SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Sustainable Water Integrated Management and Horizon 2020 Support Mechanism

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Olive Mills Best Available Techniques (BAT)

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Presentation Outline

- **Liquid waste treatment methods**
- **Solid waste treatment methods**

Olive Mill Waste

More than 30 million tons of solid–liquid waste and 15 million tons of olive mill wastewater (OMW) are produced each year by a large number of small olive mills scattered throughout the Mediterranean countries

Although OMW is a natural product, it can pollute water bodies and the environment, because of its composition:

–High BOD (up to 50 g/l) and COD (up to 100 g/l)

–Low pH (≤5)

–High EC (7-11 dS/m) and ion content

–High phenolic content

–Smell and color

–Toxic properties for living organisms

Due to pollution load it is not allowed to be discarded untreated or without control to the environment, especially in water bodies.

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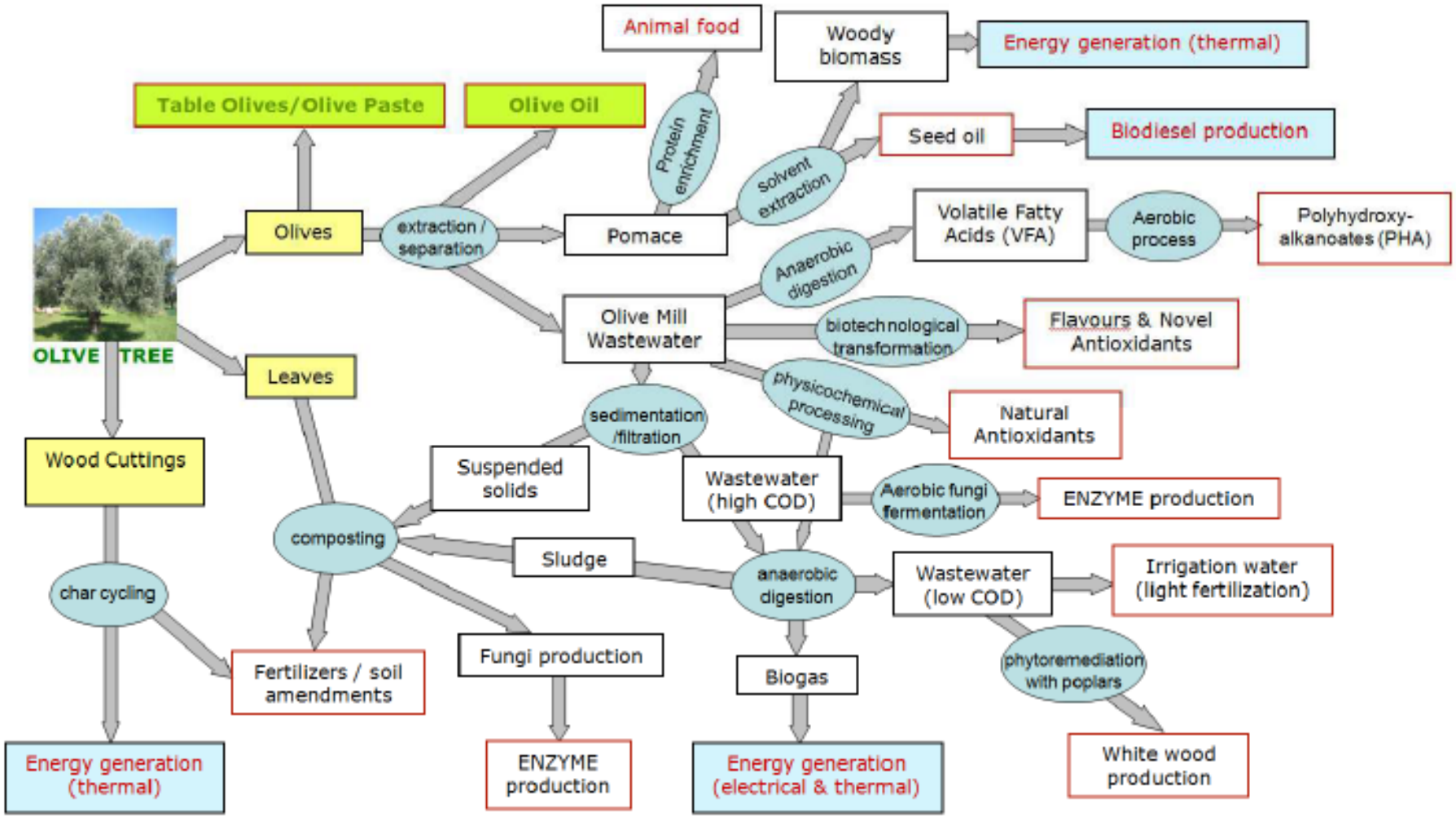
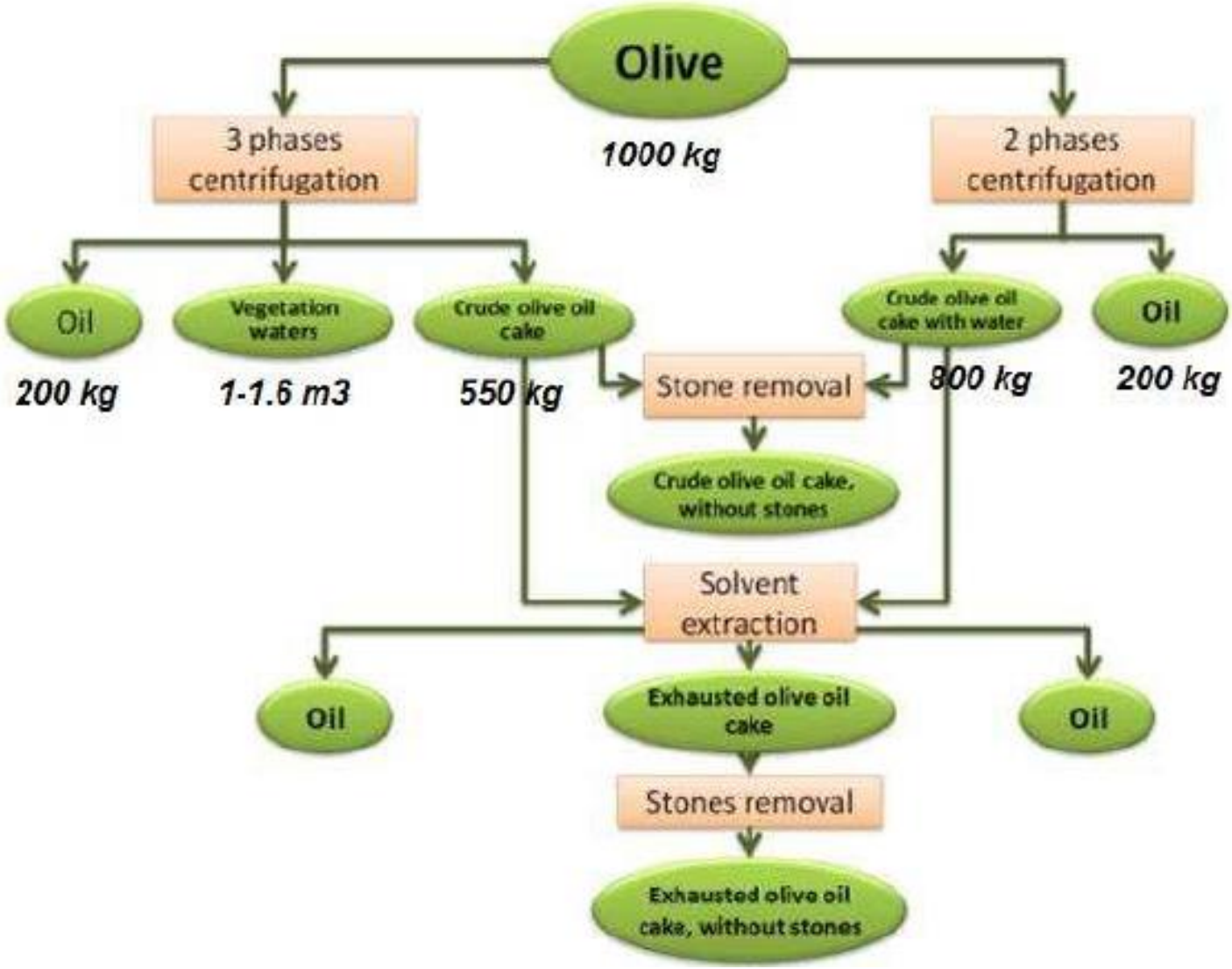
Olive Mill Waste

Olive Mill Waste



Federici F., Fava F., Kalogerakis N. and D. Mantzavinos, "Valorisation of agro-industrial by-products, effluents and waste: concept, opportunities and the case of olive mill wastewaters", *J Chem Technol Biotechnol*, 84, 895-900 (2009).

Olive Mill Process



Olive Mill Waste

OMW possesses a double nature. It is a **strong pollutant** and at the same time a **possible source of valuable components**, such as polyphenols, flavonoids, anthocyanins, inorganic trace elements, etc., that could be isolated (removed) and economically exploited.

A large number of treatments/technologies (physical, chemical, biological) have been tested in many countries, which could be classified in the following categories:

- **Detoxification processes** (aerobic and anaerobic, physicochemical)
- **Processes for production of various products** (fertilizers, compost, antioxidants, biopolymers, animal feed)
- **Integrated processes aiming at energy recovery** (biogas, electricity)
- **Combined processes**.

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OMW treatments in MED countries

Detoxification Processes

Aim at ‘‘cleaning’’ the waste so as to allow its safe, subsequent disposal at water or soil reservoirs. The most important are biological and physicochemical processes.

a. Biological processes. Use **microorganisms** to break down the chemicals present in OMWW. They are divided into aerobic and anaerobic processes according to the type of the micro-flora used.

b. Physicochemical Processes.

Neutralization, Precipitation/Flocculation. Involve the use of **additional chemicals** in order to destabilize the suspended and colloidal matter of OMW and form an insoluble solid that can be removed easily from the waste.

Oxidation processes. Several oxidizing agents have been tested for OMW treatment like **hydrogen peroxide, ozone, chlorine, chlorinated derivatives** in combination with ultraviolet radiation (Advanced Oxidation Processes)

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OMW treatments in MED countries

c. Thermal Processes

Use manmade heat source or a natural source of thermal energy (air, sun). Most important are **evaporation, lagooning** (natural evaporation) and pyrolysis. The main drawback of these processes is related to the post treatment and disposal of the produced emission.

d. Membrane Processes

Membranes are effective for **separation of oil-water** mixtures without adding solvents. With ultrafiltration, only a small amount of retentate (waste) is produced (permeate is 90–95% of the volume of the feed) and very high removal of lipids is achieved. Main problems: the high capital costs, the need of qualified personnel, not affordable for small oil mills.

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OMW treatments in MED countries

Processes aiming at the production of various products

OMW may be regarded as an inexpensive source of inorganic and organic compounds to be recovered because of their potential economic interest or their ability to be transformed into products for use in agriculture, biotechnology, and the pharmaceutics industry as well as in the food industry.

a. Production of Fertilizers (Recycling of the Waste at Land)

Biofertilization or *Bioremediation*. OMWW should not be directly applied on soil and crops because of its phytotoxic properties. Treating OMW with an enriched aerobic microbial population of this kind results in a non-phytotoxic thick liquid that could be characterized as an organic soil-conditioner biofertilizer

Composting. Refers to the process of controlled aerobic biological degradation of organic substrates (wastes, residues, ect). In the case of OMW composting, OMW quantities are added to the solid substrate during the thermophilic stage to replace the water evaporated.

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OMW treatments in MED countries

b. Recovery of Antioxidants

OMW contains water-soluble compounds with potential antioxidant properties, like polyphenols, flavonoids, anthocyanins, tannins, oleanolic acid, and maslinic acid. The processes of extraction of antioxidants of high added value from OMW are patented.

c. Production of Biopolymers

The production of biopolymers from OMW is a very interesting alternative, studied during the last years due to the high added value and excellent properties of these substances. The two main categories of these substances are: exopolysaccharides and polyhydroxyalkanoates.

d. Production of Animal Feed

Olive cakes or solid residues of various OMW processes could be used in animal feeding, as they are rich in oil, carbohydrates, and proteins. Problems arise from OMWW's high concentration of potassium and phenolic compounds which are anti-digestive factors

Liquid waste treatment methods

Disposal and management of highly contaminated wastewater constitute a serious environmental problem due to the biorecalcitrant nature of these types of effluents, in most cases.

Generally, **biological treatment (mainly aerobic)** is the preferred option for dealing with urban and industrial effluents because of its relative cost-effectiveness and applicability for treating a wide variety of hazardous substances.

Some **drawbacks** may be found when applying this technology. For instance, some chemical structures, when present at high concentrations, are **difficult to biodegrade** because of their refractory nature or even toxicity toward microorganisms.

Thus, several substances have been found to present **inhibitory effects** when undergoing biological oxidation. Among them, phenolic compounds constitute one of the most important groups of pollutants present in numerous industrial effluents

Olive Mill Effluents

The olive oil industry (a common activity in Mediterranean countries), in particular, generates highly contaminated effluents during different stages of mill olive oil production (washing and vegetation waters).

Therefore, most treatment processes used for high-strength industrial wastewaters have been applied to olive oil mill effluents (OME). Yet, **OME treatment difficulties** are mainly associated with:

(a) high organic load (OME are among the strongest industrial effluents, with COD up to 220 g/L and sometimes reaching 400 g/L)

(b) seasonal operation, which requires storage (often impossible in small mills)

(c) high territorial scattering

(d) presence of organic compounds that are difficult to degrade by microorganisms (long-chain fatty acids and phenolic compounds of the C-7 and C-9 phenylpropanoic family)

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Olive Mill Effluents

The following **key treatment methods are mainly applied to liquid waste**. Some of these methods can also be used in the treatment of liquid–solid waste, for example, treatment by fungi, evaporation/drying, composting, and livestock feeding.

Regarding the olive oil industry, it should always be considered that complicated treatment methods that lack profitable use of the final product are not useful, and all methods should have a control system for the material flows

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Low cost methods

- **Drainage of olive oil mill liquid waste in some types of soils**, with rates up to 50 m3/ ha-year (in the case of traditional mills) and up to 80 m3/ha-year (in the case of decanting-based methods), or to apply the olive oil mill liquid wastes to the irrigation water for a rate of less than 3%. These processes are risky because they decrease the fertility of the soil. This calls for greater care and scientific research into these methods prior to agronomic application.

Low cost methods

- **Simple disposal and retention in evaporation ponds** (large surface and small depth ponds), preferably in distant regions, to be dried by solar radiation and other climatic factors. This method does not require energy or highly trained personnel. Drawbacks are associated with the evaporation process, which generates odors and additional risks for the aquatic system of the area (filtration phenomena, surface water contamination, etc.).

In addition, the disadvantages include: the need for large areas for drying in selected regions with impermeable (clay) soil distant from populated areas; the requirement, in most cases, for taking necessary precautions to prevent pollutants reaching the groundwater through placement of impermeable layers in the ground and walls of ponds; ineffective in higher rainfall regions; emergence of air pollutants caused by decomposition of organic substances. **Dried sludge** from corporation ponds can be used as **fertilizer, either directly or composted with other agricultural byproducts**

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Low cost methods

- **Mixing the olive oil mill liquid wastes with municipal solid wastes in sanitary landfills** leads to increased organic load on site. Consideration should be made regarding the **pollutants that may reach the groundwater**, in addition to the risks of combustion due to **generation of combustible hydrocarbon gases**. These factors should be taken into account in designing and establishing landfills, not forgetting the necessity to collect and treat the drainage wastewater resulted from applying this method. This method is cost-effective and is suitable for final disposal of the wastes, with the property of **obtaining energy from the generated gases**. Nevertheless, there are drawbacks such as the **air pollution** caused by the decomposition, the need for advanced treatment for the highly polluted collected drainage wastewater, and the need for using large areas of land and particular specifications.

Aerobic treatment

When biodegradable organic pollutants in olive oil mill wastewater are eliminated by oxygen-consuming microorganisms in water to produce energy, the **oxygen concentration decreases and the natural balance in the water body is disturbed**. To counteract an overloading of the oxygen balance, the largest part of these oxygen-consuming substances (defined as BOD) must be removed before being discharged into the water body. **Wastewater treatment processes have, therefore, been developed with the aim of reducing the BOD concentration as well as eliminating eutrophying inorganic salts**, that is, phosphorus and nitrogen compounds, ammonium compounds, nonbiodegradable compounds that are analyzed as part of the COD, and organic and inorganic suspended solids.

In aerobic biological wastewater treatment plants, the natural purification processes taking place in rivers are simulated under optimized technical conditions. **Bacteria and monocellular organisms (microorganisms) degrade the organic substances dissolved in water and transform them into carbonic acid, water, and cell mass**. The microorganisms that are best suited for the purification of a certain wastewater develop in the wastewater independently of external influences and adapt to the respective substrate composition (enzymatic adaptation). Owing to the oxidative degradation processes, oxygen is required for wastewater treatment. The oxygen demand corresponds to the load of the wastewater.

Aerobic treatment

A number of factors should be considered when discharging industrial wastewaters, including olive oil mill effluents, into municipal plants:

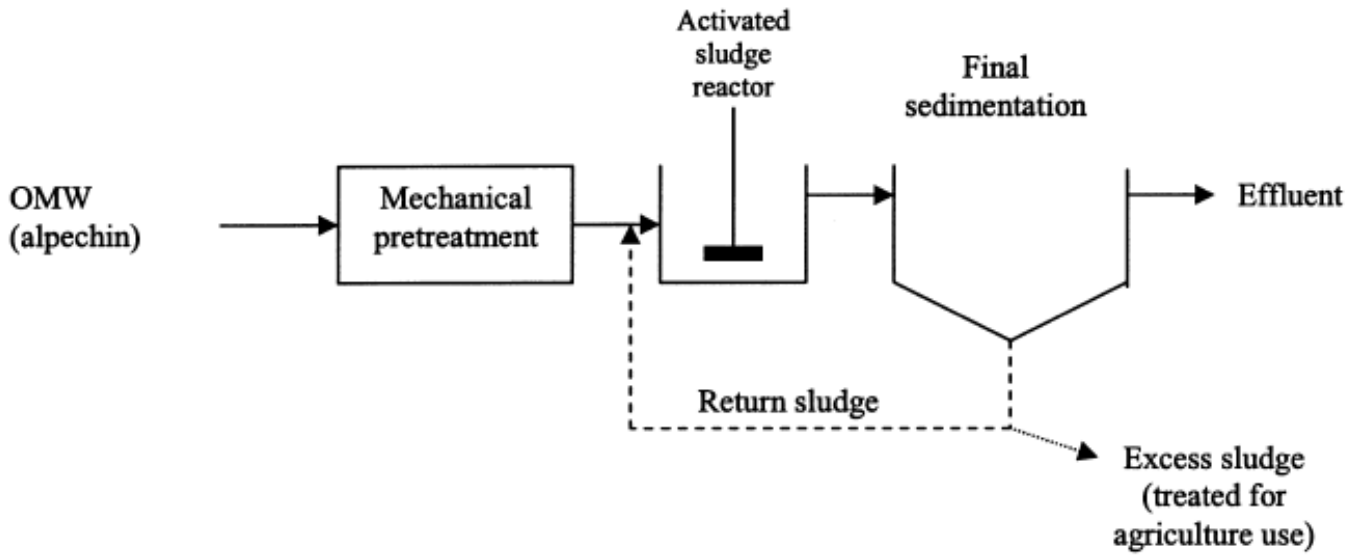
- **Effect on effluent quality**. Soluble industrial wastewaters will affect the reaction rate K. Refractory wastewaters such as olive oil mills, tannery, and chemical will reduce K, while readily degradable wastewaters such as food processing and brewery will increase K.
- **Effect on sludge quality**. Readily degradable wastewaters will stimulate filamentous bulking, depending on basin configuration, while refractory wastewaters will suppress filamentous bulking.
- **Effect of temperature**. An increased industrial wastewater input, that is, soluble organics, will increase the temperature coefficient, thereby decreasing efficiency at reduced operating temperatures.
- **Sludge handling**. An increase in soluble organics will increase the percentage of biological sludge in the waste sludge mixture. This will generally decrease dewaterability, decrease cake solids, and increase conditioning chemical requirements.

Aerobic treatment

The **activated sludge** process is a biological wastewater treatment technique in which a **mixture of wastewater and biological sludge (microorganisms)** is agitated and aerated. The biological solids are subsequently separated from the treated wastewater and returned to the aeration process as needed.

The activated sludge process derives its name from the biological mass formed when air is continuously injected into the wastewater. Under such conditions, microorganisms are mixed thoroughly with the organics under conditions that stimulate their growth through use of the organics as food. As the microorganisms grow and are mixed by the agitation of the air, the individual organisms clump together (flocculate) to form an active mass of microbes (biologic floc) called activated sludge .

Aerobic treatment



Anaerobic treatment

Anaerobic processes are increasingly used for the treatment of industrial wastewaters. They have distinct advantages including **energy and chemical efficiency and low biological sludge yield**, in addition to the possibility of treating organically high-loaded wastewater (COD 1500 mg/L), with the requirement of only a small reactor volume.

Anaerobic processes **can break down a variety of aromatic compounds**. It is known that anaerobic breakdown of the benzene nucleus can occur by two different pathways, namely, photometabolism and methanogenic fermentation. It has been shown that benzoate, phenylacetate, phenylpropionate, and annamate were completely degraded to CO2 and CH4. While long acclimation periods were required to initiate gas production, the time required could be reduced by adapting the bacteria to an acetic acid and substrate before adapting them to the aromatic.

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Principle of Anaerobic Fermentation

In anaerobic fermentation, roughly four groups of microorganisms sequentially degrade organic matter.

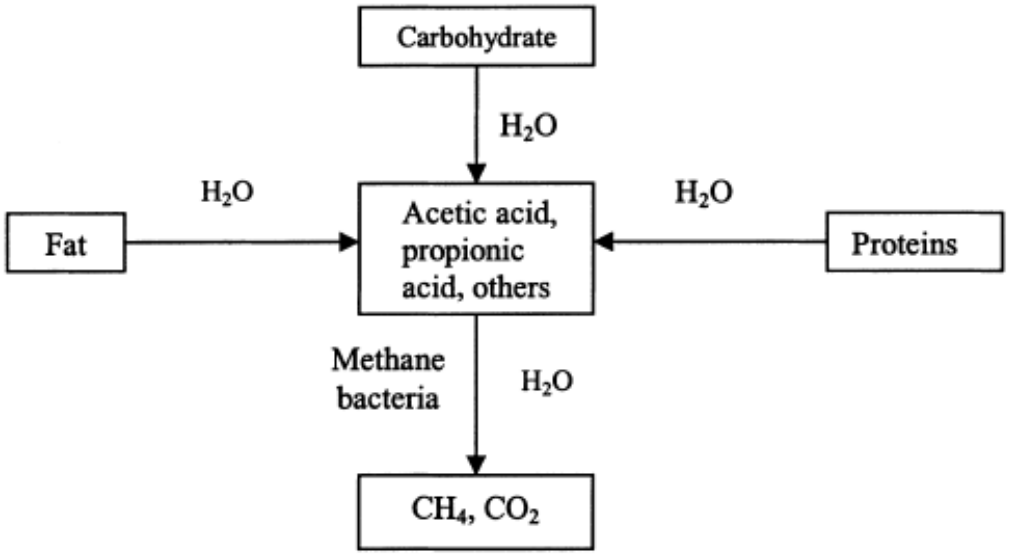
Hydrolytic microorganisms degrade polymer-type material such as polysaccharides and proteins to monomers. This reduction results in no reduction of COD.

The monomers are then converted into fatty acids with a small amount of H2.

In the acidification stage, there is minimal reduction of COD.

Should a large amount of H2 occur, some COD reduction will result, seldom exceeding 10%. All formed acids are converted into acetate and H2 by acetogenic microorganisms.

Principle of Anaerobic Fermentation



Factors Affecting Anaerobic Process Operation

The anaerobic process **functions effectively** over two temperature ranges: the mesophilic range of 85–1008F (29–388C) and the thermophilic range of 120–1358F (49–578C). Although the rates of reaction are much greater in the thermophilic range, the maintenance of higher temperatures is usually not economically justifiable.

Methane organisms function over a pH range of 6.6–7.6 with an optimum near pH 7.0. When the rate of acid formation exceeds the rate of breakdown to methane, a process imbalance results in which the pH decreases, gas production falls off, and the CO2 content increases.

pH control is therefore essential to ensure a high rate of methane production. According to German literature, the tolerable pH range for anaerobic microorganisms is between 6.8 and 7.5. This means that the anaerobic biocenosis is very pH-specific.

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Anaerobic Treatment Systems of Wastewater

Seasonal operation of olive oil mills is not a disadvantage for anaerobic treatment systems because **anaerobic digesters can be easily restarted after several months of mill shutdown**.

At present there are no large-scale plants. However, the anaerobic contact reactors and upflow sludge-blanket reactors have been mainly studied using several **pilot tests**, besides other tested reactors such as anaerobic filters and fluidized-bed reactors.

Sludge retention is decisive for the load capacity and, thus, the field of application of an anaerobic reactor. In the reactor, favorable sludge retention is realized in a simple way.

Combined Biological treatment processes

Before discharge to a nearby water recourse, OMW could be subjected to either of the two subsequently proposed complete treatment systems.

Anaerobic processes are especially suited for the treatment of high-load wastewater with a COD concentration of thousands (mg/L) in industry. Moreover, the climatic conditions in the olive-growing and production countries are optimal for anaerobic processes.

Combining anaerobic and aerobic processes lessens the disadvantages resulting from separate applications. The first step includes the advantages of the anaerobic process concerning degradation efficiency, energy self-sufficiency, and minimal excess sludge production.

The disadvantages of aerobic treatment are nearly compensated by the anaerobic preliminary stage.

The high quantity of excess sludge that normally results is strongly reduced. At the same time, the aeration energy needed for the aerobic process is also considerably minimized. With regard to treatment efficiency, plant reliability, and costs, the anaerobic–aerobic model well suits the treatment of olive oil mill wastewater from both ecological and economical aspects

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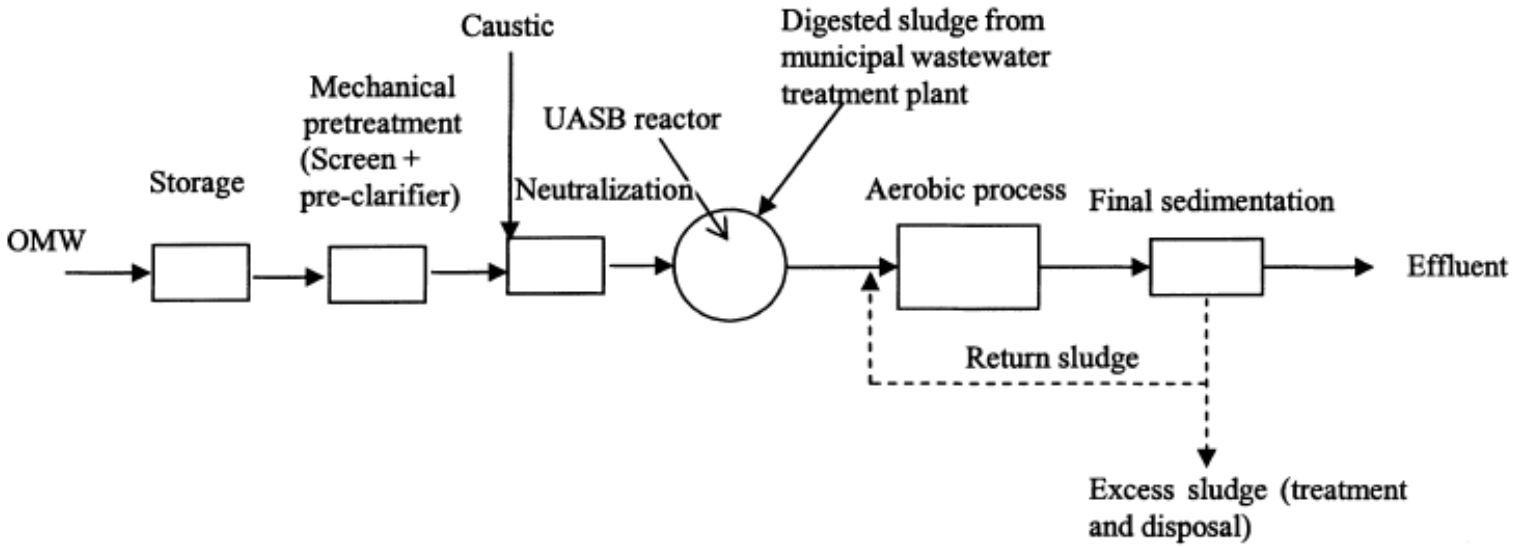
Combined anaerobic–aerobic treatment model (on site)



Wet Air Oxidation and Ozonation

The type of chemical preoxidation used in integrated processes is highly dependent on the characteristics and nature of the wastewater to be treated. Thus, in the case of **effluents with a high content of phenol-type substances**, oxidizing systems **based on the use of oxygen or ozone at high temperatures and pressures** have been shown to readily degrade phenolic structures. Wet air oxidation (WAO) is an oxidation process, conducted in the liquid phase by means of elevated temperatures (400–600 K) and pressures (0.5–20 MPa). The oxidant source is an oxygen-containing gas (usually air).

As pressure increases, the temperature rises, which leads to an increasing degree of oxidation. With far-reaching material conversion, only the inorganic final stages of CO2 and water (and possibly other oxides) are left. With incomplete degradation, the original components (which often are nondegradable) are decomposed to biodegradable fragments. Therefore, it is useful to install a biological treatment stage downstream of the wet oxidation stage

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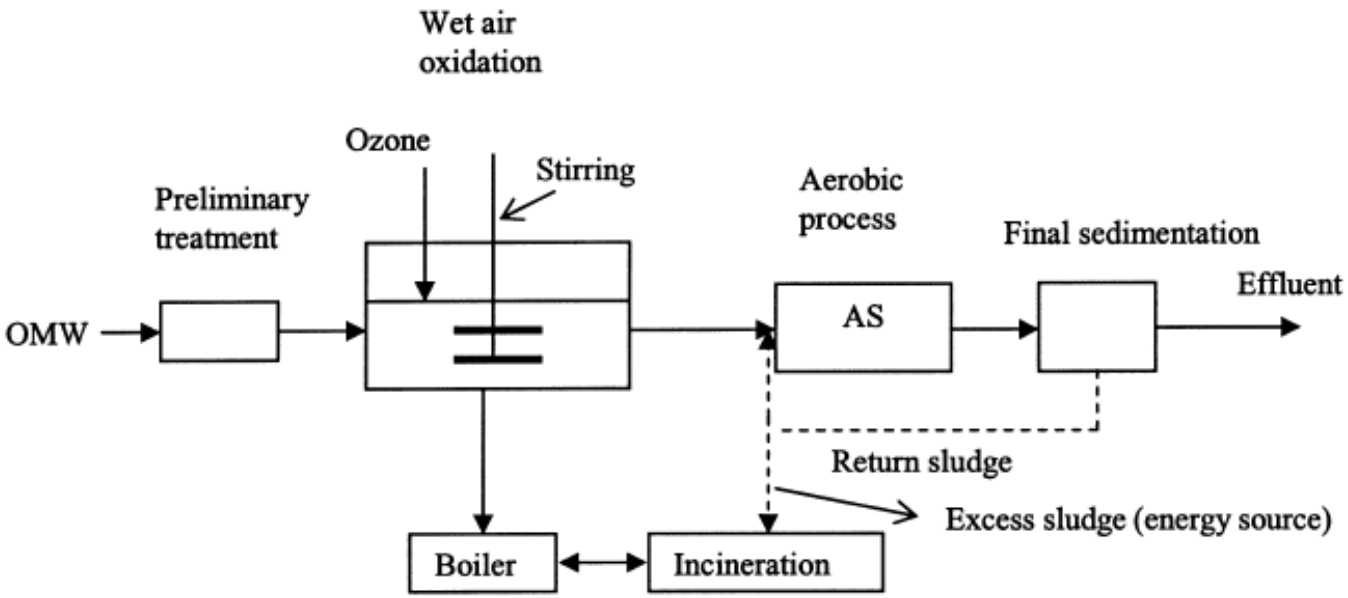
Wet air oxidation–aerobic process



Fungal Treatment

Several types of industrial wastes contain phenols. Many of these compounds are extremely harmful as they are highly toxic both towards microorganisms and vertebrates. **Enzymatic approaches to removing phenols** have been tried for some years as they have several advantages compared with the conventional methods (solvent extraction, chemical oxidation, absorbance on active carbons, etc.).

Recently, results have been obtained for the removal of phenols using phenol oxidizers, which catalyze oxidative coupling reactions of phenol compounds and do not require hydrogen peroxide (H2O2). Olive oil mill wastewaters (OMW) contain large concentrations of phenol compounds, which are highly toxic. The structure of the aromatic compounds present in OMW can be assimilated to many of the components of lignin.

However, some microorganisms actively degrade lignin, among which the “white-rot” fungi are particularly efficient. These organisms utilize mainly peroxidases and phenol oxidizers. Potential applications of white-rot fungi and their enzymes are gaining increasing importance in the detoxification of industrial wastewaters, reducing the toxicity of many aromatic compounds (pesticides, disinfectants, phenols) in several types of polluted environments.

Decolorization

An important step in the **degradation of olive oil wastewater is the breakdown of colored polymeric phenolics** (decolorization) to monomers, which may subsequently be mineralized. A significant correlation has been demonstrated between **sewage decolorization and reduction of total organic carbon and phenolic content**. However, decolorization of wastewaters appears to be associated only with a partial depolymerization. A decrease in the content of the lower molecular mass components and an increase in the proportion of components of intermediary molecular mass have also been demonstrated.

Crude oil wastewater and solutions of its brownish pigment change in both color and solubility as the result of pH modification. It appears that sewage decolorization may be produced simply by a process of adsorption or by adsorption associated with subsequent chemical modification of chromophores.

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Precipitation/Flocculation

Precipitation involves **transforming a water-soluble substance into its insoluble particular form by means of a chemical reaction**. Certain chemicals cause precipitation when they react with dissolved and suspended organic compounds. By adding flocculants and coagulation aids, the finest suspended compounds or those dissolved in colloidal form are then transformed into a separable form.

This means that, in contrast to precipitation, **flocculation** is not a phase-transition process. The wastewater may be **further treated by activated carbon, ultrafiltration, or reverse osmosis**. Iron sulfate and aluminum sulfate are commonly used as efficient chelating agents of complex organic compounds in certain wastewaters. Their adsorption capacity is complex and depends on the composition of the precipitated molecule. Lime stabilization is a recognized means of treating municipal sludge prior to land application. The addition of lime temporarily halts biological activity.

Adsorption

Currently, the most commonly used methodologies for the treatment of aromatic-bearing wastewaters include solvent extraction, physical adsorption separation, and chemical oxidation . The adsorption method, which refers to **bonding of dissolved compounds (adsorbate) at the surface of solid matter** (adsorbent), for example, activated carbon and bentonite, is used for adsorption of dissolved organic pollutants in water. In the field of olive oil wastewater, these are coloring substances (mainly tannic acid), hardly or nonbiodegradable pollutants, bactericidal or inhibiting compounds, which have to be removed.

Adsorption not only takes place at the visible surface of the solid, but also in its pores. Activated carbon is especially suited because of its large inner surface (500–1500 m2/g) and its high adsorptive capacity, but unfortunately it cannot be reused. However, the calorific value is very high so it can be incinerated without problems.

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Biofiltration and Ultrafiltration

Physical processes including filtration, centrifugation, sedimentation, and ultrafiltration are highly efficient methods for phase separation. **Filtration processes are used to remove solid material as far as possible from the wastewater**. Particles and liquid are separated as a result of pressure difference between both sides of the filter, which enables the transport of water through the filter. During the filtering process, the solids accumulate in the filter and reduce the pore volume, resulting in a change of resistance to filtration and of the filtrate quality. As soon as the admissible resistance to filtration is reached, the filter must be backwashed by forcing clean water backwards through the filter bed. The washwater is a waste stream that must be treated.

Compounds that are already dissolved cannot be treated, except by biofiltration. In this case, the filter serves also as nutrient for bacteria so that dissolved organic substance can be aerobically degraded. The purification capacity of biofiltration plants is between 70 and 80%. Up to 100% of the solids can be reduced.

A prerequisite for biofiltration is sufficient oxygen supply. If the alpechin is insufficiently treated, the filter will be quickly clogged. The material kept back in the filter can be used in agriculture

Evaporation/Drying

Evaporation is a method used to **concentrate non-steam-volatile wastewater components**. The evaporation plant contains a **vapor condenser by which vapor and steam-volatile compounds are separated from the concentrate**. While the concentrate is then recycled into the evaporator, the exhaust steam can be used for **indirect heating** of other evaporator stages.

The degree of concentration of the wastewater components depends on different factors, for example:

. reuse of the concentrate (e.g., reuse in production, use as fodder, recovery of recyclable material);

. type of disposal of the concentrate (e.g., incineration, landfill)

. properties of the concentrate (e.g., viscosity, propensity to form incrustation, chemical stability).

Advantages of this method include:

. the residue (dried oil wastes) can be reused as fertilizer;

. only a small area is needed;

. exhaust steam can be reused as energy;

. considered state of the art in the food industry .

Disadvantages are:

. the exhaust steam from evaporation is organically polluted and needs treatment;

. rather high operation and maintenance costs;

. requires high energy;

. requires trained personnel

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Electrolysis

There are methods still in the experimental stage for treatment of olive oil mill wastewater, one of which is electrolysis. This method is based on **electrolytic oxidation of margine constituents**, using titanium/platinum for the anode and stainless steel for the cathode. The following data are drawn from laboratory experience.

The process has the following components:

. electrolytical cell

. recirculation reactor

. margine input

. pH control

. cooling system

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Bioremediation and Composting

The aim of bioremediation is to **repurpose the liquid waste or the liquid fraction of solid-liquid waste, by diverse aerobic fermentation**. The composting of the solid waste or the solid fraction of solid-liquid waste, produces a useful material for plant growth.

Research work has shown that margine is a good substrate for certain microbial fauna. It is especially useful for producing fertilizer for agricultural purposes. Under aerobic conditions, the margine content aids the qualitative breeding of nitrogen-consuming bacteria, especially of acetobacter.

This feature was taken into consideration when developing a treatment method for the wastewaters from olive oil production with high organic load. Using this method, a substrate for soil improvement with high nutrient content is obtained from the wastewaters.

SOLID WASTE TREATMENT METHODS

Many of the abovementioned treatment methods for liquid waste are **suitable for the treatment of solid/liquid waste** arising from the two-phase decanter. Some of these methods are also appropriate for the treatment of solid waste, such as recycling methods (composting and livestock feeding). In this respect, a distinction should be made between aerobic treatment systems for liquid waste (such as activated sludge, trickling filter, bioremediation) and aerobic treatment systems for solid waste (such as composting).

Based on the various experiments and published research for waste, especially solid waste and liquid–solid waste, suitable methods can be proposed for treating waste from olive oil mills

These treatments are classified into three groups: physical, biotechnological, and chemical processes. At the same time, it should be realized that no specific treatment or solution can be generalized. Each case must be studied and evaluated according to local circumstances.

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Biotechnological Processes

Biotechnological processes mainly include **aerobic (composting), anaerobic (mixed fermentation), solid fermentation, and fungal treatments**.

Because olive oil mills are operated over limited periods, that is, about 3 months only per year, an ideal treatment method would be one that could be shifted for treating other types of waste after the end of the olive oil production season.

. The **composting method for solid waste treatment is preferable to other methods**. This process takes place without serious emissions into air, water, or soil and therefore conforms to the key objectives of Mediterranean environmental policy. Since operational and personnel costs are rather low, this process might also be accepted by plant operators.

. The costs of a composting plant strongly depend on the sales potential for the final product in the individual countries. In Greece, for example, higher receipts from compost selling are possible than in Spain. As a result the total costs of a plant also change.

Anaerobic treatment by itself is not suitable for solid waste because of its low water content.

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Physical processes

Evaporation/drying processes and their advantages and disadvantages in liquid waste treatment have already been discussed. In solid waste treatment, these processes can be discussed in detail as follows.

Two of the most important problems related to the treatment of solid waste or solid/ liquid waste are the optimization of drying and oil recovery by physical means (to get, as much as possible, olive oil instead of olive oil waste).

Chemical Processes

Incineration plants are widely known as the conventional means for municipal solid waste treatment for many decades up to the present day. This method, which consists of oxidation of organic substances in high temperatures, has its advantages and disadvantages.

Pyrolysis, in contrast to incineration, is a **thermic-decomposed reaction of materials containing a high percentage of carbon (without oxygen) in high temperatures**. Thus, pyrolysis is a reduction process that might trigger degasification. It is possible to introduce gasification when there is a partial reaction of coke and water with oxygen. These substances react to carbon oxide and hydrogen. The heat obtained in this process helps to crack heavy molecules.

Although the pyrolysis can be used to recycle solid residuals and produce heat, it **has not become widespread for technical and/or economical reasons**. Additionally, there are no known successful applications, even at pilot plant scale of either incineration or pyrolysis in treatment of olive oil mill waste.

Composting in windrows

Country: SPAIN, Area: Guadalcazar, Cordoba
Company: Aceites Coto Bajo EXP Agric. S.A.
Amount: 25.000 m3 two-phase OMW per year.
INPUT: 40% two-phase OMW+ 40% chicken manure + 20% leaves
PRODUCTS: Organic compost
Technical problems:
1) Non-homogeneity of raw materials.
2) Bad odours during start up period.
FINAL PRODUCT: 30.000 ton/year
Land use: 2 X15.000 m2 (dimensions 5mX100mX2,5m)
Investment cost:
300,000 € civil engineering works
300,000 € turn over equipment
Operating cost:
6 h/week X 15 €/h
Production cost: 0.05-0.06 €/kg-compost
(expected to be reduced to 0.03 €/kg)

Composting in a U-lane

Country: SPAIN Area: El Molar - Cazoria (Jaen)
Company: Geacom (UBEDA-ES).
Amount: 9.000 tons two-phase OMW per year
INPUTS: 40% two-phase OMW + 20% sheep manure (0.04 €/kg) + 40% leaves
PRODUCT: Organic compost (C/N < 12, N-P-K: 1.2-0.4-1.6, pH:9.6)
Investment cost: 300.000 € (50% financed by Andalusia)
There is a problem with the wide distribution of compost.
Operating cost: 2 h/day for the control of the process plus 3-4 h/week for maintenance.
Personnel cost: 6,800 €/year while the maintenance cost is 4,500 €/year.
The indirect revenue is estimated 200-250 €/ha/year savings in chemical fertilizers.

Electro-coagulation

Country: SPAIN. Area: Jaen, Company: CYCLUS ID
Process steps: Homogenaization, Filtration (0.3 mm)
Electro-coagulation, Floatation & pH control
Drying of solids
INPUT: 2-phase OMW
OUTPUT: Treated effluents with COD
(~1500 mg/L) acceptable by local WWTPs
Amount: 2 m3/h, 4.000 m3/year,
Investment Cost: 100,000 €
Area required: 25 m2 inside the olive mill housing with a capacity of treating 2.0 m3/h OMW.
Skilled workforce of 2 h/day and 1 person for 1 h/day is required
for managing WW physicochemical parameters
Operational cost: between 1.5-1.8 €/m3.

Aerobic biological trickling filter + constructed wetland

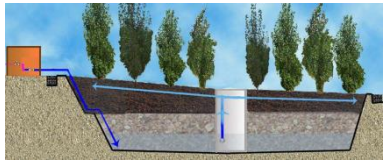
Country: **GREECE,** Area: Amphilochia, Company: D. Vagenas (U. Ioannina/U. Western Greece).)
INPUTS: OMW+ pomace + leaves
Bioreactor: Continuous recirculation with a residence time of 24h.
Sedimentation→ Constructed wetlands
PRODUCT: compost (sludge + leaves + pomace)
Investment cost:
30,000 € equipment + land cost for CW
+ 5-10,000 € composting unit (OMW treated: 30 m3/day)
Operating cost: 0.1 € / m3 (electricity)
Manpower: 2h / day
Land use: Composting: 10m X 4 m
Bioreactor: 3,5m X 1,8 m, CW: 2.000 m2

Evaporation – Hydrolysis–Oxidation : E.H.O.®

Country: **GREECE,** Area: Sparti (Laconia)
Company: ENVITEC A.E.
INPUT: OMW
PRODUCTS:
1) Irrigation water (80-85% OMW)
2) Bio-fuel 4.000 kcal/kg (in powder form
10 ton from100 m3 OMW)
Investment cost:
100-150 € / m3 (i.e., for 1000 m3 OMW→ 100-150.000 €)
Operating cost:
3-5 € / m3 (electricity– 31 kWh/m3)
Manpower: One person per shift.
Expected income: 40 €/ton bio-fuel
Land requirements: very small (<100 m2)
Problems:
Cost & need of specialized personnel.

Phytoremediation

Country: ITALY, Area: Terni, Company: ISRIM S.C.a r.l.
Amount: 50-10.000 m3 OMW/year
INPUT: OMW
Land use: 1,5 – 2 m2/m3
(i.e. 1500-2000 m2 / 1000m3 OMW)
Investment cost: 100-110 € / m3
(i.e., 1000 m3 OMW/year → 100.000 €)
Operating expenses:
0.2 € / m3 /year (electricity for the pump)
Manpower: Not needed.
Expected income: 0.1 € / m3 /year (from wood sales)
Problems:
Initial investment cost
Land requirements (30% more than a 1 m deep evaporation pond)



Anaerobic digestion in a WWTP

Country: PORTUGAL, Area: Abrantes
Company: LNEG – INETI
(Renewable Energy dept)
Investment cost: 300.000 €
Operating cost: 14.000 €/year
INPUTS: 5 ton/day OMW+ 46 ton/day activated sludge + 1,5 ton/day OM-solids + 2,2 ton/day municipal organic waste
PRODUCTS: 300 m3/day biogas + Irrigation water + compost (1.6 m3/day)
Expected Income: 26,000 € (0.2 € / kWh x 357 kWh/d x 365 d)
The process has eco-friendly features since it produces three byproducts: water suitable for irrigation, sludge for agricultural soil enrichment and energy for WWTP running.

Bio-fuel pellets Biocombus

Country: PORTUGAL, Area: Murca
Company: Universidade de Tras-os-Montes
Investment cost: 8.88 €/ton
Operating cost: 26.48 €/ton
INPUT: 20.000 tons pomace + 3.000 tons cork sawdust.
PRODUCT: 13.500 ton/year pellets/briquettes (20,6 MJ/kg)
Area required for the installation: 0.07 m2/t wet bagasse.
Expected income: 140 €/ton (sales of pellets/briquettes)
The technology is eco-friendly since the whole input material coming in the plant is completely transformed in pellet.
The technology has been patented (UTAD-EP 1849756 A1) by the University of Traseos-Montes e Alto Duro of Portugal.

CIP-Eco-innovation: Filtration with sawdust & phytoremediation

Country: Greece, Area: Crete
Company: Technical University of Crete, MESOGIAKI S.A.)
Investment cost (for 1500 to 2.000 m3/year OMW):
Extraction of polyphenols: 250.000 € (equipment)
Phytoremediation with poplars: 100.000 €
Composting unit: 50.000 € (equipment & concrete)
INPUTS: OMW
Sequential filtration of OMW through a series of filters consisting of
- Natural materials (peat, sawdust) Chemicals (resins)
COD reduction by 75-80%.
Phytoremediation: “Light OMW” taken to poplars field
Extraction of polyphenols (from ion exchange resins)
Composting of sawdust & leaves
Products: wood, polyphenols, compost

OMW application on the soil

Research has shown that soils can be used as a natural system for OMW treatment since organic compounds are fast decomposed and soils have high buffering capacity

Advantages:

- Low cost
- Increase of soil fertility (mostly K)
- Fast decomposition of the organic part
- No pollution of surface or ground water
- Increase of yield (corn, grapevines)

Phytotoxicity:

- Only in annual crops if planted before or right after the application
- Reduction of germination percentage
- Negative effects are not observed if crops are planted about 2 months after the application
- For olive trees, only in young trees when high doses were applied

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OMW application on olive orchards

The controlled soil application of OMW is practiced in many olive growing countries. Many studies have been carried out the last 20 years with controlled raw OMW application on olive orchards at volumes from 8-20 m3 per year. All studies confirmed that there are no harmfoul effects on the soil, plant and the water aquifer.

Must remove solids before doing anything else. Use filters (series), self cleaning, or use of Coagulation and Sedimentation: cost of chemicals

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Working for a Sustainable Mediterranean, Caring for our Future

Thank you for your attention.

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