, with the clarified waste discharging into an outlet channel.

Bertin Vortex System

This ingenious process has been developed by the French engineer, Bertin.

The wastewater is collected in a circular tank, in the center of which is installed a vertical axle fast rotating propeller ca. 40 cm below the surface. The rotary motion results in a vortex, in the center of which oil particles gather. They are easily pumped out.

Unfortunately, the Bertin process does not work if the oil content is relatively low. It requires, at the top of the tank, an oil layer 3-5 mm thick.

Widely used in refineries, the process was tested in our plants, but with no success.

Electroflotation

This method was developed in France by a subsidiary of the Saint-Gobain Cy. Very efficient but rather costly, its application is limited to waste volumes under 100 m^3/hr.

Electroflotation might be described as a flotation of insoluble particles by gas bubbles obtained through electrolysis. The bubbles attach to oily droplets which rise to the surface where they are skimmed.

For the treatment of 15 m^3/hr, Saint–Gobain builds a standard-size cell, with an electroflotation surface of 4 m^2 (two electrodes, 2 m^2 each). The electric power requirement amounts to 4.5 kW (direct current 12 V, 400 amp). Such a cell is 1.30 m high, 2 m long, 2 m wide, and costs ca. 120,000 Frs.

Other Treatment Methods

Lagooning: Shallow natural lagoons or deeper artificial lagoons are used with mechanical oxygenation. Depending upon the size of the lagoon, the detention time might be a few days or a few weeks. This method, however, may be inconvenient, as it requires large areas and a sunny climate. It is mainly used by refineries located in great open spaces.

Activated sludge: Waste stays in an aeration basin for a few hours. Biodegradation occurs by the action of bacteria and agglomerated microorganisms. Steady agitation provides dissolved oxygen. After passing through a secondary settling tank, sludge is separated and partially recycled. The cyclindroconic basins may reach 50 m in diameter.

COMPLETE WASTE TREATMENT

All the methods we have enumerated may be termed "primary treatment," with the exception of the waste recycling which radically solves the problem.

Actually, and for waste flows up to 100 m^3/hr, some companies (e.g., Degremont in France) have devised complete treatment units. They include a receiver equipped with a pump; a static separator equipped with a skimmer (for 100 m^3/hr, volume of the separator is 44 m^3); a device for addition of aluminum sulfate at the rate of 120 mg/liter; a flotation tank (volume 25 m^3 for 100 m^3/hr); a neutralization tank (volume 17 m^3 for 100 m^3/hr) equipped with an automatic limestone distributor and allowing the injection of a flocculent (afcolac) at the rate of 5 mg/liter; a settling tank (volume 340 m^3 for 100 m^3/hr); a sludge collector; and a final, vacuum rotating filter.

These units demand very careful maintenance and take a lot of space, but they work well. A solution must be found for the final disposal of the filtered muds. We have one of these units in the Coudekerque plant and use it for heavily oil-loaded wastes. The cost would be prohibitive for the treatment of more than 200 m^3/hr.