Advanced Systems for the Enhancement of the Environmental Performance of WINEries in Cyprus

Technical Specifications Manual

Membrane Biological Reactor & Solar Photocatalytic Treatment Plant

winec

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University of Cyprus

S.K. euromarket LTD
WATER & WASTEWATER ENGINEERING

ΤΣΙΑΚΚΑΣ

ΤΑΛΩΣ

Basic Operating Principle

The Winery Wastewater Treatment Plant was developed in order to eliminate the organic content of effluents deriving from wineries during grape processing and wine production.

The plant consists of three sequential treatment steps; (1) preliminary treatment, (2) biological treatment, and (3) advanced oxidation. The Preliminary Treatment includes the screening step followed by an equalization/balancing tank where wastewater pH is adjusted. The biological treatment includes a pre-aeration/nitrification tank to ensure oxygen saturation of the wastewater and a membrane biological reactor (MBR) which utilizes microorganisms to biologically oxidize the organic content. Finally, the advanced oxidation step includes a solar reactor, with compound parabolic collectors, (CPC type) which employs solar light for the polishing of the wastewater stream by eliminating any residual organic content present in the effluent prior to discharge into the environment.

There are design and setback requirements in order to protect the surrounding environment.

Design Data

The Winery Wastewater Treatment Plant (WWTP) employing MBR and Solar technology has been designed according to the following data:

	Influent
Average Flow (DWF):	4.0 m^3/d
Daily Peak flow:	8.0 m^3/d
Feed Rate to balance tank:	0.2 m^3/hr
BOD_5 concentration:	2500 mgO_2/L
COD concentration:	6000 mg O_2/L
Total Nitrogen	Deficient*

* The total nitrogen and total phosphorous concentrations need to be adjusted prior MBR treatment to ensure availability of nutrients for the healthy development of activated sludge. Normal concentrations should be in the ratio of 100:5:1 with respect to BOD:N:P. The addition of nutrients (e.g. urea and phosphoric acid) is necessary.

The MBR followed by solar oxidation is a technical solution ensuring that effluent quality is excellent (see page 14) and usage of final effluent for irrigation is possible.

System Components & Technical Specifications (1/9)

1. SCREENING

Screening is an essential part of the process in order to avoid abrasion problems with grape seeds circulating between the membranes.

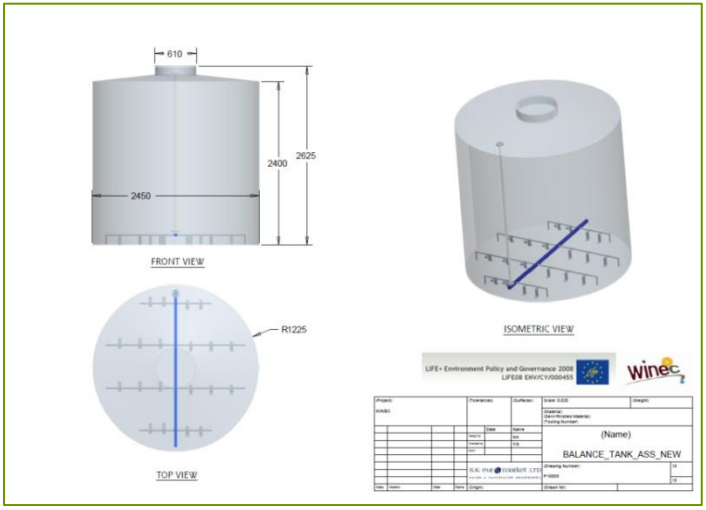
Raw winery wastewater is collected through a gravity wastewater system into a prefabricated static basket screen with openings of 2 mm which is installed in a pit. All particulate matter with diameter exceeding the 2 mm is thus removed before wastewater enters the balancing tank.

Pre-screened wastewater is delivered to the balancing tank by a gravity pipe.

System Components & Technical Specifications (2/9)

2. BALANCING TANK

- Prefabricated tank (HDPE) installed above ground. Wet volume of the tank (10 m^3) allows homogenization and flow stabilization.
- Air is injected into the tank by an air blower through course bubble diffusers.
- Water level in the tank is controlled via level sensors.
- Nutrient addition (urea and phosphoric acid) is entered manually when necessary.
- Feed pump installed in the machinery room transfers wastewater at constant flow to the MBR biological reactor.



System Components & Technical Specifications (3/9)

3. pH ADJUSTMENT

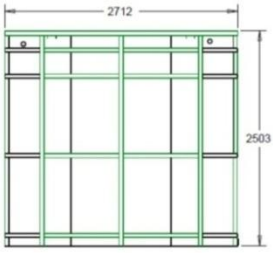
A return line on the outlet of the feed allows measurement of pH via a pH sensor and a measuring instrument.
Measured values are compared to the desired set point and correction of pH is made by dosing acid or caustic soda solution to the return line by dosing pumps.

System Components & Technical Specifications (4/9)

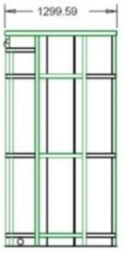
Following the balancing tank, winery wastewater with adjusted pH is pumped by a self priming feed pump into the prefabricated MBR system consisting of two compartments which are designed to ensure the removal of all pollutants in the wastewater to the required standards.

MBR system consisting of two compartments:

1. Pre-aeration (nitrification)
2. Membrane Bioreactor



FRONT VIEW

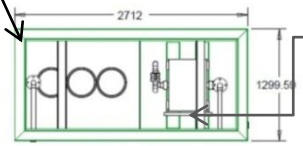


SIDE VIEW

ISOMETRIC VIEW

Pre-aeration (nitrification)

Membrane Bioreactor

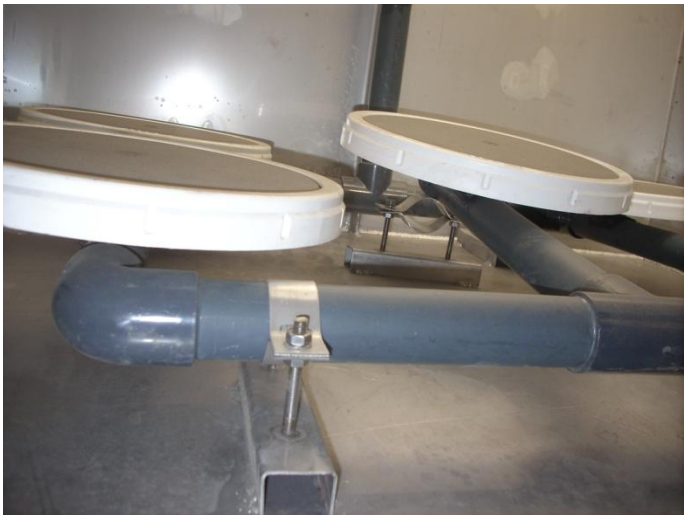


TOP VIEW

System Components & Technical Specifications (5/9)

1. PRE-AERATION / NITRIFICATON TANK

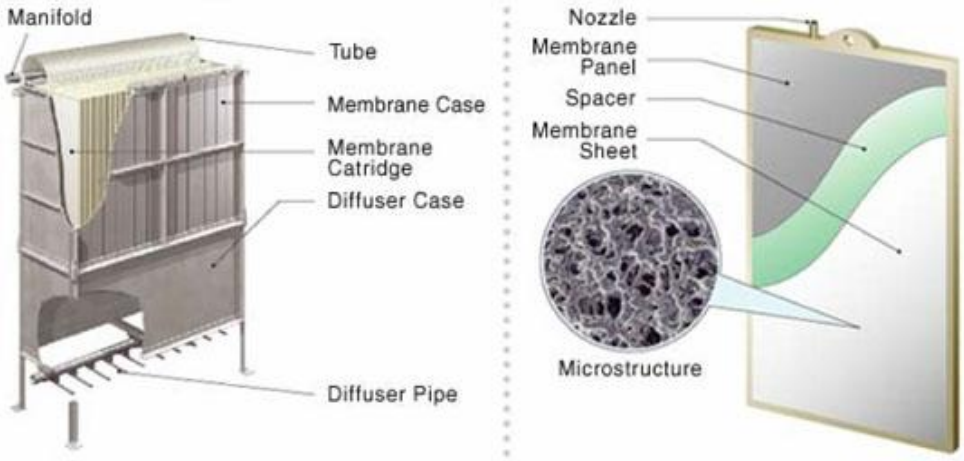
- Pre-aeration/nitrification is the initial treatment stage of prefabricated biological system.
- The mixing of the tank content is promoted with the supply of air that is primarily used to enhance oxidation of the nitrogenous and organic carbon substances.
- Aeration is provided by air blower through three fine bubble air diffusers supplied and installed at the bottom of the tank.



System Components & Technical Specifications (6/9)

2/I. MEMBRANE BIOREACTOR (MBR)

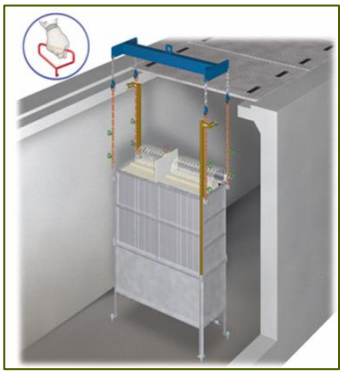
- It is the core unit of the biological process.
- It allows the development of bacterial cultures that are capable of biodegrading the organic pollutants and the separation of purified effluent with the use of submerge membrane unit.
- A continuous feed of air is provided by air blower into the tank content that is also used for the air scouring of the membrane modules. A mixture of activated sludge and organic substances is developed in the reactor.

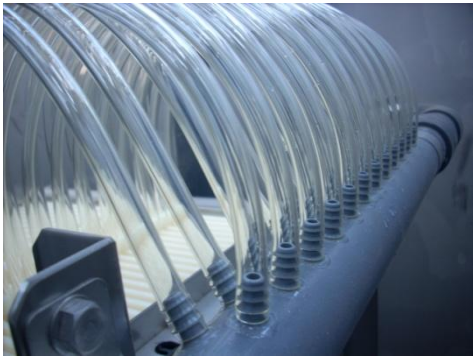


System Components & Technical Specifications (7/9)

2/II. MEMBRANE BIOREACTOR (MBR)

- A submerged membrane module serves as the solid-liquid separation stage. In this manner activated sludge is maintained into the reactor while treated effluent permeates through the membrane to a common manifold and is stored in the final effluent tank.
- Effluent is pumped to the final effluent storage tank, via permeate pump which is installed above ground, next to MBR unit. A flow indicator, installed on the discharge side of the permeated pump allows monitoring of product flow rate.

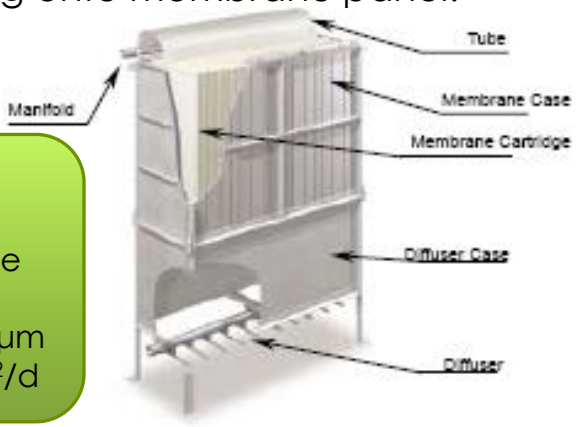




System Components & Technical Specifications (8/9)

2/III. MEMBRANE BIOREACTOR (MBR)

- Submerged Membrane Unit (SMU) is composed of membrane case and diffuser case as shown in the Figure below. In the membrane case, a flat membrane sheet sits at 0.7 mm intervals.
- A flat membrane plate, Membrane Cartridge, is constructed by ultrasonically welding sheets of chlorinated polyethylene on both front and back of ABS resin membrane panel.
- Membrane sheets, a spacer is laid to distribute filtered water into a series of channels that lead to a nozzle on top of the cartridge. Moreover the spacer prevents membrane sheets from sticking onto membrane panel.

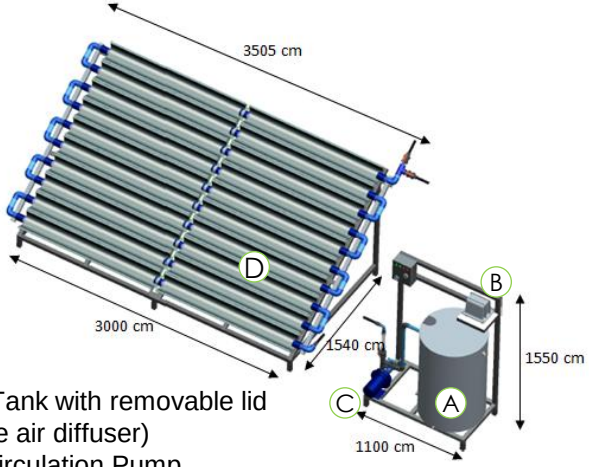


- No of SMU: One
- 25 cartridges/unit
- Total available surface area: 20 m^2
- Filtration Degree: 0.4 µm
- Design flux: 0.5 $m^3/m^2/d$

System Components & Technical Specifications (9/9)

The pilot plant for the solar oxidation process is a skid mounted unit and it consists of:

- Wastewater Buffer/Storage Tank (A)
- Air blower to diffuse air into tank via coarse bubble air diffuser (B)
- Feed pump to pump/recirculate effluent to solar collectors. Feed pump rate is monitored via flow indicator (C).
- Compound parabolic collector (CPC) type solar reactor (D). A number of CPC assemblies is installed to provide sufficient retention time for complete elimination of the residual organic content of the wastewater.



COMMON NAME

A. Effluent Storage Tank with removable lid
B. Air Blower (bubble air diffuser)
C. Feed Pump / Recirculation Pump
D. Compound Parabolic Collector (CPC) unit

Normal Operation

Regular Service Maintenance

Do's and Don'ts

- Avoid introducing in the wastewater stream effluents with higher organic load than the corresponding design characteristics (see page 3).
- Never exceed the daily peak flow of 8 m^3.
- Inspect the grid at a regular time basis and clean it when necessary (during harvest season it may require daily manual solids removal).
- Keep all components relatively clear of dust and dirt.
- Do not discharge any chemicals into wastewater stream that may be inhabitant to the biological process
- Visual inspection and monitoring of the treatment plant and equipment according to manufacturer's instruction
- Sludge concentration in MBR system should not be more than 15,000 mg/l MLSS (*Mixed Liquor Suspended Solids*). If more remove sludge by opening the sludge discharge valve. Make sure that the liquid level in the reactor is above the SMU.
- Adjust blower's operation to cope with seasonality and maintain dissolved oxygen concentration equal to 2mg/l
- Chemical cleaning of membranes is necessary when suction pressure is higher than 0,25 mbar vacuum.
- Proceed with MBR air diffuser cleaning-flushing by opening cleaning valve for one (1) minute in a weekly basis.
- Regularly clean the CPC unit of solar reactor with water to maintain the glass and aluminum surfaces clear of dust and salt accumulation.
- During operation of the solar system a thin colored film may form covering the inner area of the glass tubes; as its presence decreases the efficiency of the process it should be removed by passing a few times a stream of tap water adjusted to pH 10.
- Prior to final discharge of the treated effluent adjust the pH ~7.

Wastewater Quality Characteristics

The table shows the main quality characteristics of the wastewater stream entering and exiting the treatment plant. The results were obtained during normal operational testings of normal operation employing winery wastewater of varying quality characteristics (e.g. produced during vintage and non-vintage periods)

	INFLUENT	EFFLUENT**
Chemical Oxygen Demand (COD) (mg O_2 /L)	1250 - 7000	30 - 45
Dissolved Organic Carbon (DOC) (mg/L)	500 - 2700	8 - 27
Biochemical Oxygen Demand (BOD_5) (mg O_2 /L)	75 - 2700	≤10
pH (20 °C)	5 - 6.8	3 - 4
Total Suspended Solids (TSS) (mg/L)	420 -1400	3 -10
Total Nitrogen (TN) (mg/L)	0.7 - 45	0.2 -15
Total Phosphorous (TP) (mg/L)	3.3 - 10	0.1 - 0.9
Fats and oils (mg/L)	14 - 40	~0

** The above characteristics will be achieved provided that (i) in the MBR system the sludge concentration does not exceed 12,000 mg/L MLSS, there is adequate concentration of nutrients and the dissolved oxygen is maintained between 1.5-2.0 mg/L;, and (ii) the input stream of the solar oxidation system is introduced with 3mg/L Fe^{2+} and 500 mg/LH_2O_2 and is irradiated with solar light for 180 min under continuous recirculation.

Plant Efficiency & National Discharge Limits

The table shows the efficiency of the Treatment Plant during normal operation testing employing winery wastewater of varying quality characteristics (e.g. produced during vintage and non-vintage periods)

	EFFICIENCY‡ (%)	Discharge Limits (mg/L)***
Biochemical Oxygen Demand (BOD_5)	**≥99.6% (≤10 mg/L)**	**10 (25)**
Total Suspended Solids (TSS)	**>99% (≤10 mg/L)**	**10 (35)**
Total Nitrogen (TN)	**58-71% (≤15 mg/L)**	**15 (15)**
Chemical Oxygen Demand (COD)	**>99.4% (30-45 mg/L)**	**- (125)**
Total Phosphorous (TP)	**91-97% (≤0.9 mg/L)**	**- (2)**
Fats and oils	**98.5-100% (~0 mg/L)**	**5 -**

‡ The numbers in brackets refer to the corresponding values of the treated effluent.

*** Cypriot discharge limits for treated effluents released into surface waters. The numbers in brackets refer to the corresponding Greek discharge limits (FEK 192/B/14.3.97)

Membrane bioreactor followed by solar pilot plant

The picture above demonstrates the final winery wastewater treatment plant (WWWTP) constructed at Tsiakkas winery as part of Action 5.

The design, construction, installation and commissioning of Winery Wastewater Treatment (WWWT) plant were undertaken by **S.K. EUROMARKET LTD** (Associated Beneficiary of the project)

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