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Research Article

Depuration of Wastewater from Table Olive Industries

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Abstract

The Alpechines or Margins from the Table-Olive Industry is the most complicated wastewater to treat. Here we present one industrial system installed for over 10 years in three of the leading world industries located in the South of Spain. The system allows the reuse of the depurate water for irrigation of the olive trees, the sludge as a highly-regarded fertilizer for the olive fields and other crops, whereas the salt may be reused. A secondary benefit of this system is that the typical stench associated with table olive processing is eliminated.

Keywords: Table Olives; Waste Water; Depuration; Sludge; Fenton Method; Ultrafiltration; Nanofiltration; Reverse Osmosis

Introduction

The Alpechines or Margins resulting from the production of table olives are probably the most difficult wastewaters to treat of any in the food industry. These residues combine the complex characteristics of olive oil production as well as the waste from the table olive preparation: high amount of organic matter with values from 50,000 to 80,000 mg/l, BOD from 4,000 to 12,000 mg/l, SS from 35,000 to 80,000 mg/l, and COD that can arrive at 220,000 mg/l, high concentrations of salt, and sodium hydroxide.

This organic matter is composed of easily degradable products such as sugars, fatty acids, amino acids and proteins), but also substances difficult to decompose, such as polyphenols and inorganic compounds like nitrogen, phosphorus, sodium, potassium, iron, etc., that cause enormous difficulties for its bacterial degradation.

In this paper we present an industrial system for the treatment of these wastewaters, installed for more than ten years in three of the world's largest manufacturers of table olives. The system closes the circle of industrial production, reusing depurated water for irrigation, sludge as fertilizer (highly appreciated by farmers) in olive groves and extracting salt for reuse. The process does not produce the foul odors associated with the industry thus allowing the plants to be located in urban areas [1-4].

Material and Methods

The industrial system starts with bacterial degradation in the biological tank, with a very high concentration of bacteria's. Despite the high salt concentration the system is able to maintain a high concentration of very active bacteria in the tank, helping to degrade the sludge completely.

The water is pumped out to the ultrafiltration system to remove the bacteria's from the water. The specific membranes used avoid the typical problems of continuous membrane obstruction and fouling. The filtered water passes through a nanofiltration membrane, to eliminate the long biological molecules. The reject flow passes to the Fenton treatment to break these molecules down and then returned to the biological tank (See figure 1).

The nanofiltered water passes through reverse osmosis to remove the high salt concentration, obtaining reusable water and salt. A programed PLC controls all the system, parameters and functions, with remote control system and an automated alarm system. These integrated systems simplify the process management and allow for in-house control of the system.

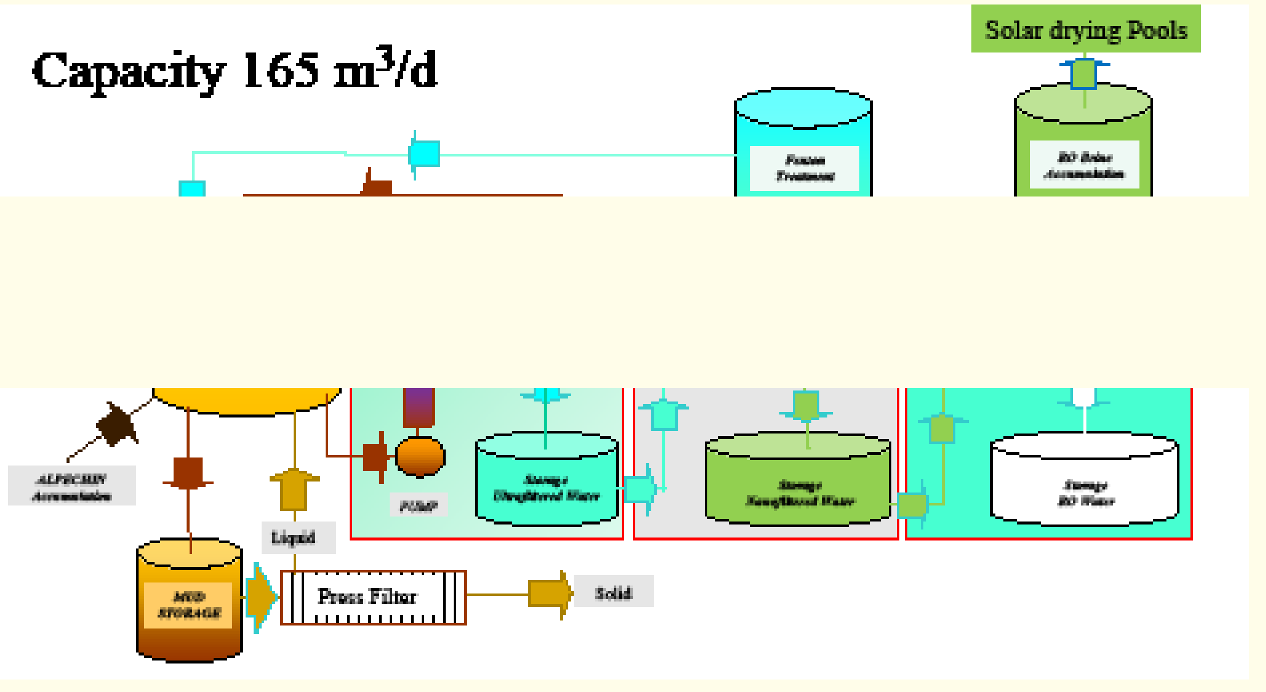

Figure 1: Flow diagram description of the depuration system, for 165 m^3/ day of Table Olives Wastewater.

Biological Treatment

The biological reactor maintains very high levels of bacteria concentration; it maintains the biological load rate always less than 0,1 kg BOD5/day kg VSS, usually around 0.07 - 0.06. This concentration results in Solids Suspended of between 14 - 15 kg SS/m3. This, combined with total oxidation, degrades the organic matter reducing the quantity and obtaining a total aerobic degradation of the sludges. The oxygen inflow is introduced by mixers situated along the biological tank.

Ultrafiltration

The liquor is pumped out to the ultrafiltration system, at a pressure of 3 Bars. The sludge passes through tubular membranes that produce lateral filtering thus avoiding the clogging problems typical of those processes. The rejected sludge returns to the biological tank and the filtered water is stored in another tank. The ultrafiltration process retains the bacteria's, which return to the initial tank, but allows the passage of many long biological molecules that stain the permeated water a deep purple color (See figure 2).

Figure 1: From left to right: Initial Wastewater, filtered by Ultrafiltration, by Nanofiltration and by Reverse Osmosis.

Nanofiltration

The ultrafiltered water is pumped out to the nanofiltration membranes at a pressure of around 17 Bars. The ultrafiltered water passes through two standard nanofilter modules. The rejected water is subjected to a Fenton treatment and returns to the biological reactor. The nanofiltered water has a light yellow color and is stored in a tank (See figure 2).

Reverse osmosis

Due to the industrial process, the level of salinity in the whole process is very high the process thus far described does not separate the salt from the water. If we want to reuse the water for irrigation it is necessary to desalinate it by reverse osmosis. From the nanofiltration tank the water is pumped out to the Reverse Osmosis membranes, the reject is accumulated in a tank and the permeate goes to a tank to irrigate the fields close to the plant.

Desiccation process

The brine concentrate is carried out to the solar drying areas to obtain a very high quality salt. This process was designated to reuse this salt in the industrial table olive process but recent European regulations prohibit any possibility of this. This pure desiccated salt must therefore be deposited in official dump sites.

Results and Discussion

The difficulty with this treatment is the continuous variation of parameters depending of the season, the quality of olives, etc. The intake waste water analysis varies between 33 to 220 mg/l of Ammonium, 9.000 to 20.000 mg/l of Clorures, 25.000 to 45.000 mg O_2/l of COD, and between 200-300 mg/l Phosphorous (See table 1).

Compound	Value	Units
Ammonium (NH_4^+)	33 - 220	mg/l
Chloride (Cl^-)	9,000 - 20,000	mg/l
BOD_5	6350 - 9730	mg O_2/l
COD	25000 - 45000	mg O_2/l
P Total	200 - 300	mg/l
Nitrates	< 5,0	mg/l
Nitrites	< 0,03	mg/l
N Total	1033	mg/l

Table 1: Variability of intake Alpechin or Margin depends on the different industrial process during the season.

The final depurated water analysis is : Oil and Fats 15 mg/l, Clorures 285 mg/l, Conductivity 1250 μS/cm, COD 224 mg/l, and suspended solids 125 mg/l (See table 2). There is a great demand for the sludge, which is highly appreciated by the farmers as fertilizer.

Compound	Value	Units
Oil and Fats	< 10	mg/l
Conductivity	160 - 610	μS/cm
BOD_5	< 10	mg O_2/l
COD	< 30	mg/l
P total	< 5	mg/l
SS	< 5	mg/l
pH	5 - 8,575 10ter	
N total	< 10	mg/l

Table 2: Final analysis of the depurated water after the Reverse Osmosis process.

Conclusion

The system, installed in the three biggest table olive companies in the south of Spain, alters the concept of this industrial wastewater management. The traditional solution is to partially desiccate the wastewaters in big pools and then, in the best of cases, it finishes up in an official dumping area. This has a big impact on the living conditions for kilometers around these pools because the gases emitted are simply unbearable.

We present an industrial process, validated by the most important industries in the table olive process, which offers a practical solution to the one of the most difficult wastewaters management cases, while avoiding the shortfalls of traditional solutions.

Using this method, we close the circle; reusing the water for irrigation, the sludge as fertilizer and producing high quality salt.

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