CHARACTERIZATION OF THE WASTEWATER FROM THE TWO-PHASE CENTRIFUGATION SYSTEM FOR OLIVE OIL EXTRACTION

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ABSTRACT

The two-phase centrifugation system reduces to a minimum the use of hot water during the centrifugation and produces oil and a solid residue ("alperujo") containing 55-75% of moisture and a new liquid effluent constituted by water used in other stages of the process. Samples of this new liquid effluent were taken at six factories located in Cordoba province to determine its chemical characteristics: pH, chemical oxygen demand (COD), electrical conductivity (EC) and total suspended solid (TSS), fat, cations and trace element contents. Values of COD, EC and TSS and fat contents in the new liquid effluent were lower than those recorded for the "alpechín"(olive oil wastewater produced in the three-phase system). Nevertheless, these values are still higher than those allowed by the Spanish low and therefore the discharge of this effluent into the watercourses has to be limited and controlled.

INTRODUCTION

The technology of the olive oil industry in Spain has improved since the seventies, when the three-phase centrifugation system for the oil extraction appeared. This extraction system is a continuous process in which oil, vegetable water and a solid by-product ("orujo") are separated. The great environmental problem of the three-phase system is the large amount of water used and the generation of an important volume of a high-polluting effluent during a short period of the year (November-March). The vegetable water of the olives plus the water used in other stages of the extraction process constitute this effluent called "alpechín". Alpechín was produced at a rate of ca. 2 L kg^{-1} of olive and had a high pollution potential: DBO 35-100 g L^{-1}; DQO 45-130 g L^{-1}; CE 8-22 dS m^{-1}. The disposal of alpechín constituted a critical environmental problem (Cabrera Capitán, 1995).

From the earliest nineties most of the olive oil factories of Andalusia adopted a continuous two-phase centrifugation system. This system reduces to a minimum the use of hot water during the centrifugation in comparison with the three-phase system, and produces oil and a solid residue constituted by pulp, stones and vegetable water ("alperujo") containing 55-75% of moisture and 3.4% of oil. The higher moisture content of alperujo in comparison with that of the orujo, and the content of soluble organic compounds (carbohydrates, pectines and polyphenols) coming from vegetable water, constitutes the main problem for the chemical extraction of the residual oil (Hermoso et al., 1995).

Despite of the saving of water during centrifugation, the two-phase system generates a new liquid effluent-mainly constituted by the water used in other stages of the process. This effluent is produced at a rate of ca. 0.20 L kg^{-1}, theoretically supposing a reduction of ca. 80% of the volume of the liquid effluent compared with that produced in the three-phase system, the so-called "alpechín". At the same time, the DQO (ca. 10 g L^{-1}) of the two-phase effluent is much lower than the corresponding of alpechín (García-Ortiz and Frías Ruíz, 1994).

Nowadays, most of the olive oil of Andalucía (ca. 80% of the Spanish production) is extrac-

ted by the two-phase centrifugation system. The present communication deals with the result of a survey carried out in six factories located in Cordoba province, currently using the two-phase system, to determine the volume, chemical characteristics and fate of the effluent generated by this system.

MATERIAL AND METHODS

Samples of the liquid effluent were collected from six olive oil factories located in Cordoba province (Spain) and stored at 4ºC prior to analysis.

Values of pH and EC were determined using CRISON standard electrodes, COD by the closed reflux colorimetric method (APHA, 1992) and TSS after filtration through Whatman GF/C fiber filters and on a dry weight basis (105ºC). Fat content (ether extractable) were determined by extraction in Soxhlet with cellulose filters. Analysis of Ca, Mg, K, Na, P and trace elements was carried out using an ICP-EOS.

RESULTS AND DISCUSSION

Chemical characterization of the wastewater from the two-phase system

Table 1 shows the annual data of six factories using the two-phase system. The volume of effluent generated ranges between 0.2 and 0.5 L kg^{-1} of olive (average 0.3 kg^{-1}) what represents a reduction of 1 L kg^{-1} in comparison with the alpechín produced by the three-phase system. Wastewater is usually set aside in evaporation ponds.

***Table 1**. Annual data of six factories using the two-phase system.*

Factory	olive	oil	alperujo		wastewater
			Mg y^{-1}		L kg^{-1}
Agrícola Rute	15000	2700	9000	4500	0.30
San José. Los Llanos	10000	1800	8000	5000	0.50
La Muralla. Zambra	6500	1200	4500	1300	0.20
Olivarera Lucena	8570	1750	7500	2700	0.30
N. S. Araceli Lucena	11000	2300	8000	2700	0.25
Olivarera Cabra	18000	3600	13500	4500	0.25

The results of the analysis showed a high variability of the values obtained (Table 2 and 3).

An important reduction of the values of chemical oxygen demand (COD), electrical conductivity (EC), suspended solid (TSS) and the fat contents was observed in comparison with the data recorded for the "alpechín" (Table 2). Nevertheless these values are still higher than those allowed by the Spanish law for treated waters and therefore the discharge of this effluent into the watercourses is not allowed.

***Table 2**. Some chemical characteristics of the wastewater from the two-phase extraction process in comparison with the three-phase process.*

Extraction system		pH	EC dS m^{-1}	COD	TSS g L^{-1}	Fat
Two-phase	Average	5.20	3.30	23.7	5.01	1.10
	Range	3.89-6.73	0.52-7.56	1.1-90.3	0.2-31.2	0.13-7.0
Three -phase	Range	4.7-5.2	7-16	45-60	9.0	3-10
Spanish law		5.5-9.5		0.5	0.3	0.04

EC, electrical conductivity; COD, chemical oxygen demand; TSS, total suspended solids.

Values of macronutrients in the wastewater from the two-phase system were in general lower than those recorded for the "alpechín" (Table 3). However, this water still contains an important nutrient charge that can be recycle as plant fertilizer.

***Table 3**. Values of the macronutrient content of the wastewater from the two-phase extraction process in comparison with the three-phase process.*

Extraction system		Ca	Mg	K	Na	P
				mg L^{-1}		
Two-phase	Average	486	58.5	1144	50.6	57.1
	Range	78.7-1341	12.2-178	45.1-3536	16.0-88.7	2.27-200
Three -phase	Range	120-750	100-400	2700-7200	40-900	300-1100

The low concentration of heavy metals confirms the safety of the waters from both extraction processes (Table 4). These wastewaters do not present any risk of heavy metal contamination.

***Table 4**. Values of the heavy metal content of the wastewater from the two-phase extraction process in comparison with the three-phase process.*

Extraction system		Cu	Fe	Mn	Ni	Zn
				mg L^{-1}		
Two-phase	Average	0.58	20.3	1.11	0.18	0.72
Three -phase	Average	1.51	68.4	1.08	0.25	4.10

Alternatives for the use of wastewater from the two-phase system

Despite the reduction of organic load of the wastewater produced in the two-phase system in comparison with the alpechín, its treatment for depuration is not a common practice. Instead, this wastewater is currently kept aside in the old ponds used for alpechín evaporation. Wastewater in ponds causes the same problems than alpechín: foul odorous, insect proliferation, leakages, infiltrations and over-flowing with sludges.

We have records of the use of this wastewater for irrigation. Data in Table 3 show that the value of EC of the average wastewater is 3.3 dS m^{-1}. The irrigation with wastewater having values of EC ≥ 3 dS m^{-1} can cause severe salinization of soil, affecting crop water availability. However, wastewaters with EC < 3 dS m^{-1} have no or moderate effect on soil salinization. On the other hand, the average value of SAR (sodium adsorption rate) - a parameter related to the sodication of the soil exchange complex - is 0.58. Waters with SAR in the range 0-3 and EC >0.7 dS m-1 have not sodicity hazard (Ayers and Westcot, 1994). Nevertheless, because of the huge ranges of the values of EC and of the concentrations of Ca, Mg and Na, the use of these wastewaters for irrigation must be study in each particular case. As law regulates disposal of wastewaters, its use for irrigation must be done with the due permission of the environmental authorities.

Another use alternative of this wastewater is its utilization in the composting plant of alperujo. The direct incorporation of alperujo into agricultural land can be a serious problem because degradation products inhibiting root growth are released and because the high C/N ratio of this product that can cause phenomena of N immobilization during long periods of time. Co-composting of alperujo with other agricultural by-products overcome most of these drawbacks. The efficiency of composting and the quality of the final product are controlled by several factors which affect microbial metabolism (i. e.: temperature, time, aeration, moisture content, pH,

particle size, nutrient content, etc; Tchoganogolus et al., 1994). Among the factors, the moisture content has been referred to as the critical design and operating factor to optimize compost-engineering systems. Moisture content must be high enough to maintain biological activity but not so high as reducing the rate of oxygen needed for aerobic microorganisms. At the same time the final product should be reasonably dry to be stockpiled and transported economically. Not less important is the saving of water in the composting process, especially in regions where water is a scarce resource as is Andalucia in the south of Spain. In dry regions, composting systems must lead to low consuming water technologies. For this reason wastewater from the two-phase system can be use in composting plant of "alperujo" to maintain optimum moisture content of the compost mass. This alternative supposes the saving of water in the composting plants and the recycling of the nutrient contained in the water from the two -phase system.

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