

# Vegetation Water Management by Evaporation Basins

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## 1. Introduction

Vegetation waters produced during olive oil processing have started to cause important environmental problems during last decade in all the olive growing countries.

In the most of cases the olive vegetation waters produced by the olive oil factories are conducted, without any treatment, to the nearest waters resources (rivers lakes etc) wherefrom they, finally, flow to the underground waters or to the sea causing severe environmental problems. Usually vegetation waters being very rich in sugars consist the base for the development of a large variety of micro-organisms which may consume an important part of the oxygen contained in the surface waters or may cause toxic or pathogenic effects on the plant or animal organisms. In other cases vegetation waters are conducted to cultivated lands, shrubs or bare soils where they cause toxic or pollution problems or flow to the water environment.

The pollution potential and the composition of the olive vegetation waters in organic and mineral material per unit of olive vegetation waters produced depends on the type of oil factory. Vegetation waters have higher pollution potential and higher concentration in organic and mineral material in the classical than in the centrifugal of 3 phases oil extraction systems (Tab.1).

However, the amount of the olive vegetation waters produced per unit of elaborated olive fruits is much lower in the classical system than in the centrifugal of 3 phases system. The ratio of the vegetation water produced per unit of elaborated fruits is: 0,65:1 and 1:1 for the classical system and centrifugal of 3 phases system respectively (Michelakis N. 1994). Thus, the pollution potential per unit of elaborated fruits is about the same for both systems. In the centrifugal of 2 phases systems the ratio of vegetation waters per unit of elaborated fruits is much lower (0.2:1) while the composition in mineral and organic material is about the same as in the classical system. Thus, the pollution potential per unit of elaborated fruits in the centrifugal of 2 phases system is notably lower regarding the classical system and more lower regarding the centrifugal of 3 phases system.

Most important reasons responsible for the increase of the intensity of the problem during last years can be considered the following :

- The significant increase of the olive oil production in almost all olive producing countries.

- The important increase of the vegetation waters produced per unit of elaborated fruits with the expansion of the centrifugal 3 phase oil extraction systems in all the world.

Many efforts have been made to solve the pollution problem of olive

vegetation waters during last decades (Amirante R. 1994, Fiestas J. 1994 ) but for the moment does not exist any method combining the practical, economical and technical feasibility required to insure a significant applicability in practice.

The method of the evaporation basins although is not the most ideal, continue to present a significant feasibility for many areas. This method has been extended rapidly during last decade in Crete where nowadays is used by about 70 % of the olive factories.

**Tab. 1. Chemical Composition of Olive Vegetation Waters**

VEGETATION WATERS CHARACTERISTICS	TYPE OF THE OIL FACTORY	
	CLASSICAL SYSTEM	CENTRIFUGAL OF 3 PHASES
Salinity (mmhos/cm)	8,0 -16,0	8,0 -16,0
PH	4,5 - 5,0	4,7 - 5,2
Pollution Potential :		
COD (kg/m <sup>3</sup> )	120 - 130	45 - 60
BOD (kg/m <sup>3</sup> )	90 - 100	35 - 48
Total Solids (%)	12,0	6,0
- Organic	10,5	5,5
- Inorganic	1,5	0,5
Organic Material (%)	10,5	5,5
- Total Sugars	2,0-8,0	0,5-2,6
-Nitrogen	0,5-2,0	1,7- 0,4
- Organic acids	0,5 -1,0	0,2-0,4
- Polyalchools	1,0- 1,5	0,3-0,5
- Polyphenols	2,0 - 2,4	0,3 - 0,8
Mineral Material (%)	1,50	0,50
- P	0,10	0,03
- K	0,70	0,30
- Ca	0,07	0,02
- Mg	0,04	0,01
- Na	0,09	0,03
- CO <sub>3</sub>	0,37	0,10
- SO <sub>3</sub>	0,04	0,015
- Cl <sub>2</sub>	0,03	0,01
- SiO <sub>2</sub>	0,005	0,002

## 2. Description of the Method

According to the evaporation basins method the olive vegetation water produced by the oil factories is conducted by means of plastic pipes either by natural flow or pumping in open water-tight basins constructed in some distance from the factory. (Fig. 1). Vegetation waters plus the rainfall within the basins are subjected to natural evaporation by means of the solar energy. When the evaporation is terminated a solid material consisting of the organic and minerals material contained to the vegetation waters is concentrated at the bottom of the basin (Fig.2). This solid material, rich in organic and mineral material is used as a fertiliser for olive orchards or as a fuel in the oil factory.



Fig.1 • Group of evaporation basins on sloping fields



Fig.2. Evaporation basin with the residual solid material

A right constructed evaporation basin has to be completely impermeable in order to avoid the infiltration of the waste waters to the deeper soil layers and the consequent pollution of the underground waters. For this reason impermeable soils (Fig.3) have to be chosen or artificial impermeable material (plastic films or cement) have to be used on the bottom of the basin (Fig.4).



Fig.3. Evaporation basins on calcareous impermeable soils



Fig.4. Evaporation basin with plastic film on the bottom

An other important factor for a well functioned evaporation basin is its dimensions and particularly its surface area which has to be calculated to insure the finish of the evaporation at least before the middle or end of the next summer.

When sloping fields are available it is recommendable the construction of more than one communicated basins at different levels. In this case the vegetation water is leaded firstly to the upper basin from which it flows to the lowers ones after a certain depth is filled. By this way, the most of the solid material is concentrated in the upper basin where it can be collected and treated easier.

It is indispensable to install an iron net protection frame around the basin in order to avoid falling of men or animals.

### 3. Design of the Evaporation Basin

Basic requirements that have to fulfil an evaporation basin are:

- Adequate capacity enough to receive the total amount of vegetation waters of the oil factory plus the rainfall of the area

- Large surface area enough to insure the natural evaporation of the total introduced liquids in a determining time, usually not later than the end of the Summer.

Consequently, the design of an evaporation basin depends mainly on the volume of vegetation waters to be evaporated, the date on which the evaporation process has to be terminated and the height of the rainfall and evaporation in the area.

### 3.1.Preliminary Design Factors

The preliminary design factors which have to be examined before the final design of an evaporation basin are the elaboration capacity of the factory, the soil, topographic and climatic condition of the area where the basin will be constructed and on the other social and economic activities (tourist, industry etc.) in the area.

Oil factory capacity conditions :

- The maximum amount of olive fruits, expected to elaborate the oil factory per year and it's distribution per month during the season .

- The elaboration capacity of the oil factory per hour and the average working hours per day.

- The ratio vegetation waters produced per unit of elaborated fruits in the oil factory.

Climatic conditions:

- The average maximum Rainfall per month during the evaporation season.

- The average minimum Real Vegetation Water Evaporation in the area per month during the evaporation season. This can be calculated from existing statistical data of Class "A" pan Evaporation in the area multiplying by the Vegetation Water to Class A pan Evaporation Coefficient. (Michelakis et al, 1997).

- The velocity and the frequency of the most commonly blowing winds in the area.

Soil and topographic conditions.

The impacts of the evaporation basin on the natural and social environment of the area is of great importance.

The microbial or chemical contamination of the underground waters due to the

Vegetation waters deep infiltration can be avoided using Impermeable soils such as calcareous- clay soils composed by pure and undisturbed matric material or artificial impermeable material.

The bad smell or sensitive environmental pollution can be avoided using places

away from the urban areas and opposite to the main winds.

### 3.2. Calculation of the Dimensions

The surface area  $S$  and the depth  $D$  of the basin are the main parameters

needed for a well basin construction .

#### Vegetation Waters

The depth  $H$  (m) of the total liquids (vegetation waters plus rainfall) contained in the Evaporation basin (Fig. 1) on a date  $x$  will be:

$$\underline{\underline{H=W+R -E_v}} \quad (1)$$

In which :

$W$  is the depth (m) of vegetation waters introduced in the basin till the  $x$  date

$R$  is the cumulative rainfall (mm) in the area from the beginning of the season

(October) till the  $x$  date

$E_v$  is the cumulative evaporation (m) of the liquids (vegetation waters or rainfall) from the date when they start to exist in the basin till the  $x$  date

On the time  $T$  when the evaporation will be terminated, it will be  $H=0$  and the eq. 1 becomes :

$$W = E_v - R \quad (2)$$

The total depth  $W$  of vegetation waters in the basin can be expressed as

$$W=V/S \quad \text{or} \quad W =cF/S \quad (3)$$

In which

$V$  is the total volume ( $m^3$ ) of the vegetation waters introduced in the basin

$S$  is the surface area of the basin  
( $m^2$ )

$F$  is the total amount (tons) of the elaborated fruits during the season and  $c$  is the ratio ( $m^3/ton$ ) of vegetation waters per unit of elaborated fruits

The Surface  $S$  ( $m^2$ ) of the basin combining eq. (2) and (3) can be calculated by the equation

$$S = \frac{cF}{Ev - R} \quad (4)$$

The Depth  $D$  (m) of the basin must be adequate to receive the maximum expected height  $H$  of the liquids in the basin. Thus, from eq. (1) it will be:

$$D = (R + W - Ev)_{max} \quad (5)$$

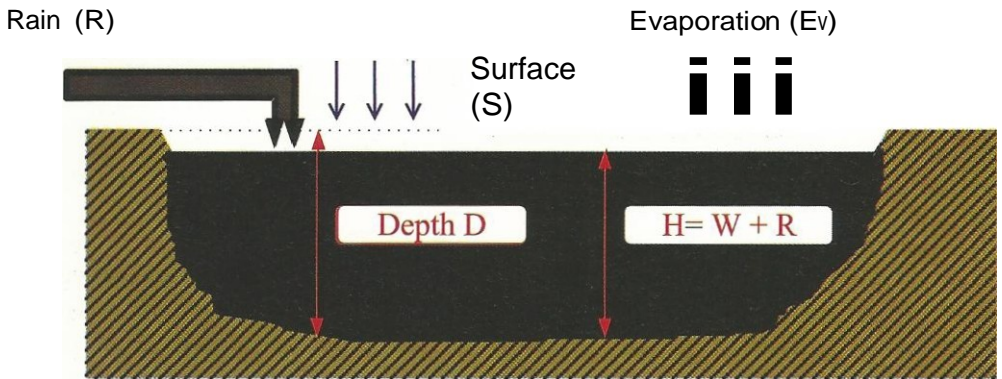


Fig.S Schematic representation of the cross section of a typical evaporation basin

The maximum value of eq. (5) depends on the course of the rainfall  $R$  and Evaporation of vegetation water  $Ev$  in the area as well as on the course of vegetation waters production by the oil factory. Thus, the depth  $D$  can be calculated comparing the statistical values of  $R$  and  $Ev$  per month in the area.

However, in a right design of an evaporation basin for safety reasons it is recommendable to account the maximum statistical values of the  $R$  and  $W$  and the minimum of the  $Ev$  per month.

Of course, the rate of Evaporation  $Ev$  of vegetation waters is not the same with the rate of  $E_o$  of the evaporation of the natural water. Thus, Evaporation coefficients  $K_v$  of vegetation waters to the natural water ( $K_v = Ev/E_o$ , or better to the Class A pan evaporation ( $K_v = \bar{Ev} / E_p$ ) have to be used (Michelakis et al1997)

to calculate the Ev montly values in each area

#### 4. Problems and Perspectives

##### 4.1. Advantages and Disadvantages

As main advantages of the evaporation basin method can be considered:

- The easy and low cost construction when impermeable soils are available and digging machines can be used.
- The minimal to zero cost of operation since the unique care required is the addition of some  $\text{CaCO}_3$  in some cases and the gathering of the solid material at the end of evaporation .

As disadvantages of the method can be considered :

- The large land area required ( $1000 - 3000 \text{ m}^2$ ) depending on the potential of the oil factory and the climatic conditions of the area.
- The probability of leakage and undesirable smells etc. in cases of no right construction and operation. Leakage is probable when permeable soils are used without any protection, while bad smells are produced when anaerobic fermentation take place due to the excessive depth of the basin or to the addition of other urban waste waters.

##### 4.2. Perspectives of the method

- Possibility of covering the basins with plastic material to reduce the area required and to avoid sensitive and bad smell pollution in areas where the price of the land remarkable or the rainfall height is much high.
- Possibility to use the solid material remaining at the end the evaporation as a crop fertiliser because of it's high content in organic and mineral elements.
- Possibility to use the concentrated solution at the end of the evaporation period as a liquid fertiliser or as irrigation water suitable for biological crops.

However it is obvious that to achieve above possibilities suitable knowledge and technologies are required and relevant research has to be planned and executed.

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