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## INTRODUCTION

The Olive Mill Wastewaters (OMWW) represent one of the most difficult to manage and most polluting agro-industrial wastes in the Mediterranean area. Several physical, chemical and biological processes have been proposed for the treatment of OMWW (Roig et al., 2006), but none of them proves to be a real solution to the problem, technically and economically feasible.

If, on one hand, the OMWW present problems for its disposal, on the other hand it is a source of compounds with important biological properties, among which the phenolic compounds, with antioxidant, anti-inflammatory, anti-atherogenic, anti-viral and anti-carcinogenic properties (Obied et al., 2005).

The project RE-WASTE (Recovery, recycling, resource. Valorisation of olive mill effluents by recovering high added value bio-products) is aimed at spreading the consciousness that it is possible to turn a waste, which is difficult to dispose of, into a source of energy and molecules with biological activities, by means of a process sustainable from an economical and environmental point of view.

The project, co-funded by the European Commission within the LIFE+ programme (project n. LIFE07 ENV/IT/421), started in 2009 and will be concluded in 2012. It foresees the collaboration between Industria Olearia Biagio Mataluni srl (coordinator), Euroimpresa SpA, Parco Scientifico e Tecnologico di Salerno e delle Aree Interne della Campania (from Italy) and the Centro Tecnológico Nacional de la Conserva y Alimentación (from Spain).

The project RE-WASTE allowed to test at pilot scale a technology for the valorization of OMWW, by recovering purified water, phenolic extracts and biogas.

## THE SECTIONS OF THE PLANT

### 1 Pre-treatment

It is aimed at reducing the content of oil and solids, in order to increase the permeability of the successive phases of membrane filtration. The pre-treatment section is composed of a flotator, a decanter, a centrifuge and a filter press.

### 2 Membrane tangential filtration

The effluent, after the pre-treatment, is subjected to three successive steps of tangential filtration (ultrafiltration, nanofiltration and reverse osmosis) on spiral wound polymeric membranes.

The three successive steps allow to separate and concentrate different organic fractions from OMWW. The polyphenols are concentrated in the nanofiltration concentrate.

Ultrafiltration	6 pressure vessels, each containing 1 membrane 8" Membrane surface 32,5 m <sup>2</sup> (350 ft <sup>2</sup> ) - Cut-off 100 kDa
Nanofiltration	2 pressure vessels, each containing 2 membranes 8" Membrane surface 32,5 m <sup>2</sup> (350 ft <sup>2</sup> ) - Cut-off 500 Da
Reverse Osmosis	2 pressure vessels, each containing 2 membranes 8" Membrane surface 32,5 m <sup>2</sup> (350 ft <sup>2</sup> ) - Rejection MgSO <sub>4</sub> 94%



Fig. 1. The pilot plant

### 3 Purification on adsorbent resins

The fraction containing polyphenols (nanofiltration concentrate) is subjected to a purification on adsorbent resins.

The phenolic compounds are retained on the column of adsorbent resin, from which they are then desorbed with ethanol, obtaining an alcoholic extract concentrated in phenolic compounds. The column is then regenerated to be re-used.

Polymer	Purilite Macronet MN-202 (stirene-divinilbenzene)
Specific surface	800-1100 m <sup>2</sup> /g
Porosity	1-1,1 ml/ml
Desorption solvent	ethanol
Regeneration solvent	water solution of NaOH 2%
Elution rate	3 BedVolumes/h during adsorption and regeneration 1,5 BedVolumes/h during desorption

### 4 Anaerobic digestion

The organic fraction concentrated by reverse osmosis, poor in phenolic compounds, is subjected to anaerobic digestion to produce biogas. The inoculum (sludges coming from a digester operating with cattle manure) is put in the reactor and diluted with water. After the acclimatation of the inoculum, the substrate is added to start the production of biogas.

Inoculum (g/l)	100 - 200
Reverse osmosis concentrate (ml/l)	200 - 500
Ratio inoculum/work volume	0,10 - 0,15
pH	about 7
Temperature (°C)	37

## THE PROCESS

A pilot plant for the valorisation of OMWW (Fig. 1) was installed at the industrial site of Industria Olearia Biagio Mataluni in Montesarchio (BN, Italy), near the olive mill. The plant has a capacity of 1 m<sup>3</sup>/h of OMWW and is completely automated.

The plant is composed of several sections (Fig. 2):

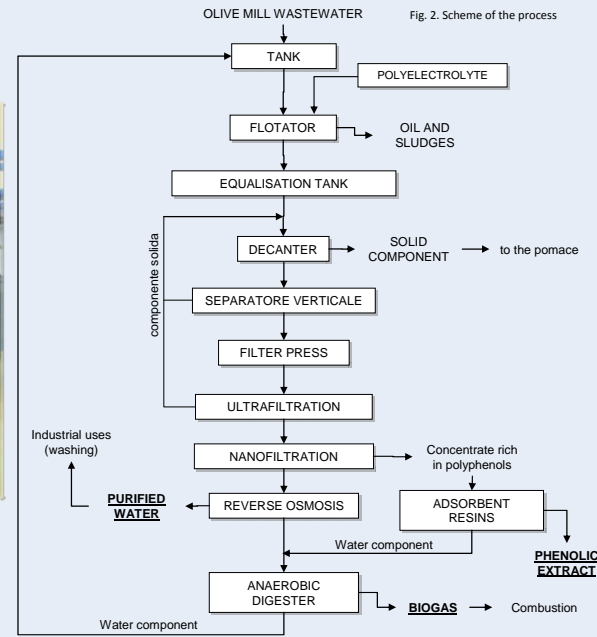


Fig. 2. Scheme of the process



Section of nanofiltration and reverse osmosis



Section of anaerobic digestion

## RESULTS

obtained with the pilot plant during the milling season 2010/2011

### COMPOSITION OF INITIAL OLIVE MILL WASTEWATER

Parameter	Value
TOTAL BIOPHENOLS	1295 mg/kg
HYDROXYTYROSOL	339 mg/kg
OIL CONTENT	1,5%
TOTAL SOLIDS	6.1%
COD (Chemical Oxygen Demand)	210000 mg/kg



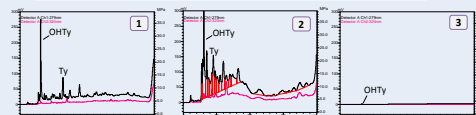
### EFFECTIVENESS OF PRE-TREATMENT

	TOTAL SOLIDS	OIL CONTENT	BIOPHENOLS (mg tyrosol/kg water)
INITIAL EFFLUENT	6,1%	1,5%	1295 mg/kg
AFTER FLOTATOR	3,7%	0,4%	↓
AFTER DECANTER	2,6%	0,09%	
AFTER CENTRIFUGE	2,4%	0,04%	
AFTER FILTER PRESS	1,2%	0,03%	

The pre-treatment proved effective in reducing oil and solid content in the effluent, without compromising significantly the phenolic content.

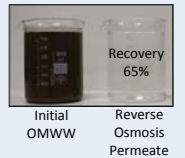
### EFFECTIVENESS OF MEMBRANE FILTRATION

	TOTAL BIOPHENOLS (mg tyrosol/kg water)	HYDROXYTYROSOL (mg tyrosol/kg water)
PRE-TREATED WATER (1)	1237 mg/kg	394 mg/kg
NANOFILTRATION CONCENTRATE (2)	4194 mg/kg	1005 mg/kg
REVERSE OSMOSIS PERMEATE (3)	4 mg/kg	4 mg/kg



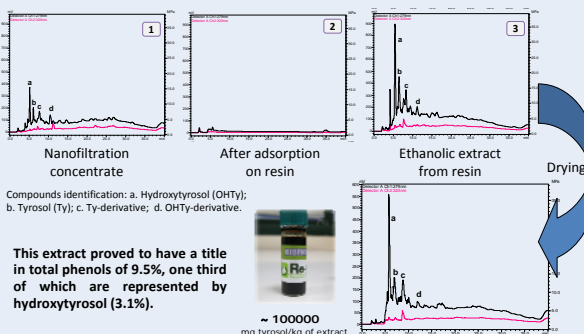
HPLC phenolic profiles of pre-treated water (1), nanofiltration concentrate (2) and reverse osmosis permeate (3).

### RECOVERY OF WATER



COD 175 times lower than the initial OMWW

### EFFECTIVENESS OF ADSORPTION ON RESIN



This extract proved to have a title in total phenols of 9.5%, one third of which are represented by hydroxytyrosol (3.1%).



### EFFECTIVENESS OF THE ANAEROBIC DIGESTION

Production of about 6 L biogas/L reverse osmosis concentrate



## CONCLUSIONS

The process for the treatment of OMWW applied at pilot scale within the project RE-WASTE proved effective in recovering from the waste:

- ✓ High percentage of water (65%)
- ✓ A concentrated phenolic extract (title 9.5%) rich in hydroxytyrosol
- ✓ Biogas

## REFERENCES

Obied et al., 2005. Bioactivity and analysis of biophenols recovered from olive mill waste. J. Agric. Food Chem. 53, 823-837.  
Roig A., Cayuela M.L., Sánchez-Monedero M.A., 2006. An overview on olive mill wastes and their valorisation methods. Waste Management 26, 960-969.