



# Advanced systems for the enhancement of the environmental performance of WINERies in Cyprus



The **WINEC project** (LIFE08 ENV/CY/000455) is co-financed by the LIFE financial instrument of the European Union and aims at identifying the major environmental problems specifically associated with the operation of wineries and establishing environmentally friendly and effective solutions in order to effectively deal with those problems.

## Beneficiaries:

- ◆ GAIA- Laboratory of Environmental Engineering, University of Cyprus
- ◆ Technical University of Crete
- ◆ RTD Talos Ltd
- ◆ S.K. Euromarket Ltd
- ◆ Department of Environment, Ministry of Agriculture, Natural Resources and Environment
- ◆ Tsiakkas Winery

Newsletter

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## WINEC PROJECT

In order to proceed with the design for the pilot winery wastewater treatment plant for Tsiakkas Winery the research teams of **GAIA-Laboratory of Environmental Engineering of the University of Cyprus and Technical University of Crete**, performed a laboratory scale assessment of various parameters including TOC, COD, BOD and phenols. Degradation kinetics were also investigated. Experiments took place in order to identify the most efficient Advanced Oxidation Process between the **solar Fenton** and **solar Fenton-like** processes for the advanced wastewater treatment of the winery effluent. Related to the continuation of the experimental work at the laboratories of both universities two prototype solar photocatalytic reactors have been constructed. The design stage of the pilot plant was completed by S.K. Euromarket Ltd and the construction is almost completed. Finally the Environmental Management System of Tsiakkas Winery will be audited internally for the second time with the collaboration of the project beneficiaries within the summer months in order to reassess the system and the improvement of the winery's environmental performance.

## Characterization of winery wastewater

The characterization aimed at the identification of the physical and chemical characteristics of wastewater produced by the wine production. Specifically, the following parameters have been determined (Table 1): pH, Total Solids (mg/L), Total Volatile Solids (mg/L), Suspended Solids (mg/L), Suspended Volatile Solids (mg/L), Biochemical Oxygen Demand (BOD<sub>5</sub>) (mg/L), Chemical Oxygen Demand (COD) (mg/L), Total Nitrogen (mg/L), Total Phosphorous (mg/L), fats and oils (mg/L), phenolic compounds (mg/L) and heavy metals.

Winery wastewater effluents were taken from Tsiakkas winery in two different periods: i) September to October (vintage period) and ii) December to January (non-vintage period). In addition winery wastewater effluent was taken from a winery located in Paphos, Cyprus, and was first subjected to screening, sequential grid removal and biological oxidation in Sequencing Batch Reactor (SBR) to reduce both organic and solid contents, at the non-vintage period (October).

**Table 1:** Characteristic parameters of winery wastewater effluents at vintage and non-vintage periods and effluents after SBR treatment at non-vintage period.

Parameter	Vintage period	Non-vintage period	Non-vintage after SBR
pH (20 °C)	4.5 - 5	6.2 - 6.8	8.25 - 8.32
Total Solids (mg/L)	5300 - 5400	2350 - 2650	3672 - 3740
Total Volatile Solids (mg/L)	2980 - 3080	800 - 900	2430 - 2612
Suspended Solids (mg/L)	1100 - 1200	450 - 650	225 - 245
Suspended Volatile Solids (mg/L)	980 - 1070	350 - 360	140 - 175
Total phenols (mg/L)	49 - 55	3.89 - 6.58	3.76 - 4.66
Total Nitrogen (mg/L)	433 - 438	110 - 130	6.72 - 6.82
Chemical Oxygen Demand - COD (mg/L)	41000 - 43000	1790 - 1840	264 - 270
Biochemical Oxygen Demand - BOD <sub>5</sub> (mg/L)	31500 - 32200	1549 - 1622	111 - 113
Total Phosphorous (mg/L)	10.9 - 13	3.3 - 3.4	32 - 46.8
Fats and oils (mg/L)	38 - 41	13 - 15	< 4 mg/L
Copper - Cu (mg/L)	0.5 - 0.56	0.01 - 0.015	0.18 - 0.20
Cadmium - Cd (mg/L)	0.01 - 0.02	0.005 - 0.006	0.17 - 0.19
Iron - Fe (mg/L)	1.63 - 1.65	1.6 - 1.63	0.05 - 0.07
Sodium (mg/L)	0.67 - 0.7	0.55 - 0.6	1.42 - 1.50
Potassium (mg/L)	4.6 - 4.7	4.55 - 4.63	4.5 - 4.9

Based on the measurements, the main conclusions that can be drawn is that the pollution load of the winery wastewater significantly changes over the year, in relation to the working period (vintage, racking, bottling). Due to the fact that wineries have a seasonal activity, wastewater production occurs mainly during harvesting and wine making periods.

During the vintage period COD and BOD<sub>5</sub> levels are very high, due to the high levels of organic matter that the wastewater effluents contain. The organic content of winery wastewater consists of highly soluble sugars, alcohols, acids and recalcitrant high-molecular-weight compounds (e.g. polyphenols, tannins and lignins) not easily removable by biological means alone. On the other hand organic matter is reduced during the non-vintage period due to the fact that the winery wastewater is mainly produced through the cleaning activities and there is no production of wine.

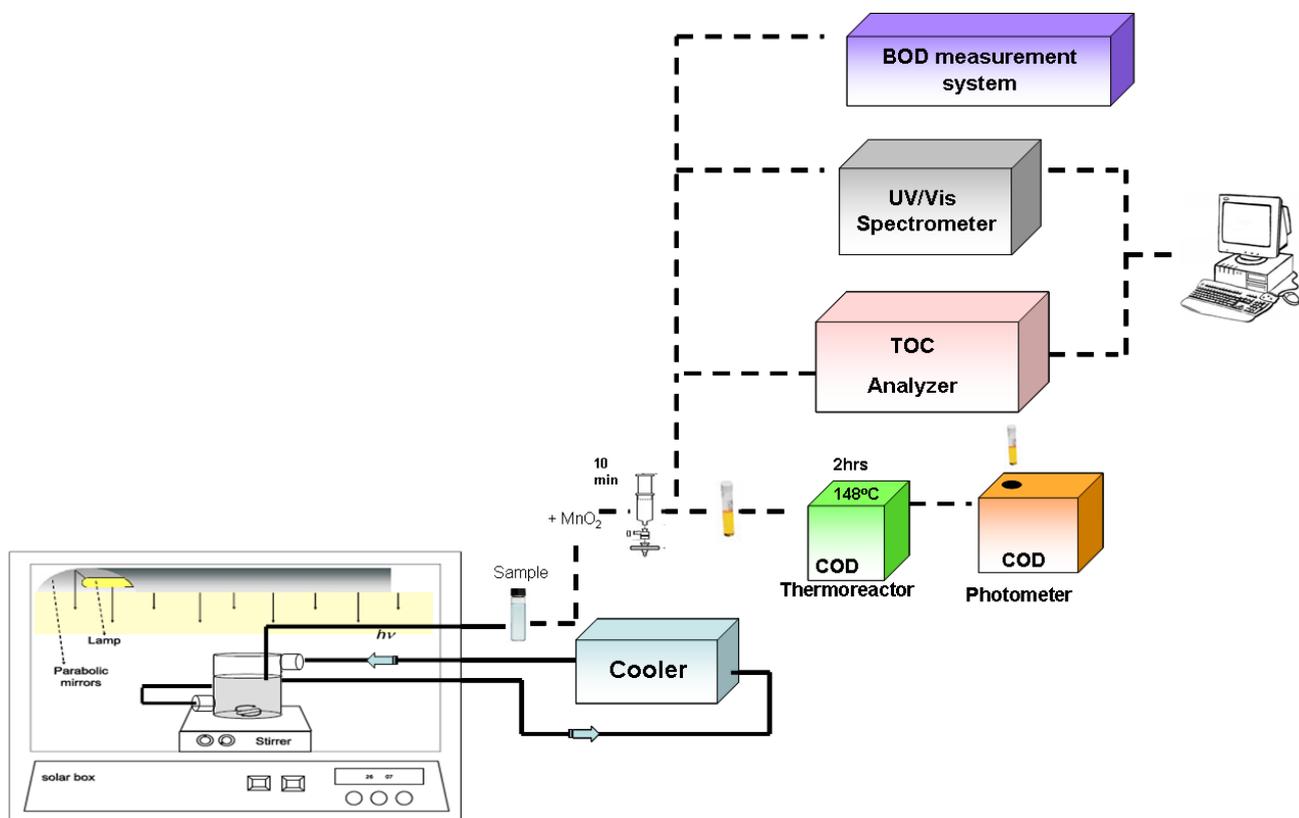
## Chemical treatment of winery wastewater

A partially biologically treated effluent with chemical oxygen demand (COD) and biochemical oxygen demand (BOD<sub>5</sub>) values of 270 mg/L and 112 mg/L respectively, was subjected to both homogeneous solar Fenton and heterogeneous Fenton-like oxidation and the organic content removal of winery wastewater effluent was studied. The study included the investigation of the following:

- \* Effect of catalyst (FeSO<sub>4</sub>·7H<sub>2</sub>O and Fe<sub>2</sub>O<sub>3</sub>/SBA-15)
- \* Effect of oxidant (H<sub>2</sub>O<sub>2</sub>)

- \* Effect of pH (2-8)
- \* Effect of temperature (15-40 °C)
- \* Effect of solar irradiation (photolysis – photo-bleaching – solar + catalyst – dark-Fenton – solar-Fenton)
- \* Total phenols removal
- \* BOD/COD ratio and AOS
- \* Dissolved Organic Carbon (DOC) removal
- \* Degradation kinetics
- \* Color removal.

## Bench scale experimental set up of solar-Fenton



## Conclusions

The conclusions drawn from the present study can be summarized as follows:

- \* Solar Fenton proved to be more efficient than solar heterogeneous Fenton-like process in respect to both DOC and COD removal percentages.
- \* The use of extra ferrous salt for the solar-Fenton had an insignificant beneficiary effect on the reduction of COD, while for the heterogeneous Fenton-like process the optimum concentration was 100 mg  $\text{Fe}_{\text{SBA-15}}/\text{L}$ .

## PROJECT BENEFICIARIES



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- \* For the solar Fenton, the addition of H<sub>2</sub>O<sub>2</sub> from 50 to 500 mg/L increases the reduction of COD from 58 to 69%, respectively, while further increase causes no further improvement. During the heterogeneous Fenton-like process, the optimum COD removal was achieved at 100 mg/L H<sub>2</sub>O<sub>2</sub>. Further increase caused a decrease in the treatment efficiency.
- \* During the solar Fenton process the pH range should be kept between the optimum ranges of 2.8-3.0. The heterogeneous Fenton-like process proved to be a very flexible method, since under both acidic and alkaline conditions the same reduction in the organic content is achieved.
- \* The reduction of organic content increased with increasing temperature and especially the COD removal ranged from 46 to 72% for 15 to 40 °C for the solar-Fenton process, while for the heterogeneous Fenton-like process the higher temperature (i.e. 40 °C) seems to cause a slight decrease in the mineralization efficiency of the process.
- \* Winery wastewater effluents degradation both for solar Fenton and solar heterogeneous Fenton-like process follows a first-order kinetic law in the first 25 min.
- \* Under the optimum experimental conditions total phenols removal after 120 min of solar Fenton was 71%, while for the heterogeneous Fenton-like process it was about 80%.
- \* The color removal reached a maximum of 53% at a reaction time of 120 minutes with the solar Fenton process.

## FUTURE ACTIONS

Regarding the progress of the project the following actions are either ongoing or planned to take place within the next time period:

- \* The construction of the pilot winery wastewater treatment plant for Tsiakkas winery is nearing completion by S.K. Euromarket Ltd.
- \* Following the construction and operation of the pilot plant a guided tour for a number of involved stakeholders (e.g. winery owners, wastewater engineering companies, institutions and involved public bodies) will take place at the premises of the winery. In addition, an employee training will be conducted to the winery employees and environmental manager related to the operation of the plant.

For further information on the WINEC project  
please visit our website:

[www.eng.ucy.ac.cy/winec](http://www.eng.ucy.ac.cy/winec)

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