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Mobile Integrated Sustainable System for Treatment of Organic Wastewater (MISSTOW)

MISSTOW
Regulatory Concern
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WHEN BUSINESS MEETS THE ENVIRONMENT

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CONTENT

ENVIRONMENTAL PROBLEM TARGETED: OLIVE OIL MILLS' WASTES

The combination of severe water shortage, densely populated urban areas, and highly intensive irrigated agriculture, makes it essential that countries will put wastewater treatment and reuse high on its list of national priorities. Sewage treatment effluent is the most readily available water source and provides a partial solution to the water scarcity problem. In some Mediterranean countries national policy calls for the gradual replacement of freshwater because of the decision to increase the use of effluent and set up a committee to review existing regulations and to recommend new regulations for effluent use for irrigation or disposal to stream and receiving water. The recommended values must be designed to minimize potential damage to water sources.

In terms of area occupied, the olive trees are among the most cultivated crops in the Mediterranean basin. There are approximately 750 million productive olive trees worldwide, occupying an area of 7 million ha. The Mediterranean region alone provides 98% of the total surface area dedicated to olive cultivation and 97% of the olive world production, which is, on average, 17×10^6 tons per year (Faostat 2007). The main olive oil producers are Spain (27%), Italy (26%), Greece (18%), Turkey (6%) and, to a lesser extent, Tunisia, Morocco and Syria (4% each) and Portugal, Egypt and Algeria (2% each).

The amount of olive waste generated, about 13×10^6 tons per year, represents a key environmental problem in Mediterranean areas, especially because the olive oil production is concentrated between November and March each year. The olive waste is thus generated in huge quantities in a short period of time and, due to considerable concentrations of phenols, lipids and organic acids, it is also highly phytotoxic. On the other hand, these residues contain valuable resources like large quantities of organic matter and a wide range of recyclable nutrients.

For many years, the olive mill waste water (OMWW), produced using the three-phases system, has been the most pollutant waste produced by the Mediterranean olive mills. For this reason the management of this liquid residue was extensively investigated. However, from the early 1990s, the implementation of a new extraction two-phase system, mainly in Spain, originated a new solid waste (TPOMW or alperujo) which requires a different management since it causes a different environmental impact.

By now, the careless management of these hazardous residues has been representing an environmental concern for water, soil and atmosphere. In contrast, numerous environmental and social benefits could be obtained by producing either biogas via anaerobic fermentation, bioactive ingrdeints or biomass through phytoremediation. The energy obtained by the valorization of the olive waste meets the requirements of the EU White Paper on Renewable Energy encouraging the development of alternative ways of renewable energy production in order to reduce CO_2 emissions.

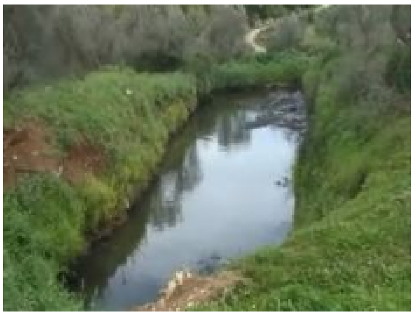
The problem of the disposal/reutilization of the olive wastes is strictly related to EU environmental policies according the following legislations:

- 6^{th} EAP, EU Directive: (I) 2000/60/EC in matter of water policy;
- 2006/12/EC in matter of waste policy;
- COM (2006) 231, COM (2006) 232, SEC (2006) 1165 and SEC (2006) 620 in matter of soil protection;
- The European Strategic Energy Technology Plan (Set-Plan IP/07/1750) in matter of energy policy

The consumption of olives and olive oil is believed to bring health, however, the side products (wastewaters-OOMW and solid wastes-SW) from their production and treatment could be disastrous for the environment if no precautions or suitable managements are taken. Olive oil is a valuable commodity with a high nourishing value; however its production techniques generate several negative environmental impacts mainly due to the production of waste, the excessive usage of energy and water as well. The olive oil extraction industry represents an important activity in the Mediterranean area. Among European countries, but also worldwide, Spain and Italy are the two leaders in olive oil production, whereas Greece holds the third place.

In general, for each ton of olive oil produced about 1,560kg organic pollutants (dry basis) are obtained while the polluting load related to the disposal of 1 m^3 of OOMW is equivalent to 100-200m^3 of urban wastes (corresponding to the ones produced by 100,000 people). These pollutants are toxic due to their phenolic compounds content (8.8-9.6% of Volatile Solids or 138-150 kg/ton olive oil).

Wastewaters are characterized by high BOD_5 and phenolic compounds content as well as by high value of COD/BOD ratio (2.05-2.35). OOMW presents different characteristics, depending on the variety of olive and ripeness, climate and soil conditions and the oil extraction method. OOMW is an aqueous, dark (due to polyphenols content), foul-smelling and turbid liquid, which includes emulsified grease, is easily fermentable and has a high organic content (40-165 g/l). The OOMW pH is low (4.5-6.0), its electrical conductivity high (35000-100000dS/m), and it has high free polyphenol concentrations (3,000-24,000 mg/l) due to olive pulp esters and glycoside hydrolysis, produced during oil extraction. The main constituents of the organic fraction of the wastewaters are proteins and sugars that are easily biodegradable and, to a lesser degree, organic acids, polyalcohols, fats, polyphenols, and others. The presence of this waste in soil causes phytotoxic and antimicrobial effects, while in rivers decreases the dissolved oxygen content and fish population but increases the organic matter and K, Fe, Zn and Mn contents. The annual olive oil mill wastewater production in Mediterranean countries is estimated to be over $3x10^7$ m^3. On the other hand, the solid waste (SW) that are produced contain almost 94% organic matter and although they could be highly beneficial to agricultural soil, it has been shown that they contain also toxic compounds and oil that may increase soil hydrophobicity and decrease water retention and infiltration rate if applied to soil without pre-treatment.



In the Mediterranean region there are big olive oil industries, which, most of them produce oil according to the national legislative frameworks, meaning that waste treatment is including in their activities. However, the majority of mills are small domestic enterprises, scattered throughout the countries, their owners are not well familiar on the risks and on the alternative solutions and technologies for waste treatment, while in case that they are informed, they are not willing to adopt new technologies mainly due to their cost. Thus, in most of the cases, wastes are disposed untreated in the environment (into rivers, sea, land, or into lagoons/ponds).

Traditional methods of olive oil mills' wastes disposal are:

a) Evaporation ponds: based on the removal of water with the aid of solar energy avoiding anaerobic fermentation (low deep ponds).
b) Disposal in soil
c) Incineration: Given the high organic load of OOMW, incineration may constitute an appealing method to treat these residues inherent disadvantages of incinerators (fuel costs, gas emissions, etc.) have to be balanced.

d) Other uses: Effluents of olive mills have been utilized as a source of fermentation products, as a source of fat and oils preservatives, antioxidants and antimicrobials (i.e. phenolic compounds), etc.

The annual oil mills waste production of Mediterranean olive-growing countries is estimated to ranging from 7 million to over 30 million m^3, depending on annual olive production. The average total production amounts approximately to 10 $x10^6$-$12x10^6$ m^3/year and occurs over a brief period of the year (November-March).

The most serious environmental problems from the improper disposal of mills' wastes caused due to physicochemical characteristics of wastewaters as well as, of their polyphenolic content.

Spain is the world's biggest producer of olive oil with around 30% of total production. 92% of the 2.1 million hectares (5.19 million acres) of olive groves which cover the Spanish countryside are dedicated to oil production, the average annual production typically running between 600,000 and 1,200,000 metric tons, 20% of which is exported. Andalusia region accounts for 60 % of the nation's area under cultivation, and for 75 % of Spain's olive oil. Spain produced 20% of the wastes of the Mediterranean basin (2 $x10^6$-$3x10^6$ m^3/year) before the implantation of the two-phase extraction process in most of the Spanish olive oil factories, which represented an equivalent pollution of $10x10^6$-$16x10^6$ inhabitants in the short milling period. The yearly production of wastes with the two-phase extraction process from the whole Spanish olive oil industry may approach four million tons.

In Spain, the virgin olive oil production sector has improved over the last decades introducing technological advances and increasing its total milling capacity even in the oil mill model. For the last 20 years the trend has been to achieve a majority of the production sector looking for a size economy and a reduction in production costs. In the seventies, there were 6,000 oil mills in Spain while nowadays around 1,750 are registered with MAPA (Spanish Agriculture, Fisheries and Food Ministry) to apply for subsidies for recent crop years.

In South Spain, Wastewater from olive mills has been used as a fertilizer with promising results. It has been also used in the irrigation of some kinds of crops.

Italy is the second European producer; two-thirds of the production is represented by extra-virgin oil with 37 DOP (Protected Origin Appellation) widespread on all the national territory. In Italy there are about 6,180 olive oil mills and the overall amount of processed olives in 2006/2007 was about 3,500,000 t with a production of about 600,000 t of oil. 90% of the entire oil production comes from Southern Italian Regions: Sicily, Calabria and Puglia. The introduction of new mills has increased the productivity and has decreased the need for manpower, increasing the problem related to the disposal of olive mills' wastes due to an increased production of wastes themselves. In Italy, more than 2,000 t/year of olive oil wastes are produced and half of them come from Puglia Region.

Disposal of wastes is regulating by national laws. The first law concerning olive oil mills' wastes management was No 319 proclaimed in 1976. Before that, wastes could be poured into the sewer. Oil mills should have been provided by purifiers but this was not possible because of the very high costs of the devices compared to the very small dimensions of farms. So in the second half of 80's a derogation system was applied which permit the disposal of wastes on soils since it has been accepted that the environmental impact of waste is significantly lower on cropland than in water bodies if certain amounts are distributed up to set thresholds in relation to time and surface. Current thresholds established by law 574/96 set 50 m^3/ha/year for OOMW coming from traditional cycle olive mills and 80 m^3/ha/year for OOMW coming from continuous cycle olive mills. These limits are valid for humid olive husks too.

Greece ranks third in the world in terms of olive oil production after Spain and Italy. There are about 10^8 olive trees and 2,800 olive oil mills mainly in Crete, Peloponnese, Central

Greece, Chalkidiki, the Ionian and Lesbos islands, which operate from late October to late February each year. The average oil production in 2006/2007 was about 250,000t. 90% of olive mills are centrifugal systems and the rest are traditional (pressure squeezing). Although the disposal of mills wastes in the environment is not permitted, it is estimated that up to 1.5 million tones of olive oil mills' wastes are disposed untreated each year.
The wastewater, which is produced by the Greek table olive industry, is disposed in most of the cases untreated in soil or water bodies. The usual treatment and disposal method for wastes in Greece is the evaporation in lagoons/ ponds after wastes neutralization with lime, although there are also many cases of sea, river and underground disposal. There are, however, cases of implementing innovative waste treatment technologies, but mainly through research projects. Some of the many existed agricultural associations are involved in these projects but their activities and benefits of the adopted practices are not wide disseminated until now.
During the production period (3-5 months) the ponds are filled whilst the evaporation process is ongoing till the ponds are emptied (8-9 months) and the leftover solid wastes can be removed. In practice, the evaporation lagoons/ponds are rarely of the proper size and construction and wastewater often overflows affecting the neighbouring systems (soil, surface and underground water) but also other professional activities of the residents such as agriculture and livestock farming. The base of the lagoons is not impermeable (no geo-membrane or other protective material is used) and thus, since in Greece and other Mediterranean countries karsts are seen, the probability for groundwater and deep soil horizons contamination is high. Mills' owners often pump the excess volume of wastewater to prevent overflowing and use them as fertilizers by transmitting them to neighbouring agricultural tree-lands. Wet sludge from lagoons is used as fertilizer. Because owners need to empty the lagoons from the remaining solid waste and because they have no other possibility to treat or compost it, they dispose the untreated sludge to trees. This uncontrolled activity has caused severe damages to trees irrigated by wastewaters or fertilized with sludge and also to soil quality.
Since there are plenty of olive oil mills in Mediterranean countries, in other words plenty of soil/water pollution sources and considering the specific characteristics and properties of mills' wastes, there is a need of studying the suspected contaminated sites, registering them as polluted and taking action for their remediation and future protection. This could be feasible only with the development of a strategy/policy at national level, which will include the creation of a national inventory of contaminated sites and actions to be taken against soil/water pollution. From this point of view, the successful completion of the project will provide significant benefits to involved countries as well as to other oil productive European and Mediterranean countries. In specific, the project will help in facilitating the Soil Thematic Strategy implementation by providing authorities the scientific, technological and methodological know-how to identify and to study the suspected contaminated sites and register them as contaminated, if it is so, and by suggesting and implementing integrated technologies for the improvement/remediation of polluted soils, which will be practical tools for authorities for medium- and long-term actions regarding their soil conservation/restoring policy. Moreover, the project will promote best practices, improvement of knowledge and its dissemination and exchange of information.

EU legislation and the olive sector

The environmental impact of olive cultivation and olive oil production is particularly important for the European Union because three EU countries - Spain, Italy and Greece - are by some distance the world leaders in these sectors. Particular problems include soil erosion, rising water consumption, desertification, pollution due to use of chemicals and fertilisers, damage to biodiversity, and waste generation.

A number of EU policies and laws address these problems, and so, directly or indirectly, EU legislation acts on the olive oil sector in a number of ways.

The Common Agricultural Policy (CAP)

The CAP is the EU policy instrument that impacts most directly on olive producers. In fact, the CAP was one of the causes of the great expansion of olive oil production in Europe, with agricultural subsidies being previously directly coupled to the level of production (subsidy expressed in € per tonne produced).

Whereas olive farming was traditionally practiced on upland terraces, with relatively low impacts in terms of use of chemicals or extraction of water, the drive to expand production led to high density planting of olive trees on lowland plains, and the introduction of intensive farming practices, such as machine harvesting and industrial-scale processing of the olive oil.

The CAP has progressively been reformed in an attempt to counter the damaging aspects of the earlier agricultural policy. In 2003, CAP reform led to payments to olive farmers being split as follows:

Single Farm Payment – Olive producers receive a flat payment calculated on the basis of the average amount they received in production-related subsidies from 1999-2003. Olive farms smaller than 0.3 hectares receive 100% of their average production-linked payments in order to simplify aid for smaller growers, while providing a stable income support. The main aim of the single payment is to guarantee farmers more stable incomes. Farmers can decide what to produce in the knowledge that they will receive the same amount of aid, allowing them to adjust production to suit demand. For olive growers, the new direct payments began to replace the previous production- related scheme in 2005-2006.

Olive Grove Payment – A maximum 40% of the subsidy could remain linked to olive production but is intended to ensure that olive farming is done in a socially and environmentally sustainable way. Member State authorities had to identify up to five different categories of olive groves for additional support. These are chosen based on their environmental and socio-economic value, with aid per hectare fixed accordingly. The measures backed by Member States should focus on: maintenance and restoration of terraces and stone walls, maintenance and restoration of wildlife habitats and landscape features, maintenance of permanent grass, reduction of soil vulnerability by increasing organic matter content, and creation of earthworks to reduce run-off on steep slopes. The aim of this approach is to ensure olive tree maintenance and avoid the degradation of land cover and landscape. Only Spain applied this measure from 2005 to 2010. The olive grove payment has been repealed as from 2010 as part of the “Health Check” CAP Reform in late 2008.

The new rules also give EU countries some discretion to influence olive oil quality, beyond the standard regulatory regime laid down for the sector. Member States may use up to 10% of their national envelope for quality and environmental measures under activity programmes carried out by operator organisations. Italy, Greece and France have been using this facility since 2004.

Cross-compliance for olive growers

The CAP reform in 2003 was also the point at which the 'cross-compliance principle' became obligatory. Under this, all CAP payments received by the farmer are linked to the meeting of certain minimum requirements and standards relating to the environment and animal welfare, as well as maintaining the land in good agricultural and environmental condition. With some 2.3 million olive growers in the EU, the revised rules could potentially generate significant environmental benefits.

Specifically, cross-compliance introduces the possibility of reducing the payments in case the farmer does not respect the requirements and standards in the above-mentioned domains. In the olive sector, this mechanism can help minimise damaging practices such as excessive use of herbicides, intensive soil tillage, and illegal water extraction. The requirements include in particular observance of obligations related to the Birds and Habitats Directives, the Nitrate and Groundwater Directives and the directive on the authorisation of pesticides. Under the good agricultural and environmental requirements, farmers must also respect the national authorisation procedures for the use of water for irrigation (as from 2010), the maintenance of olive groves in good vegetative conditions and the rules about the grubbing-up of olive trees as defined by Member States.

Cross-compliance also offers biodiversity benefits. Olive groves managed in a more traditional way are notable for ground vegetation cover, and require little application of pesticides and herbicides. The revised CAP rules mean there is more emphasis on maintaining natural habitats such as copses and hedges, while birds, flora and fauna are protected.

Agri-environmental measures and olive cultivation

Through agri-environmental measures, EU rural development policy supports specifically-designed farming practices that help to protect the environment and maintain the countryside. Farmers commit themselves on a voluntary basis to adopt, for a five-year minimum period, environmentally-friendly farming techniques that must go beyond the cross-compliance standards as well as minimum requirements for fertiliser and pesticide use, and other relevant mandatory requirements established by national legislation and identified in the rural development programmes. In return they receive annual payments, which compensate for the additional costs and loss of income that result from altered farming practices.

Environmental legislation affecting olive oil production

The Sixth Environment Action Programme (6th EAP) is the framework for environmental policy-making in the EU for the period 2002-2012. Under the 6th EAP, the European Commission developed seven Thematic Strategies addressing key environmental challenges. For the olive oil sector, the most relevant of these are those on pesticides and soil. Other important initiatives within the 6th EAP framework deal with waste, water and biodiversity.

Sustainable use of pesticides

The Thematic Strategy on the sustainable use of pesticides was adopted in 2006 by the European Commission (COM (2006) 372), in order to complement existing EU pesticide rules. It is meant to cover the use phase of authorised pesticides – for example, in relation to their application by aerial spraying.

The strategy was accompanied by a proposal for a framework directive on the sustainable use of pesticides. In parallel, a proposal for a Regulation on the placing of plant protection products on the market was put forward by the Commission.

The European Parliament and EU Council reached a political agreement on these two initiatives at the end of 2008, with the Parliament approving the deal in January 2009 and the Council in September 2009. Both legal acts were published on 24 November 2009.
The main elements of the legislation, which will affect olive growers as well as other farmers, are: a). a change in the way pesticide substances are evaluated; the creation of three EU mutual-recognition zones so that pesticides authorised by one country would be automatically considered authorised by other countries within the same zone (though individual countries would retain the right to impose national bans on particular substances); and b). introduction of rules on pesticide use, such as a general ban on aerial spraying and prohibition of pesticide use in certain places, such as near schools or in buffer zones along rivers and other water bodies.

The Soil Thematic Strategy

One of the main environmental issues related to olive cultivation is damage to soils. Intensified olive farming is a major cause of soil erosion, thus reducing the productive capacity of the groves and, potentially leading to other problems such as desertification and run-off of top-soil into water courses.
The main aspect of the Soil Thematic Strategy was the proposal, by the European Commission, for a Soil Framework Directive (COM (2006) 232). This would require Member States to systematically identify damaged soils and combat soil degradation. Member States would also be required to identify areas where there is a risk of erosion, landslides, loss of organic matter in soils, or compaction or salinisation of soils. Member States would then adopt risk reduction and remediation plans for affected areas, within national remediation strategies.
However, Member States have so far been unable to agree on the Soil Framework Directive, with some countries believing that soil quality can be regulated at national, rather than European level. Further discussions on the potential directive are expected to take place under the Spanish Presidency of the EU during the first half of 2010.

Water usage and quality

Issues related to water quality and usages are of great significance to olive growers. Olive production does not require such high inputs of water as arable crops or crops such as lettuce or tomatoes, but expansion of olive production has nevertheless led to water shortages in some areas. Some areas already suffering from depleted groundwater reserves have seen an increase in the area of land under cultivation for olives – for example, southern Spain, which is one of the world’s key olive-producing areas. Sinking of non-authorised boreholes for water with which to irrigate crops compounds the problems faced by these areas.
One way in which over-consumption of water can be controlled is through water pricing. The Water Framework Directive (2000/60/EC) requires full-cost recovery to be adopted as the guiding rule for water-price setting, thereby reducing or eliminating artificial incentives to develop irrigation.
The WFD also deals with water management in the broad sense. It requires Member States to take a strategic and integrated approach to the management of all water resources and river basins. Authorities must follow a series of steps laid down in the directive, including planning of river basin districts, identification of pressures and impacts, and implementation of appropriate remedial measures.
The directive also addresses water quality, with the aim by 2015 of achieving an appropriate ecological and chemical status for surface waters, as well as an acceptable chemical and quantitative status for groundwater. A body of water would be considered to have ‘good

chemical status' if it met all of the environmental quality standards for priority substances and certain other pollutants.

The Groundwater Directive (2006/118/EC) is a daughter directive of the Water Framework Directive, dealing with the issue of water quality. In negotiations between the European institutions, the question of the non-deterioration of groundwater quality and the relationship with EU legislation on water pollution by nitrates were key. Final agreement on the directive resulted in a level of nitrates of 50 milligrammes per litre being defined as 'good chemical status'. The new groundwater rules also left untouched the earlier Nitrates Directive (91/676/EEC), which has the general objective of protecting EU waters against excessive nitrates from agricultural sources, and also plays an important role in olive grove cultivation. Nitrogen inputs in the most intensive, irrigated olive farming can reach high levels (up to 350 kilogrammes per hectare in extreme cases), and experience from arable farming suggests that a problem of groundwater pollution is likely to exist in some olive areas.

Wastewater and waste

Wastes generated by the olive sector can be divided into solid wastes (such as olive husks or crude olive cake, a residue remaining after the first pressing of the olives) and liquid wastes (olive mill wastewater). A number of EU laws regulate what should be done with these – and other – waste products. The over-arching principles that should be applied in managing waste are laid down in the Waste Framework Directive (2008/98/EC), which requires Member States by 2020 to recycle at least half of their household and general waste. The Waste Framework Directive, which was revised in 2008, also includes rules on hazardous waste and waste oils, which were previously covered by separate legislation.

EU countries have until late 2010 to fully implement the revised Waste Framework Directive. The revised rules also formalise a five-step previous waste management hierarchy that Member States must follow when setting out national waste management plans. According to the hierarchy waste should be dealt with first by prevention, then re-use, followed by recycling, recovery, and finally, disposal. Under the method of recovery, waste is either converted into usable forms or is incinerated so that energy is 'recovered.' Disposal, meaning landfilling in most cases, can only be done once the previous four steps have been exhausted. Member States will produce waste management plans that institute this hierarchy as they implement the revised Waste Framework Directive; these plans are likely to affect the waste management techniques used by olive oil producers, as well as other sectors. Where waste is disposed of, rules pertaining to landfilling are set out in the Landfill Directive (99/31/EC).

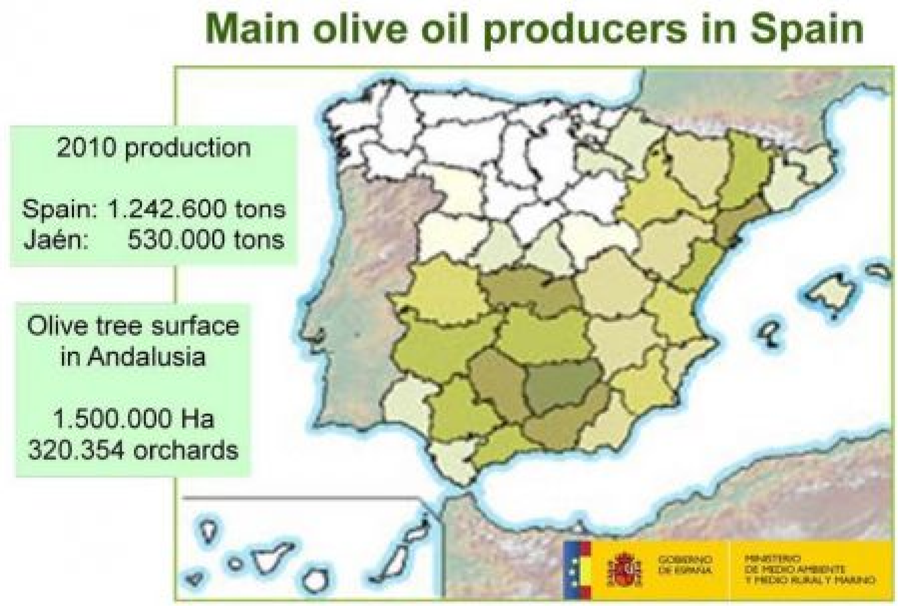
Liquid wastes from olive oil production, meanwhile, fall under the Urban Waste Water Treatment Directive (91/271/EEC). This concerns the collection, treatment and discharge of urban wastewater and the treatment and discharge of wastewater from certain industrial sectors, including manufacture of fruit and vegetable products, under which olive oil production would fall.

REGULATIONS IN THE DFIFFERENT COUNTRIES

Current Practices for Olive Processing Waste Management

SPAIN

The largest average annual production of olive oil in Spain comes from the Region of Andalusia, where are located most of the 1,700 olive-mills that operate in Spain. Andalusia has more than 1.5 million hectares of olive trees. The number of olive orchards in Andalusia is 320,354, the 44% of which are located in Jaén (the darker green province in the map).



In Andalusia the most common size of olive orchards is between 1.0 and 5.0 hectares (47% of total farms and 24% of total olive trees surface in Spain).

Until the year 1980, the majority of olive-mills were traditional press systems and evaporation ponds were used for the liquid effluent. In the early 1980s, the three-phase extraction system started to dominate. In 1982, in Spain a law forbade river disposal of OMWW and subsidized construction of storage ponds to promote evaporation during the summer period. Around 100 evaporation ponds were constructed, which improved the water quality, but raised annoyances in ambient air quality because of odour problems. In 1992, the two-phase extraction system was introduced in the region of Andalusia. Nowadays, almost all olive-mills in Spain use two-phase centrifugal decanters. There is still some liquid effluent from the process, but existing evaporation ponds are more than adequate to handle it. Since olive-mills have already started to use water recycling, it is expected that eventually most of the evaporation ponds can be closed down. However, the semi-solid residue (TPOMW or 2POMW) has reached an amount of more than 4 million tons/year and a lot of effort has been put on finding a solution for its management.

Although there is an absence of a definite valorisation strategy, the most common practices for TPOMW management in Spain are second extraction for energy recovery, composting and use in agriculture, disposal in evaporation ponds, and use of wastes for animal feeding.

The use of TPOMW for energy recovery by applying

second extraction of residual oil is the most accepted technology and the first treatment option in Spain. However, the high moisture content of TPOMW makes the extraction difficult when performed in classic extraction plants and initial drying in power plants is considered necessary. Co-generation power plants use natural gas to produce electricity. The thermal energy produced during combustion is used for TPOMW drying. After this stage the dried wastes can be used for 2nd oil extraction. After the residual oil extraction, the oil-free wastes are used for energy production or used as biomass in the same plant.
Olive prunings are also used as biomass. It is estimated that 28,000t are treated as pellets while the consumers are estimated to be almost 17,500 households.
Up to 300,000t of TPOMW are treated annually by this technology while it is estimated that the treatment cost per kg of TPOMW is 0,012€ + VAT + transport costs to plant

ISRAEL

There are about 120 olive presses in Israel, 89 of them in the north of the country, of which 12 are in the Kinneret (Sea of Galilee) watershed and 11 in the Kabri spring watershed.
Olive mill wastewater, generated by the olive oil extraction process, presents a serious environmental problem due to its high concentration of polyphenols and organic matter, in addition to suspended particles, oils and other compounds. Typically, raw olive mill wastewater has a chemical load of between 100,00 - 200,000 mg/l, a BOD load of 70,000 - 160,000 mg/l, lipids of between 2,000-8,000 mg/l and tannins between 800 - 3000 mg/l while the permitted values for discharge to the sewage system are 2,000 mg/l COD, 1,000 mg/l BOD and 100 mg/l lipids.
Discharge of this wastewater to the environment or to the sewage system is problematic. Discharge to the environment causes pollution of soil, surface and groundwater and damage to nature and landscape. Discharge to the sewage system causes blockage of transport lines and collapse of pumping stations leading to the overflow of wastewater to the environment, and damage to wastewater treatment plants. Therefore, discharge into the wastewater treatment plants is prohibited in Israel. The problem is exacerbated since this industry produces wastewater with high organic loads during a short period of a month to two a year.
To tackle the problem, the Ministry of Environmental Protection has increased its enforcement and education efforts, on the one hand, while testing different solutions including financial support to olive mills for the pre-treatment of their wastewater, on the other hand. In a joint cooperation between the Ministry of Environmental Protection, the Ministry of Agriculture and the Water Authority, a pilot project was launched to install pre-treatment facilities based on dissolved air flotation in the area of the Kabri and Ziv springs in north of Israel, areas identified as especially sensitive in terms of potential environmental pollution.
The results of the project within three years (2005 - 2008) are encouraging:

- A reduction in the discharge of the olive mill wastewater to wastewater treatment plants (from 83% to 51%)
- An increase in land spreading of this wastewater (from 2% to 34%)
- A reduction in discharge of this wastewater to rivers or to the environment (from 15% to 4%)
- An increase in the use of DAF installations (from none to 11%).

These results are due to a combination of financial assistance, enforcement and education. On the enforcement side, warnings and summonses were served to olive mills in the north of the country which discharged olive mill wastewater to the environment and professional guidance, supervision, monitoring and sampling of both flotation facilities and spreading were conducted by the agro-ecology coordinators of the Ministry of Environmental Protection's northern district, with the assistance of a Nature and Parks Authority inspector and a Green Police inspector. On the educational front, the project was accompanied by seminars and a guidebook with detailed explanations about the structure, operation, maintenance and treatment needed for treatment of the olive mill wastewater.

Upgraded Effluent Quality Standards in Israel

The Inbar Committee in Israel recommended new regulations for effluent use for irrigation or for disposal to streams and receiving waters (Research News, 2002). The recommended values, designed to minimize potential damage to water sources and soil, call for much higher treatment levels in existing and future wastewater treatment plants. The objective is to treat 100% of the country's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources (Aharoni & Cikurel 2006).

Table 1: Proposed new Israeli standards for effluent (average levels) *

Parameter	Units	Unrestricted Irrigation*	Rivers
Electric conductivity	dS/m	1.4	n/a
BOD	mg/l	10	10
TSS	mg/l	10	10
COD	mg/l	100	70
N-NH4	mg/l	20	1.5
Total nitrogen	mg/l	25	10
Total phosphorus	mg/l	5	1.0
Chloride	mg/l	250	400
Fluoride	mg/l	2	n/a
Sodium	mg/l	150	200
Faecal coliforms	Unit per 100 ml	10	200
Dissolved oxygen	mg/l	>0.5	>3
pH	mg/l	6.5–8.5	7.0–8.5
Residual chlorine	mg/l	1	0.05
Anionic detergent	mg/l	2	0.5
Mineral oil	mg/l	n/a	1
SAR	(mmol/L)0.5	5	n/a
Boron	mg/l	0.4	n/a
Arsenic	mg/l	0.1	0.1
Mercury	mg/l	0.002	0.0005
Chromium	mg/l	0.1	0.05
Nickel	mg/l	0.2	0.05
Selenium	mg/l	0.02	n/a
Lead	mg/l	0.1	0.008
Cadmium	mg/l	0.01	0.005
Zinc	mg/l	2	0.2
Iron	mg/l	2	n/a
Copper	mg/l	0.2	0.02
Manganese	mg/l	0.2	n/a
Aluminum	mg/l	5	n/a
Molybdenum	mg/l	0.01	n/a
Vanadium	mg/l	0.1	n/a
Beryllium	mg/l	0.1	n/a
Cobalt	mg/l	0.05	n/a
Lithium	mg/l	2.5	n/a
Cyanide	mg/l	0.1	0.005

* *From soil, flora, hydrological and public health considerations.*

The proposed regulation includes 36 biological and chemical parameters classified in three groups (Table 1):

- Organics, nutrients, and pathogens: BOD, TSS, chemical oxygen demand (COD), Fecal coliforms, dissolved oxygen, residual chlorine, mineral oil, pH, total nitrogen, ammonia, and total phosphorus.
- Salts: electrical conductivity (TDS), specific absorption rate (SAR), chloride, sodium, boron, and fluoride.
- Heavy metals: arsenic, barium, mercury, chromium, nickel, selenium, lead, cadmium, zinc, iron, copper, manganese, aluminum, molybdenum, vanadium, beryllium, cobalt, lithium, and cyanide.

To achieve the threshold values recommended for the parameters in the regulation, the quality of the effluent must be upgraded. The way to reach this objective will be different for any group of parameters. The group of organics, nutrients, and pathogens can be treated at the wastewater treatment plants, under present conditions or with some technical upgrading. Salts and heavy metals, at the present level of wastewater treatment, have to be treated at the source.

In some instances, regulations are based in Israel on European standards (e.g., regulations limiting the discharge of heavy metals); in others (Paths to Sustainability, Presented to UN, April 2005), they are specifically developed to address conditions that are unique to Israel (e.g., regulations prohibiting the discharge of brines into municipal sewage systems and detergent standards setting limits on concentration of chlorides, boron, and sodium). Special attention is currently being given to problems relating to high salinity of municipal sewage. This is an issue of particular importance in Israel, where wastewater recovery for agricultural purposes is imperative.

The wastewater from olive oil mills will have to coop with those regulations and therefore it is essential to develop methodologies that will enable the mills to obey those standards. Today there are no processes that are cheap enough for the small mills and in most cases the solution is spreading the wastewater on soil in limited quantities.

Land Spreading as a Solution

The Ministry of Environmental Protection has been searching for solutions to the olive mill wastewater problem since 1995, when it first conducted a comprehensive literature survey on methods and technologies for treating this wastewater. Subsequently, the first scientific experiments in Israel on the controlled spreading of olive mill wastewater in permanent three-year old olive plots in Kibbutz Beit Nir over a period of three years (1996 - 1998) were conducted by the Ministries of Environmental Protection and Agriculture. Contrary to common opinion and to the prevailing tradition that the spread of wastewater between rows of trees will cause their death, it was found that under controlled doses, damage will not occur and that the wastewater will act as an herbicide to stop unwanted weeds between trees. In light of the positive results, this spreading method is now successfully implemented in several olive orchards in Israel.

In 2008, the Ministry of Environmental Protection signed an agreement with the Jewish National Fund (JNF) to spread olive mill wastewater in its forests, eliminating weeds and expanding fire lines. More than 30% of the wastewater was spread in JNF forests in the north of the country, under controlled conditions, in full coordination with JNF professionals and forest rangers and with the oversight of a supervisor on behalf of the ministry, who undertook soil sampling at the end of the season. Not only damage not caused, but the controlled spreading prevented the disposal of this waste to rivers and to the Sea of the Galilee.

Controlled land spreading of olive mill wastewater (OMW) is now adopted in several Mediterranean countries as a practical alternative for its disposal. This approach has been supported by a large number of studies showing the potential fertilization value of OMW and the absence of negative effects on soil properties. In Israel, the current experience is limited. Few spreading activities have been managed and monitored by the Israel Ministry of Environmental Protection. A short-term increase in soil phytotoxicity (a bioassay with cress, *Lepidium sativum* L.) was observed in Israel, whereas the soil partly or completely recovered between successive applications. In other sites, no phytotoxicity was measured across soil profiles. Yet, the collected information shows potential leaching of organic constituents (expressed as dissolved organic carbon, DOC) and phenolic compounds (measured as total phenols, TP), as well as accumulation of presumably the more recalcitrant organic constituents. Surface spreading may cause more leaching as compared to application followed by tillage. Soil microbial activity was generally enhanced by OMW application; the application of OMW caused a temporary increase in the numbers of soil bacteria and fungi, whereas after degradation of the more labile fraction, the number of fungi increased in correlation to TP concentrations. A similar DOC/TP ratio was observed in other sites across soil profiles, suggesting no selective degradation of OMW in the upper as compared to deeper soil layers. A judicious selection of sites that are safe for OMW spreading is currently hampered by the limited knowledge about potential transport and biodegradation rates under field conditions, on one hand, and the lack of hydrological sensitivity maps of suitable resolution, on the other hand. Until a detailed study is completed that will support safe spreading, it is recommended that future OMW applications be restricted to cases of unavoidable OMW release, and not used as a widely-accepted disposal approach. Co-composting of OMW with various agricultural solid wastes is suggested as a safer recycling alternative.

Flotation as a Solution

In recent years, the Ministry of Environmental Protection initiated a review of the dissolved air flotation (DAF) method for olive mill wastewater treatment.

With the joint cooperation of the Ministry of Environmental Protection, the Ministry of Agriculture and the Water Authority, a pilot project was launched to install pre-treatment facilities based on dissolved air flotation in the area of the Kabri and Ziv springs in Israel's northern region, areas identified as especially sensitive in terms of potential environmental pollution. Some 1.5 million shekels were allocated to nine olive mills in the Achziv basin which opted to use a multi chamber with fine bubble flotators, which was specifically designed to tackle this problem. The goal was to prevent the discharge of olive mill waste into streams and to prevent the collapse of sewage pipes, pumping stations and wastewater treatment plants.

The DAF system has the ability to remove between 70% to 90% of the biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and fats, oils and grease (FOG), and is appropriate for small to medium size olive mills, which make up most of the olive mills in Israel and in the Mediterranean region.

GREECE

Almost the 70% of the Greek olive oil mills are of a three-phase centrifugal type and the rest of classical type or combinations thereof. In addition, there are 40–45 (active only 32) seed-oil extraction plants, more than 200 enterprises of standardization-packaging plants and around 25 refineries. There are only a very small number of olive-mills that uses two-phase centrifugal decanters. Some olive oil producers tried this technology, but they had to abandon it because there was no viable alternative for the management of 2POMW, while the existing extraction plants cannot handle it and do not accept it. In Greece there is no specific regulation regarding the discharge of OMWW. The olive oil producing prefectures have their own environmental requirements and, on the gained local experience and the results of sponsored research projects, they encourage different waste management approaches. Nowadays, the issuing of an olive-mill operation permit is subject to measures taken to treat the olive-mill waste. More specifically, the Prefecture of Lesvos has stipulated that OMWW must be pre-treated with lime before disposal in the natural recipients. However, this solution was not enforced and the olive-mills were granted a two-year extension of the validity of their operation permits. The Prefecture of Chios decided to construct open ponds, large enough to accommodate the entire quantity of wastewater produced in one olive cultivation season. Twelve of the fourteen olive-mills on the island dispose of their wastewater in such mud ponds. The Prefecture of Samos has granted all its olive-mills a two-year extension with regard to issuing an operation permit. Meanwhile, a wastewater management technique is due for evaluation for real-scale application by an olive-mill on Samos. This method initially includes pretreatment/fractionization of OMWW by natural sedimentation. Separate management of the individual fractions then takes place. A general conclusion drawn from research to date is that there is no single technical solution that can ensure a satisfactory level of treatment efficiency whose application cost will be within the economic means of each individual olive-mill owner. This conclusion accounts especially in the case of Greece, given its geographical distribution and the size of its olive-mill plants. In other parts of the country, evaporation ponds (lagoons) are commonly used for the treatment and disposal of OMWW, optionally after neutralization with lime. In practice, all the generated OMWW results in creeks (58%), or in sea and rivers (11.5%), or in soil (19.5%).

GREECE ISLANDS

From NAIAS (http://www3.aegean.gr/environment/eda/naias/waste.htm#regulations)

Regulations in force for OMW Disposal

Lesvos: The standing practice in the 71 olive mills on the island continues to be the unrestrained dumping of OMW in torrents/streams and ends up reaching its final recipient, the sea. A provisionary attempt to confront the problem was proposed by the Prefecture of Lesvos. This consisted of the addition of lime to the OMW before its disposal to the natural recipients, in order to lower the pollutant load. There is overall agreement that the proposed treatment system (that has been applied in only 2 olive mills on Lesvos where it is not applied in daily practice) requires improvements and additions. Thus the Prefecture of Lesvos has extended the period of putting technical applications into practice and a final decision based on the results of NAIAS programme currently underway is expected to be reached.

Chios: The Prefecture of Chios recently went ahead with a provisionary solution to the problem, with its decision to construct simple tanks/ reservoirs for the storage of the total volume of OMW produced. So far the proposed solution has been applied in 12 of the 14 olive mills on the island. The system consists of soil reservoirs or concrete tanks, with the capacity to store the entire amount of waste produced during one olive production year. In certain cases however, because of the small size of the reservoir and the soil's limited absorption capacity, the island's torrents/streams continue to be the OMW's final recipients.

ITALY

In Italy, 5000–6000 olive-mills are operating with most common extraction technology still based on simple pressure. Italy is the only olive oil producing country with a special legislation for the disposal and/or recycling of olive processing wastes. Land spreading of wastes arising from olive processing is specifically regulated under the Law no. 574 of 11/11/1996 on OMWW and olive cake. However, the prescriptions of the law have been criticized because they make the inspections quite difficult as the regional and provincial authorities, from which the inspection depend, do not know the exact dates and places of the spreading. A typical disposal scheme applied in Italy for the treatment of olive-mill wastes is outlined here.

TURKEY

In Turkey too, there is no specific regulation regarding the discharge of OMWW. The Turkish water pollution control regulation oversees protection of the water resources against pollution and sets discharge standards both for protection of the receiving media and for effluents of olive-mills. The biggest and main obstruction for the safe disposal of OMWW is that olive-mills are small and scattered in a large geographical area. In regard to solid olive-mill waste, the Ministry of Environment in Turkey has permitted the combustion of dried solid cake only in olive-mill started in 2003, with the condition that the gas emission limits are met.

PORTUGAL

In Portugal there are around 1,000 olive-mills most of which use the traditional discontinuous pressing process, although over the last few years several units have introduced continuous solid–liquid centrifugation systems. The olive oil sector has been subject to a specific intervention that started in 1997 and was completed in 1999 with the signing of an agreement. Both the Ministry of Environment and the Ministry of Agriculture were involved, while the agreement was technically supported by a University that did exhaustive characterization of the sector, studied technical solutions for OMWW and performed cost–profit analysis for their implementation. The olive-mills are subjected to monitoring under the agreement and the new legislation that has been produced (regulation for the use of OMWW in irrigation, interpretation for excluding the olive cake from classicization as ‘‘waste’’ and selection of representative sample for air emission characterization). The use of OMWW for irrigation is also subject to restrictions similar to those applicable in Italy. Namely, the limits for the spreading of OMWW on soil for agricultural use are 50m3/ha/y from a traditional press system and 80m3/ha/y from the three-phase centrifugation system. Furthermore, it is forbidden to spread within 300m from a drinking water source; within 200m from a habitation center; over territories where in the same moment some crops are being grown; over soils where there may be any kind of contact with groundwater, or where the groundwater flow is within 10m from the surface. It is also forbidden to discharge in surface waters and in the sea.

FRANCE

The annual olive-oil production comes from four regions: Provence-Alpes-Coˆ te d’Azur (61%), le Languedoc-Roussillon (17%), Rhoˆ ne Alpes (12%), and Corse (10%). In France there are more than 25,000 olive farms and 152 mills and cooperatives. Land spreading is the disposal practice most commonly used in France. The creation of evaporation ponds has been encouraged as an alternative disposal treatment. The construction costs of an evaporation pond are subsidized up to 30% by the Water Agency and supplementary by regional and departmental authorities. The norms of construction of evaporation ponds are regulated by a ministerial decree concerning the pollution control of farming effluents (JO 21/03/2002).

CYPRUS

There are 35 olive-mills in Cyprus today, with an average capacity of 1,000 tons of olives per year, producing around 7,500 tons/year of olive oil. Due to the small size of olive-mills in Cyprus, it is rather unreasonable to assume that each mill will have its own liquid waste treatment facility. Existing permitting system provides for liquid and solid waste conditions. Since facilities are SMEs they do not have to comply with Emission Limit Values (EVLs) relevant to treatment of wastes. The permit conditions are based on techniques/practices rather than treatment technologies of the wastes. The most useful practice is the storage of OMWW in artificial ponds and remaining there for evaporation (evaporation rate is about 550mm per year). Most of the plants are situated in the peripheries of villages. No discharge in the sea or in the surface waters and rivers is allowed. It is estimated that 95% of stones are used for heating, 85% of OMWW are stored in ponds and/or discharged to soil and, approximately 10% are discharged in central industrial treatment facilities, especially constructed and operated for SMEs.

The Law for the Pollution Control of Waters and Soil (No. 106(I)/2002) is the governing law in the Republic of Cyprus that aims to protect surface water, groundwater and the soil from human and industrial activities, as well as control liquid and solid industrial wastes. The Law which is broken down into nineteen Regulating Administrative Actions (RAA’s), harmonizes the Cyprus legislation frame research to the EU directives and decisions. The most relevant RAA’s to olive oil production are shown in Table 2. Additionally, there are also eleven ordinances of which those relevant to olive oil production are shown in Table 3.

The principal Ordinance regulating the disposal of Olive Oil Production Waste is the Waster Pollution Control (Waste Disposal Permit) Ordinance of 2003 (254/2003). The waste streams generated by olive mills as well as the application for the disposal permit differ according to the process used for the oil extraction (i.e., two-phase or three-phase centrifugation). Consequently, the types and amounts of waste allowed to be deposited for each process differ (Table 4).

As described in the ordinance, regardless the type of process they originate from (two-phase or three-phase) liquid wastes (wastes types a and b in Table 4) should be temporarily stored in waterproof sealed tanks.

Table 2: Regulating Administrative Actions (RAA) in Cyprus legislation associated with olive oil production

RAA	Regulations	Publication date
407/2002	Code for good agricultural practice	September 6, 2002
517/2002	Water pollution control (Use of sludge in agriculture) Regulations of 2002	November 1, 2002
534/2002	Water pollution control (Nitrogen pollution of agricultural origin) Regulations of 2002	November 8, 2002

Table 3: Ordinances in Cyprus legislation associated with olive oil production

Ordinances	Description	Publication date
45/1996	Water pollution control (Groundwater protection measures) Ordinance of 1996	February 23, 1996
254/2003	Water pollution control (Waste disposal permit) Ordinance of 2003	November 1, 2002
41/2004	Water pollution control (Action program for the Nitrogen Sensitive regions of Cyprus)	January 30, 2004
42/2004	Nitrogen sensitive zones and water categories that are subjected or are possible to be subjected to Nitrogen pollution	January 30, 2004

Table 4: Maximum annual waste quantities allowed for two- and three-phase centrifuge olive mills in Cyprus

	Maximum annual waste quantities allowed (m^3)	
Waste stream generated	Two-phase centrifuge	Three-phase centrifuge
Liquid waste from the washing of olives	180	1600
Liquid waste (water and minimal olive oil mill wastewater) originating from the centrifuging decanters where the separation of the plant liquids of the fruit from the oil takes place	1400	1400
Sludge (olive dregs) originating from the horizontal centrifuging decanter	750	750
Sludge settling at the liquid wastes evaporation tanks/ponds	-	-
Leaves from defoliation	-	-

Whether or not the streams are mixed or separated depends on the method of disposal. Additionally, sludge (olive dregs-type c) should be temporarily stored in a covered area with concrete base (platform). Liquids originating from leakages or run-offs from the temporary storage areas for the solid wastes or sludge should be collected and transferred to the liquid wastes tanks, via open-air waterproof pipes.

Liquid waste from the washing of the olives (waste stream a) can be used for irrigation of cultivations (trees, forest-trees, etc.) surrounding the olive mill. In cases where the waste is mixed with liquid waste originating from the centrifuging decanters (b), the liquid wastes must be transferred for final disposal in evaporations tanks/ponds. Evaporation tanks must be open, waterproof, and earthen and shallow (maximum depth of 1.2 m). Liquid wastes must be transferred to the evaporation tank within closed pipes or with a tanker.

Table 5: Characteristics of liquid waste entering the evaporation tank

Parameters	Maximum value allowed
pH	5.0-7.0
Electric conductivity	10,000 $\mu S\ cm^{-1}$
Suspended solids	5,000 $mg\ L^{-1}$
BOD	10,000 $mg\ L^{-1}$
Fat	6,000 $mg\ L^{-1}$
Phenols	1,000 $mg\ L^{-1}$

The required quality (maximum allowance) of the liquid wastes to be disposed in the evaporation tank is shown in Table 5.
Sludge produced by the decanter of a two-phase mill must be collected and transferred by a tanker to the appropriate facilities for incineration of composting. At the end of functioning period, no sludge should be present at the temporary storage area. Solid wastes produced by a three-phase mill must be collected and used as animal stocking or fertilizer or sent to a seed-oil production facility for further treatment. The institution exploiting the waste should maintain a database for the quantities and the ways the waste has been disposed. If the olive dregs are used as soil improver (fertilizer), the application should be at least 300 m from residential areas, with a maximum disposal rate of 3.5 tons/hectare/year.
Sludge depositing at the bottom of the evaporation tanks should be collected, when needed after the liquid present in the tank has been dried and transferred for disposal to an approved public area or as soil improver (under the conditions stated above).

The need for future legislation

The future legislations should address the following issues as a background to the enforcement of the regulations:

- Environmental awareness – aspects concerning land spreading (according to the soil structure and type to accept the wastes); effect of the nutritional aspects of the wastewater; the effect on Sewerages and Water treatment systems; effect on streams and water reservoirs; the microbiological influence of the wastes (solids and liquids); etc.
- Information about the state of the olive oil mills' industry - There is a lack of reliable data and explanations at the level which suits the mills' owners concerning the quantity of olive oil mills' waste produced of both, the two-phases and three-phases processes, its characteristics, where it is produced, and ways of treating it,
- Information relating to the disposal and recycling techniques of olive oil mills' wastes in an efficient and economic way,
- Information on the capital investment nature of the waste treatment plants that are suitable for small sized decentralised applications for the SMEs,
- Economic evaluation on the different processes and the recycling procedures – centralised on waste-to-energy solutions in addition to the environmental issues,
- Explanations on benefits for scale at the olive oil mills' waste treatments,
- Environmental regulation to be implemented at the olive oil mills and their dangers for the olive mills' industries. Proposals to meet the demands of environmental policy and sustainable management of resources according to the EU countries regulations,
- Information on subsidiaries for mills' owner to solve the environmental problems and penalties, with specific details on whom to contact and what is needed.

List of EU Projects on Olive Oil wastewater

Projects
Identification and conservation of the high nature value of ancient olive groves in the Mediterranean region LIFE07 NAT/IT/000450 **web summary**
European awareness raising campaign for an environmentally sustainable olive mill waste management LIFE07 INF/IT/000438 **web summary**
Recovery, recycling, resource. Valorisation of olive mill effluents by recovering high added value bio-products. LIFE07 ENV/IT/000421 **web summary**
Stategies to improve and protect soil quality from the disposal of olive mills' wastes in the Mediterranean region LIFE07 ENV/GR/000280 **web summary**
Environmental Friendly Technologies for Rural Development LIFE05 ENV/GR/000245 **web summary** | **website**
Processing plant for the integral treatment and valorisation of the wasted generated during the olive oil production process LIFE05 ENV/E/000292 **web summary**
A new application of phytodepuration as a treatment for the olive mill waste water disposal LIFE04 ENV/IT/000409 **web summary** | **website**
Life Cycle Assessment (LCA) as a decision support tool (DST) for the eco-production of olive oil. LIFE04 ENV/GR/000110 **web summary** | **website**
New technologies for husks and waste waters recycling LIFE00 ENV/IT/000223 **web summary**
Process development for an integrated olive oil mill waste management recovering natural antioxidants and producing organic fertilizer LIFE00 ENV/GR/000671 **web summary** | **website** | **layman's report**
Pleurotus LIFE99 ENV/IT/000063 **web summary**
Arboretum de Beauregard- the local plants at service for the restoration of the usual nature LIFE99 ENV/F/000497 **web summary** | **website**
OLEO-LIFE LIFE99 ENV/E/000351 **web summary**
Innovative demonstration facility for the treatment of waste water from olive oil presses (OMW) with material and energetic utilization of the residues LIFE99 ENV/D/000424 **web summary** | **website** | **layman's report**

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