

▪ REPORT 3.2

**IDENTIFICATION AND  
ANALYSIS OF REGIONAL AND  
NATIONAL POLICIES AND  
DISCIPLINES**

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## 1. Short presentation of the participating Regions

### 1.1 The Region of Western Greece

The Region of Western Greece stretches from the northwest part of the Peloponnese to the western tip of the Greek mainland (Figure 1). It is one of the 13 Regions of Greece, is separated in 3 administrative districts, the Prefectures of Aitoloakarnania, Achaia, Elia and covers an area of 11.350 square kilometres (8,6% of the total area of Greece). The Region features an exceptionally wide variety of terrain from tall mountains (Aroania 2335m, Erymanthos 2222m, Panachaikos 1926m), to large natural lakes (Trichonida, the largest lake in the country at 95,8 km<sup>2</sup>, Amvrakia 14,4 km<sup>2</sup>, Lisimaheia 13km<sup>2</sup> and others) and rivers (Acheloos, the second longest river in Greece at 220km, and the Pinios, Alfeios, Evinos, Selinountas, Vouraikos, Peiros and Glavkos).

The Prefecture of Aitoloakarnania, which is the largest in Greece (5448 km<sup>2</sup>), combines tall mountain ranges with many natural and artificial lakes. The Acheloos and Evinos river plains complete the geomorphology of the prefecture, and form the basic source of its economic livelihood.



**Figure 1:** Map of the region western Greece

The Prefecture of Achaia, with an area of 3274 km<sup>2</sup>, is also characterized by wide contrasts in its terrain. The greater part (around 60%) consists of mountains, with relatively small rivers (Vouraikos, Glavkos, Selinountas, Peiros) running between them down to the Gulfs of Patras and of Corinth. The economic life of the prefecture, and the Region as a whole, is centred in the port city of Patras.

The Prefecture of Ileia covers an area of 2621 km<sup>2</sup> and consists mostly of plains (60%), through which flow the rivers Alfeios, Pineios, Erymanthos and their tributaries. The plain of Ileia is the largest in in the Peloponnese, but the Prefecture is better known for the coastal wetlands of Kotichi and Kaiafa, a terrain of exceptional natural beauty and ecological wealth.

According to the 2001 census, the population of the Region of Western Greece is 741,282. This makes it the fourth most populated Region of Greece, with 7% of the country's total population.

Today the Region of Western Greece is a modern communications and transport hub that connects Greece to the rest of Europe. The busy port of Patras is not only the Region's capital but also the country's main gateway to Western Europe [1].

The population of the Region of Western Greece is allocated in three Prefectures as shown in Table 1 below:

#### Population in Region of Western Greece

Prefecture	Population 2001	Distribution of population 2001		Habitations per km <sup>2</sup>
		Urban	Rural	
Aitolokarania	224.429	113.047	111.382	41,10
Achaia	322.789	216.592	106.197	98,70
Ileia	193.288	81.994	111.294	73,80
RWG	740.506	411.633	328.873	
Greece	10.964.020	7.980.414	2.983.606	83,10

Source: National Statistical Service of Greece (Census 1991, 2001), Data NSSG 2006

Table 2 shows the distribution of the primary sector within the RWG. According to the National Statistical Service of Greece, the Prefecture of Ileia has the biggest part of the primary sector, since the 22% of the total production is coming from the activities of the primary sector. On the other hand, Prefecture of Achaia has only 5% activities in the primary sector. As far the cultivated areas are concerned a reduction of ~5% was observed the last years, in all Prefectures.

**Table 2: RWG primary sector**

	Aitoloakarnania	Achaia	Ileia	RWG	Greece
Activities in primary sector, 2004 (in M€.)	332	229	368	929	8.452
% of total activities in each prefecture	15,0%	5,3%	21,9%	11,32%	4,4%
Total of cultivated areas (1000m <sup>2</sup> ), 2002	1.041.697	716.235	1.227.234	2.985.166	34.563.825
% reduction in cultivation (1998-2002)	-5,3%	-7,4%	-4,2%	-5,4%	-3,2%

Source: National Statistical Service of Greece

### *Industries in the Region of Western Greece*

In the Region of the Western Greece there are plenty of different types of industries which are shown in Table 3. Industry is using water in large quantities during production for cooling, cleaning and other purposes. This activity threatens our water resources due mainly to the discharge of pollutants into surface water, which may also reach groundwater.

Water is essential for the survival of all known forms of life. Lack of water means lack of life. The world is increasingly facing a serious water shortage and lack of quality water supply as global agriculture and industry compete with local populations for freshwater access and use. Only 0.3% of the world's water is usable while 70% of the world's usable water is consumed by agriculture (FAO). In a UN report on

climate change (2007), it was projected that by the year 2050 the annual average of water availability is going to decrease by 10-30% over some dry regions at mid-latitudes [2].

Therefore it is essential to treat such effluents to avoid or reduce their environmental impact. The industrial sectors involved in activities that produce liquid effluents are very extensive and each has their own specific problems and thus their own knowledge and expertise in the treatment of their effluents. On the other hand the number of commercially available technologies to treat liquid effluents is very wide and in addition there are also a number of emerging technologies.

**Table 3: Number of enterprises by sector and prefecture [3]**

SECTOR	Aitolos-akarnania	Achaia	Ileia
Various Enterprises	313	48	46
Mining of coal, lignite and peat	--	1	1
Other mines and quarries	10	6	8
Food and beverages industry	356	488	332
Tobacco products industry	2	--	--
Manufacture of thread and weaving material	13	74	25
Manufacture of clothing items: processing and dyeing of furs	60	289	36
Processing and tanning of leather, manufacture of luggage, handbags, saddlery and footwear	11	50	2
Wood industry and manufacture from wood and cork, except for furniture, basketry and other woven products	111	181	115
Manufacture of wood pulp, paper and paper products	1	15	3
Publications, printing and broadcasting of pre-recorded sound and vision or information media	27	76	16
Production of coke, products of oil distillation and nuclear fuels	4	8	4
Manufacture of chemical substances and products	6	19	6
Manufacture of products from rubber and plastic materials	3	15	2
Manufacture of other products from non-metallic ores	42	101	47
Production of basic metals	4	12	4
Manufacture of metal products, with the exception of machinery and equipment	66	172	91
Manufacture of machinery and equipment	16	48	22
Manufacture of office equipment and computers	--	2	--
Manufacture of electrical machinery and appliances	5	20	2
Manufacture of equipment and appliances for radio, television and communications	--	5	1
Manufacture of medical instruments, precision instruments, optical instruments and clocks of all kinds	4	16	4
Manufacture of automobile vehicles, towed and semi-towed vehicles	3	7	1
Manufacture of other transport equipment	4	9	--
Manufacture of furniture and other industries	39	143	46
Provision of electrical power, natural gas, steam and hot water	--	2	--
Collection, cleaning and distribution of water	4	2	2
Construction	710	1255	739
Sale, maintenance and repair of automobile vehicles, motorcycles, retail sale of fuel for automobile vehicles	541	745	394
Wholesale trade and trade with commission, apart from the sale of automobile vehicles and motorcycles	408	852	310
Retail trade, apart from the trade in automobile vehicles and motorcycles and repair of personal and household goods	2.993	4.476	2.181
Hotels and restaurants	1.171	1.505	837
Overland transport and transport via pipelines	534	759	243
Transport via water routes	5	11	--
Ancillary transport related activities, travel agency activities.	54	198	38
Post offices and telecommunications	4	8	1
Insurance and pension funds, apart from compulsory social security	3	32	13
Activities related to intermediary credit financing organizations	15	39	3

SECTOR	Aitolo-akarnania	Achaia	Ileia
Real estate management	6	17	4
Leasing of unmanned machinery and equipment, rental of personal and household goods	17	31	36
Information Technology and related activities	1	15	4
Research and Development	--	6	--
Other entrepreneurial activities	357	1.039	291
Public administration and defence, compulsory social security	--	2	2
Education	55	128	49
Health and social welfare	31	87	18
Waste disposal, public health and related activities	1	7	6
Activities of organizations	74	28	8
Entertainment, cultural and sports activities	68	142	37
Other service related activities	105	268	85

As far as water supply and sewerage systems are concerned these are managed by local authorities. Municipality and community authorities were supposed to handle the management of water supply and sewerage systems. There were many projects funded by European Union directly to Municipalities to create their own sewage treatment plants. For the future the new government plants these responsibilities will be handled by the new municipalities which will be created after the merging of 5-6 smaller municipalities in a metropolitan municipality. What is missing in many local entities is the presence modern Regional Solid Waste and Recycling factories. In the area of RWG plans has been made for only one new solid waste treatment plant which will cover mostly the needs of the Patras (capital of Achaia Prefecture). The cost of this factory which will have also a department for

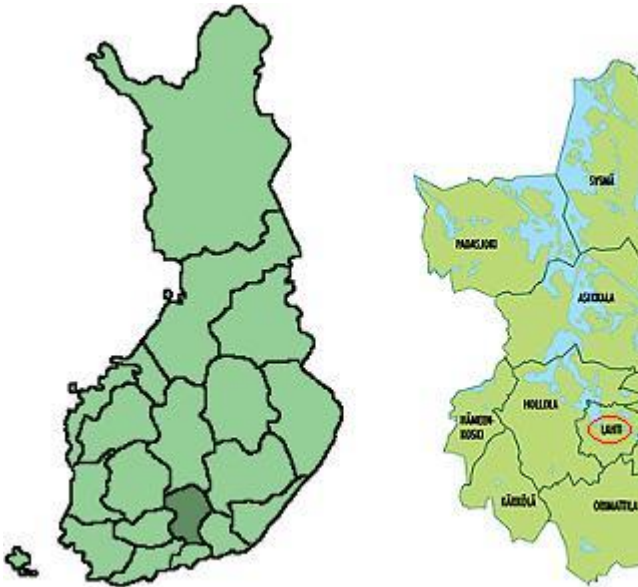
recycling is estimated to be 60 millions Euro.

As far as water resources are concerned in the region of RWG, (valid also for the whole country) cultivations consume the most of water. In RWG there is infrastructure for collecting and storing of raining water (dams, filtration units, etc) and new plants are in process to cover the needs of urban and rural habitants.

## 1.2 Päijät-Häme Region, Finland

### General

Päijät-Häme is a region in Southern Finland (6,257 km<sup>2</sup>) and its regional center is city of Lahti (see Fig. below). Besides Lahti, eleven other municipalities belong to the region of Päijät-Häme: the cities of Heinola and Orimattila, and the municipalities of Hollola, Sysmä, Asikkala, Hämeenkoski, Hartola, Nastola, Kärkölä, Padasjoki and Artjärvi. The population of the region is about 200000, half of them in Lahti. (Regional Council of Päijät-Häme 2010a, Suomen Kaupunkioapas 2010)



### About waters

A fifth of Päijät-Häme is covered by lakes. The third largest lake of Finland, Lake Päijänne, dominates the region. Another big lake is Vesijärvi (108 km<sup>2</sup>), which is connected to Päijänne via a passage. The region is an important drinking water

reservoir for the whole Southern Finland. (Regional Council of Päijät-Häme 2010a)

The special feature in the region's geography is an extensive ridge system left by ice age (called Salpausselkä). It is an important reservoir of clean groundwater for the communities built alongside the ridge. Päijät-Häme is located between two of these ridges.

### About industry

Wood and innovative potential are one of the most important resources for the region of Päijät-Häme. Although in addition to the woodworking and furniture industries, metal, plastic and textile goods are of the highest quality and locally manufactured for domestic and global markets. Progressive innovations originate especially from the environmental and recycling sector of the industry. Both agriculture and forestry still represent essential sources of income in the rural areas. (Regional Council of Päijät-Häme 2010b)

Around 10 percent of Finnish cleantech business is located in Lahti and the surrounding region, specializing in waste management and recycling in particular, as well as in water and soil related business. Lahti Science and Business Park coordinates the cleantech cluster in the

region by helping the cleantech enterprises to develop and internationalise their business. Special fields in business sector are promotion of venture capital investment and funding pilot plant activities. (Cleantech Finland 2010)

Generally in Finland, water supply and sewerage systems are managed by local authorities. In Päijät-Häme region, there are several waterworks for municipal wastewater treatment and clean water distribution. Bigger industrial plants have typically their own wastewater treatment systems.

#### ***About research***

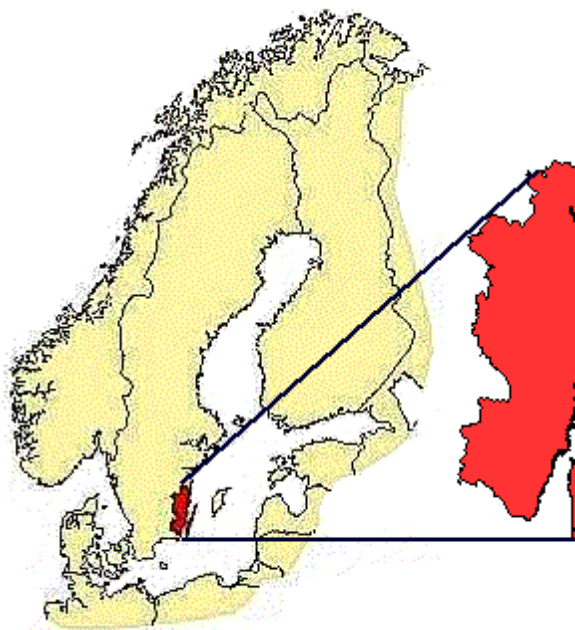
Päijät-Häme has a long tradition of pulp and paper related wastewater treatment and knowledge of closed loops and membrane technologies through the expertise of Aalto University school of science and technology (formerly Helsinki University of Technology) and Lappeenranta University of Technology. Furthermore, Helsinki University of Technology has concentrated on Environmental Technology within the Process Industry, specially eco-efficiency processes and environmentally-friendly products.

### **1.3 Kalmar Region, Sweden**

#### ***Presentation of the region***

Kalmar County is a region in the southeast corner of Sweden and it is also located, right in the center of the expansive and dynamic Baltic Sea region. From early ages the strategic location at the Baltic Sea and the contacts with the Baltic states had a significant impact on the region's trade and shipping, which is becoming increasingly interesting as the link between the European countries is growing stronger.

The population of the region is just under 234 000 corresponding to 3 % of the population of Sweden. The cities are Kalmar, Västervik, Oskarshamn, Nybro, Vimmerby and Borgholm. Kalmar is the biggest with a population of 55 600. There are also six municipalities in the county. Both visitors and residents have access to a beautiful nature and quality of life.



### Kalmar County

Kalmar County has embarked on a comprehensive program to reduce fossil fuel use. Quite many initiatives are taken aiming for the goal that the county will be fossil fuel neutral in the year 2030.

### *Water in the region*

The county covers an area of 11 694 km<sup>2</sup> and that correspond to 3 % of the total area of Sweden. Forests cover 63 % of the county and there are more than 2 000 lakes. About 20 % of the county's area is currently used for agriculture. The most significant problem in the district is eutrophication combined with quite sensitive and valuable coastal zones. Households and farming cause the majority of nitrogen discharge. Industries use the

largest amount of water. The mainland coast line to the Baltic Sea reaches 1 215 km and the archipelago comprises nearly 13 000 islands. There are 15 small rivers crossing the county, Emån being the biggest. Ground water is the main source for drinking water supply in most of the municipalities and cities. Surface water from some lakes and small rivers fill up the drinking water supply.

Water supply and sewerage systems are managed by local authorities in Sweden. Each city and municipality has its own waterworks and waste water treatment plant for municipal clean water distribution and waste water treatment. Remote domestic households are not generally connected to municipal treatment plants. A combination of a septic tank (with one or more compartments) and a drainage system is the most common treatment method for these individual septic systems. Some of the bigger industries have their own waste water pretreatment before they release the waste water to the municipal waste water treatment plant. Storm water from city centers, roads, harbor areas and industrial storage areas is often discharged directly to the receiving waters. In some cases the storm water is lead via wetlands or the municipal waste water treatment plants before discharge.

### *Industry in the region*

The county has a long and strong tradition of both small and large companies and the Linnaeus University offers important knowledge environments for research and development. Long term environmental and energy initiatives and a strong commitment to sustainable growth offer good prerequisites for companies in the cleantech business. The goal of the Linnaeus University is to have a Triple Helix Approach in the research and education projects. Engineers from the industry sometimes act as lecturer in the MSc/BSc courses at the university. The students are writing assignments and thesis work related to the industry activities. Professors from the university sometimes participate in the environmental communication between the industry and the local EPA.

Agriculture and forestry are important fields closely linked to processing wood and food processing industries. Agriculture accounts 4.4% of employment in Kalmar County, which is almost twice as much as in the country as a whole. It should be added the number employed in the food industry (1750 persons) and in forestry (4900 persons). Wooden floors, furniture and house production are representatives of the wooden industry. Dairy and brewery

products are good examples of the agricultural branch industries. Kalmar County has a high share of industrial employment, particularly in the manufacturing industry. Environmental technology is becoming one of the key growth areas in the region. The proportion of employees in the cleantech industry in Kalmar County is the highest in Sweden. There is a wide range of companies and innovations that may be of great global significance. Membrane technology systems, turn key plants for water treatment and biogas production and a system, for dewatering the sludge from septic tanks are some important examples. Tourism is another very important sector for trade and industry in the county.

### *Research*

The Linnaeus University is Sweden's newest university, the result of a merger between Kalmar University and Växjö University on 1st January 2010. The University has 34 000 students (15 000 full times students), 2 000 employees and 138 education programmes.

Linnaeus University pursues teaching and research in Kalmar and Växjö. Kalmar, with its close proximity to the coast and the Baltic Sea, is noted for its prominent research in the natural sciences. The faculty of Science and Engineering include

the School of Natural Sciences, the School of Engineering and Kalmar Maritime Academy and these are focused on research in environmental sciences and engineering. Among the specialties you find marine biology, research within microbial, plankton and fish ecology as well as coastal monitoring in the South Baltic Sea, research in waste management and recovery including solid waste management, leachate characterization and treatment, industrial waste water treatment, long time and short time storage of organic materials, landfill mining, environmental economics, metal dispersion in ground water, material sciences and renewable energies. Low cost technologies and natural based technologies are important areas e. g. adsorption treatment processes for cleaning of water – industrial waste waters in particular. In cooperation with the industry and local authorities, the university is also involved in developing the use of sustainable energy sources based on the use of algae. Forest industry and wood manufacturing industry are some other dominating areas of research.

## 2 Industrial and municipal wastewaters

There are several types of treatment methods for industrial and municipal wastewaters. Industries within municipal limits usually discharge their wastewater to the city's sewer system after pretreatment [4]. In joint processing of wastewater, the municipality accepts responsibility of final treatment and disposal. The majority of manufacturing wastes are more amenable to biological treatment after dilution with domestic wastewaters. However, large volumes of high-strength wastes must be considered in sizing of a municipal treatment plant. Uncontaminated cooling water is directed to the storm sewer. Pretreatment at the industrial site must be considered for wastewaters having strengths or characteristics significantly different from sanitary wastewater. Considerations should be given to modifications in industrial processes, segregation of wastes, flow equalization, and waste strength reduction. Process changes, equipment modifications, by-product recovery, and in-plant wastewater reuse can result in cost savings for both water supply and wastewater treatment. Modern industrial plant design dictates segregation of separate waste streams for individual

pretreatment, controlled mixing, or separate disposal. The latter applies to both uncontaminated cooling water that can be discharged directly to surface watercourses, and toxic wastes that cannot be adequately processed by the municipal plant and must be handled by the industry. Manufacturing plants using a diversity of operations may be required to equalize wastewaters by holding them in a basin for stabilization prior to their discharge to the sewer. Un-equalized flows may have dramatic fluctuations in quality that would upset the efficiency of a biological treatment system. Certain industrial discharges, such as dairy wastes, can be more easily reduced in strength by treatment in their concentrated form at the industrial site. Others, like metal-plating wastes, often require pretreatment for the removal of toxic metal ions. If reuse of the municipal wastewater is planned, rather stringent controls on industrial discharges are needed, since many of the substances in manufacturing wastes are refractory to conventional treatment and will interfere with water reuse.

Conventional water treatment is a combination of physical and biological processes designed to remove organic matter from solution. The earliest method was plain sedimentation in septic tanks.

Imhoff tanks used by municipalities were two-story septic tanks that separated the upper sedimentation zone from the lower sludge digestion chamber. Primary sedimentation of wastewaters has limited effectiveness, since less than one half of the waste organics are settleable. The initial attempt at secondary treatment involved chemical coagulation to improve settleability of the wastes. Although this provided considerable improvement, the heavy chemical dosages resulted in high cost and dissolved organics were still not removed. The first major breakthrough in secondary treatment occurred when it was observed that the slow movement of wastewater through a gravel bed resulted in rapid reduction of organic matter. This process referred to as trickling filtration, was developed for municipal installations starting in about 1910. A more accurate term for a trickling filter is biological bed, since the process is microbial oxidation of organic matter by slimes attached to the stone, rather than a straining action. A second major advancement in biological treatment took place when it was observed that biological solids, developed in polluted water, flocculated organic colloids. These masses of microorganisms, referred to as activated sludge, rapidly metabolized pollutants from solution and could be subsequently removed by gravity settling.

In summary, wastewater treatment involves the following steps: Preliminary, Primary, secondary, sludge treatment and disposal. Preliminary steps include screening to remove large solids, grit removal to protect mechanical equipment against abrasive wear, flow measuring, and pumping to lift the wastewater above ground. Primary treatment is to remove settleable organic matter, amounting to 30 to 50 percent of the suspended solids, and scum that floats to the surface. Secondary treatment is by aeration in open basins with return biological solids, or fixed-media (trickling) filters, followed by a final settling. Excess microbial growth settled out in the final clarifier is wasted while clear supernatant may be disinfected with chlorine prior to discharge to a receiving watercourse. Waste sludges from primary settling and secondary biological flocculation are thickened and dewatered in preparation for disposal. Anaerobic bacterial digestion may be used to stabilize the sludge prior to dewatering, or a mechanical process may be used to extract water directly from raw sludge after chemical conditioning. Ultimate disposal of dewatered solids may be landfill, incineration, or land application if biological stabilized.

In some cases the convectional biological treatment is enforced by advanced wastewater treatments that remove more contaminants from wastewaters. The term may be applied to any system that follows secondary treatment or that modifies or replace a step in conventional processing. The expression tertiary treatment is often used as a synonym. The common processes are filtration, phosphorus precipitation, and nitrification. The primary purpose of effluent filtration (monolayer or bilayer deep bed sand filters) is to remove suspended solids that do not settle out by gravity. Phosphorus removal is to reduce eutrophication of lakes receiving wastewater effluents. Oxidizing ammonia to nitrate reduces ammonia toxicity and nitrogen oxygen demand in the receiving stream. When planned or accidental reuse of a wastewater effluent involves human contact, virus inactivation is recommended for protection of human health. In water reclamation, the primary concern is removal of heavy metals, organic chemicals, inorganic salts, and pathogens. Finally modern techniques such as membrane filtration (Macro, ultra, nano-filtration and Reverse Osmosis) are employed for the isolation of the solids and organic compounds from wastewaters, mainly in food or agro industrial sector.

### 3. Hazardous agro-industrial wastewaters

As stated in the proposal the whole industrial wastewater treatment sector will be under evaluation during the project, but more specific development activities will be carried out in the agricultural Olive Mill Wastewater (OMW) sector. Thus special emphasis will be given in treatment methods for the olive mill wastewater which causes severe environmental problems in Mediterranean countries.

As hazardous are characterized the waste which include substances in such concentrations efficient to lend to the waste one of the following properties: explosive, oxidizing, flammable, irritating, harmful, toxic, carcinogenic, corrosive, infectious, teratogenic, transmuting, ecotoxicological.

One of the major environmental hazards not only for the Achaia Prefecture, but also for many other regions of the Greek area has to deal with agro-industrial effluents which outfall to the countryside. Among the agro-industries, the units of milk treatment, cheese production and olive mill are concerned as such of great environmental interest.

Among the agro-industries, the units of milk treatment, cheese production and olive mill are concerned as such of great environmental interest.

#### 3.1 Treatment problems of milk and dairy industry

The production of milk and dairy products is relatively limited in Achaia Prefecture, their scattered installation and their illegal operation contributes considerably in the environmental pollution of the area. The most dairy units operate in periodical base, they are scattered in the countryside while they are relatively assessed as small units. Their effluents have been considered as toxic. The ecological risk from the rejection of cheese-whey effluents in the river of Vouraikos has been estimated. The data derived to an annual forecast which gives critical levels of ecological risk during summertime and remarkable level of risk during autumn. Integrated analysis proved that effluents concentration of the river smaller than 0,064% is preredquired in order to avoid the ecological risk of the aquatic fauna, while the present ecological situation of ecosystem is far from optimal, as the rejection of the untreated effluents into the water leads to concentrations 5 times higher than the above limit, approaching 0,32% during summertime. Malformations in a small percentage of

zebra fish, led to the detection of heavy metals to all treated samples. Chromium, manganese, zinc and lead have been detected. They are not environmentally safe for direct disposal in the aquatic receiver and further treatment for the removal of the toxic factors as phosphates and the ions of nitrogen is needed [5].

### 3.2 Treatment problems of olive oil industry

Characterized by extremely high biological and chemical oxygen demand values, and containing toxic compounds, olive mill wastewater (OMW) poses acute environmental problems in all Mediterranean countries. These characteristics prevent OMW discharge to sewer systems or uncontrolled land application. The fast increase of olive planted area in European countries may aggravate the problems in the future. Due to lack of economically-viable solutions, uncontrolled disposal of olive mill wastes continue to create severe risks to water and soil quality. Existing technologies such as anaerobic treatment, flotation and flocculation are too costly for most olive mills and their products have no real economical value. Moreover, the short (2-3 months) harvest season further extend their payback periods. Until oil producers have clear economical interest to treat

their wastes, the risk for uncontrolled disposal remains imminent. Due to its significant concentration of nutrients recycling is a preferable solution, as compared to costly engineering solutions, with the exception of the possibility of extracting special, high-value molecules from OMW.

## 4. Treatment Methods for Olive Mill Wastewaters

### 4.1 Direct disposal

#### 4.1.1 Disposal to uncultivated or agricultural soils

Direct application of OMW to uncultivated or agricultural soils has been considered as an inexpensive method of disposal. If soil characteristics are appropriate, OMW can be used as a fertilizer since they contain plant nutrients (mainly K, but also N, P and Mg). OMW can also be exploited as a low cost source of water, taking into account the increasing scarcity of hydraulic resources for irrigation. Finally, their supply of organic matter enhances microbial activity and improves the physical and chemical properties of soil.

According to the literature [6] the soil has also the ability to:

- Act as a filter and detain the substances, which are in suspension in the OMW.

- Convert many ions to carbonate and sulfate compounds or to hyper oxides of ferrous or aluminum.
- With the clay and the humic that it contains, it adsorbs with physicochemical forces constituents of the disposed wastewater.
- Degrades biologically many organic compounds in a short period of time.

Riffaldi et al., 1992, [7], performed lab-experiments and studied the effect of the disposal of sludge from the olive processing on some soil characteristics. They observed that when the vegetation water sludge was incorporated in the soil, the values of phenolic substances and volatile acids resulted equal to those of the control on the 19<sup>th</sup> day after sludge disposal for the 1% and on the 42<sup>nd</sup> day for the 2% amendment. On the contrary, the course of the decline in COD was the slowest, because only at the last sampling (2%) the differences from the control values disappeared for both doses of amendment. It is worth noting that COD and volatile acid contents, that are perhaps indexes of the most degradable components of organic matter, decreased on the 42<sup>nd</sup> day also for the control. Therefore sludge incorporation in soil about 20-40 days before drilling minimizes the potential for toxin production and the possible negative effects on plant growth and yield, although the kinetics of the

disappearance of unfavorable components will depend on soil type and conditions.

They also studied the change of the fertility parameters  $\text{NO}_3^-$ ,  $\text{HPO}_4^{2-}$  and  $\text{K}^+$  because of the addition of sludge to the soil. The  $\text{HPO}_4^{2-}$  was decreased rapidly, just one day after disposal of sludge in soil, probably due to the adsorption by soil colloids. However, after about 20 days  $\text{HPO}_4^{2-}$  concentration in amended soil was no longer significantly different from control. The  $\text{NO}_3^-$ -N also decreased, and this can be attributed to a denitrification and/or immobilization process by means of soil microorganisms. The lack of  $\text{NO}_3^-$  was maintained practically throughout the entire experimental period, although the trend of anion concentration in soil was to increase as time proceeded. On the contrary, for what concerns the amounts of available K, the magnitude of variations was not affected by incubation time. However, it was significantly influenced by the amount of the sludge added into soil.

Many other researchers also claimed that the disposal of OMW to soil is not so dangerous. Catalano et al., 1985, [8], observed an increase in the production of the olive trees when they were irrigated with OMW, enrichment of the soil in P and K and decrease of the organic load of the wastewaters by 80% after 60 days. Proietti

et al., 1988, [9], also did not notice any change in the ability of photosynthesis, the transpiration, the specific weight and the amount of hydrocarbons and chlorophyll of the olive leaves. Morisot et al., 1979, [10], claimed that the organic matter of the OMW could be degraded in the soil very soon. Especially when the volume of the OMW is about 100 m<sup>3</sup>/hectare only the first 60-65 cm of the soil seem to be influenced. The irrigation with OMW is phytotoxic only for the underbrush plants, if they are planted less than 80-90 days after the disposal. Finally, Di Giovacchino and L. Seghetti, 1990, [11], said that when the disposed wastewaters are about 20-40 m<sup>3</sup>/hectare their effect reaches only the depth of 10 cm and the concentration of the phenols is proportional to this of the olive leaves and the branches that fall to the ground.

Contrary to the previous studies many researchers claim that the high content of mineral salts and the presence of organic compounds, such as fatty acids and polyphenols in the OMW are detrimental factors to soil fertility. Additionally, it is difficult to store and dispose the large amounts of this liquid waste, which is produced in a short and often rainy period of time.

The large phenolic content of OMW is considered to be harmful for plants, hence, an early plant growth inhibitor for different vegetables and a source of objectionable odor when contacted with chlorinated water (formation of chlorinated phenols). Capasso et al., 1995, [12] showed that some polyphenols, like methylcatechol and o-quinone, which are naturally present in olive oil vegetation waters, have toxic effects on some strains of gram-positive and gram-negative bacteria. Another negative property of this wastewater is its extremely high organic content. Generally, OMW has BOD values in the range of 12000-63000 mg/l and COD values in the range of 80000-200000 mg/l. These values are around 200-400 times higher than a typical municipal sewage. The high content of organics is considered a negative feature of wastewater. As microorganisms, present in the environment, consume these materials, oxygen will be depleted from the water, and hence can have an adverse effect on the aquatic life if this wastewater is discharged to water supplies [13].

Arimante, 1990, [14], claimed that the disposal of OMW to the soil should be avoided because they omit annoying smells for the first 15 days, even if they are treated with CaO. He proposed the addition of K<sub>2</sub>S<sub>2</sub>O<sub>5</sub>, which reduces effectively the

malodor but it also inhibits the growth of some germs and affects the rate of mineralization.

Finally, the black-brownish color of the OMW makes it difficult to dispose them without proper treatment.

According to the above considerations, the following recommendations for using OMW as fertilizer have been made [15]:

- The by-products should be applied at a certain distance from trees.
- Doses should not exceed  $30 \text{ m}^3\text{ha}^{-1}\text{year}^{-1}$  for OMW from traditional olive oil mills and  $100 \text{ m}^3\text{ha}^{-1}\text{year}^{-1}$  for those obtained by the continuous system.
- Applications should be made in a stepwise fashion.
- At least 1 month should elapse between the application and the sowing for seeding yearly crops.
- The by-product must never be added when the crops are in the sprouting period.

Besides, in order to dispose the OMW to the ground, the physicochemical texture of the soil must be taken into account because the water horizon should not be reached and contaminated.

#### 4.1.2 Disposal of OMW to the surface waters or the sea

Disposal of wastewaters from olive mills in surface waters like lakes, rivers and sea is technically easy and with low cost. This method has been used since ancient years and many olive mills use it until now. However, the consequences for the water ecosystems of this disposal are serious.

According to bibliography [16] the disturbance of the ecosystems in rivers, torrents and the sites where they outfall to the sea is caused because of the lack of oxygen in the water, which is important for the respiration of water organisms.

The lack of dissolved oxygen is the result of the following:

- The high organic load of wastewaters, which needs large amounts of dissolved oxygen for its degradation.
- The emulsion that floats in the water surface and its composition includes colloids, which inhibits the diffusion of oxygen in water.
- The aggregates of these emulsions that settle to the bottom of rivers, lakes and seas and limit the levels of dissolved oxygen to the deeper levels of water.

- The settling of emulsions and aggregates to respiration system of invertebrates and fishes.

The result of all the above is the view of dead fishes at the riversides or the coastlines, something that causes the sensitization of the public. In order to avoid it there are laws that forced the olive mill producers to treat the OMW and to reduce the organic load before their disposal to the rivers, lakes or the sea. Unfortunately many producers still ignore these arrangements.

## 4.2 Composting

Composting, instead of direct disposal of OMW to the soil, seems to be a promising method for recycling these pollutant liquid wastes. It is a controlled biooxidative process that involves a heterogeneous organic substrate in the solid state, which evolves through a thermophilic stage and the temporary release of phytotoxins, leading to the production of carbon dioxide, water, mineral salts and stabilized organic matter containing humic-like substances. By using this method it is possible to transform either fresh OMW or sludge from pond-stored OMW (stored for months or even years) mixed with appropriate plant waste materials (carriers) into organic fertilizers

(composts) with no phytotoxicity, to improve soil fertility and plant production.

According to the study of Cegarra et al., 1996, [17], results of field and pot experiments using OMW-composts to cultivate horticultural and other crops have shown that yields obtained with organic fertilization are similar, and sometimes higher, to those obtained with a balanced mineral fertilizer. A comparison between the macro and micronutrient contents of plants cultivated with organic or mineral fertilizers did not generally reveal important differences. However, the cases of iron and manganese are worth mentioning as their bioavailability may be linked to the soil humic complexes originated by the OMW organic fertilizers.

Paradimitriou et al., 1997, [18], also performed the treatment of OMW using the evaporative capacity of an intensive composting process. A mixture of extracted olive press cake and olive tree leaves was used as the solid substrate for composting. The OMW was added to the composting mass to replenish the water loss during processing in a pilot-scale topless static container reactor. The salinity content of the compost was the factor restricting the treatment of OMW by the process. The rate of OMW treatment achieved in this study was 2.1 l/kg starting solid substrate (dry

weight). The cumulative moisture and volatile solids contact reduction during the temperature-induced aeration period of the process was 19 and 45% respectively.

### 4.3 Evaporation

#### 4.3.1 Storage - Natural evaporation

The storage of OMW in evaporation ponds was proposed as an alternative solution for the treatment of these wastes. A statistical analysis of some chemical characteristics of fresh and pond-stored OMW samples [17] showed that the values of the coefficient of variation and the range of most of the parameters studied (organic matter, organic C, N, P, Na, Ca, Mg, Fe) were usually higher in the sludge than in the fresh OMW, as is to be expected considering that the former are influenced by the changeable climatic conditions during their storage. The mean value of the K content were clearly lower in the sludges probably due to its great mobility, which facilitates its percolation through the more or less permeable layers of soil at the bottom of ponds. However, the statistical values of the Ca content were higher in the stored samples, which may be explained by its lower mobility compared with the K, its special suitability for linking organic matter and also because it is a common component of soil minerals, which may

easily, mix with the olive wastes during their storage in ponds. Additionally, the mean values of the Fe content were clearly higher in sludges than in fresh samples, something that is beneficial in the production of OMW compost because this micronutrient is of paramount interest for plant growth, particularly in calcareous soils. Lastly, it must be noted that the mean value of N content was higher in the stored than in the fresh samples, which suggests both a selective biodegradation of the organic compounds not containing N and a degree of biological N-fixation during the storage of olive wastes. Nevertheless, the fact that the average organic matter content was higher in the sludges (71.06% against 64.61% in fresh samples) points to the elaboration of organic compounds rather than their biodegradation during OMW storage, biological fixation probably being responsible for most of the increased N content in stored samples.

After the elimination of the OMW with natural evaporation, aerobic biological processes or systems of Ultrafiltration and Reverse Osmosis may follow for the final treatment of the condensate.

The major disadvantage of this method is that the OMW ponds give off bad smells, creating a new environmental problem for the people living near them. Many olive

mills have also insufficient capacity or lack of storage capacity due to the substitution of the classic systems by the continuous ones. The later produces more than double the volume of OMW per olive milled.

The intensification of the natural evaporation capacity of ponds has been proposed [19] using:

- *Sprinklers and panels*: This system consists of panels with large surface of interchange, sprayed intermittently by a sprinkler. The panels are exposed to wind action and have an evaporation capacity 40 times greater than of a pond of the same surface area.
- *Wind-powered hydro pump*: This consists of a wind-powered turbine pump floating on the pond surface. During its rotation it lifts sprinkler tubes that distribute the OMW over the pond as droplets, thereby increasing the surface area of the OMW to be evaporated.

#### 4.3.2 Thermal concentration (forced evaporation)

The goal of this process is the water separation by using a multistage evaporation system enabling heat recovery. The concentrate from the

evaporation process has to be treated, before its disposal generally by using biological treatments, such as aerobic digestion and an activated sludge process. Drawbacks arise from the high-energy demand, considerable air emissions and complex control process that requires qualified personnel. Moreover, from an economic point of view, even if economy of scale may be achieved, high operational costs are associated. Thus evaporation is a solution suited for industrial-scale oil mills only.

#### 4.4 Physicochemical treatment

The presence in OMW of hardly or non-biodegradable dissolved organic pollutants, mainly tannic acid, asks for the adoption of physical-chemical treatments, such as adsorption, precipitation, flocculation, characterized by the addition of specific chemicals (respectively activated carbon, polyelectrolytes, flocculants). Thus, even if high removal efficiencies are obtained, from an environmental point of view, problems arise from the disposal of large quantities of produced sludge. On the other hand, low investment and operational costs characterize such plants. Therefore, this technology is better suited for small-scale oil mills.

#### 4.4.1 Treatment of OMW with calcium hydroxide [CaO, Ca(OH)<sub>2</sub>]

In this process the liquid wastewaters, directly after their separation, are removed in a tank and stay there for about 24-48 hrs until their suspended solids settle [6]. After sedimentation, the upper phase is directed to a second tank, where the treatment with lime takes place. The used quantity is 0.5-1% and causes the neutralization of the acids and the increase of the pH value to 6.2 or higher. In addition, aggregation and sedimentation is performed which reaches the 20% of the OMW volume. With this procedure the pollutant matter decreases by 60-70% and a partial bleaching of the waste is observed.

The main disadvantage of this process is that the remaining sludge must be farther treated because it omits bad smells, whereas the upper liquid phase still contains a high organic matter and remains pollutant for the environment.

Esra S. Aktas et al., 2001, [20], also proposed the lime treatment of OMW in order to reduce their polluting effect. Lime is cheap and can easily be purchased anywhere. They showed that COD values of the wastewater samples from centrifugal systems could be reduced by 46%. The

amount of total solids and volatile solids could be dropped by 46.9 and 53.2% respectively, polyphenols by 62.5%, volatile phenols by 32% and nitrogenous compounds by 80%. The o-diphenols, which are highly phytotoxic could be removed totally by lime.

Furthermore, after lime treatment the liquid phase is evaporated more easily since a large quantity of fatty components, which do not permit the evaporation of water by forming an impermeable film on the surface of the wastewater, have been removed by lime.

The disadvantage of the process that they proposed is that the filtrate can't be used as a fertilizer for agricultural purpose because lime removes high degrees of nutrient substances, such as carbohydrates and nitrogenous compounds.

#### 4.4.2 Treatment of OMW with clay

Kamal Al-Malah et al., 2000, [13], used a series of treatment steps composed of settling, centrifugation and filtration to condition OMW. The filtrate was then subjected to post-treatment process, namely adsorption on activated clay. Centrifugation and filtration treatment processes showed an effective reduction of total solids content. They also reduced phenolic and organic contents and showed

an increase in pH and alkalinity values. The dynamic response of pH, phenols concentration and COD at different concentrations of activated clay showed a peak at which maximum adsorption capacity is achieved. The maximum adsorption capacity was reached within 4h and the maximum removal of phenols was about 81%, while it reached about 71% for organic matters.

The treatment of OMW with clay was also studied by Oukili et al., 2001, [21], but in their experiments clayey soils were combined with hydrogen peroxide, which acts like an oxidizer. This combination was capable to nearly remove black-brownish color of OMW with elimination of the phenolic compounds responsible for this. The bleaching led to about 87% decrease of polyphenols and a 66% decrease of the COD. The high color removal can be explained as follows: Some polyphenols, which are easily adsorbed by the clayey soils, are not degradable whereas other polyphenols, which are not adsorbed by clayey soils, would be potentially degradable by the hydrogen peroxide. Indeed, the structure of clay and its concentrations in iron salts contribute into the adsorption and the catalysis oxidation of polyphenols with H<sub>2</sub>O<sub>2</sub>.

After elimination of the phenolic compounds responsible for the black-brownish color, the treated OMW (yellow coloration) can be retreated by other processes (such as biologic one) to remove simple phenolic compounds responsible for the yellow color.

#### 4.4.3 Membrane filtration

Conventional biological treatment is not always sufficient for OMW, since they are loaded with non-biodegradable substances. Therefore, the treatment has to be completed by other processes, such as membrane filtration (e.g., osmosis or Ultrafiltration). Byproducts of this process are the concentrate from the filtration process and the membrane itself, which have to be disposed. However, despite optimal COD reduction, this technology is hardly suited for the treatment of OMW in small-scale oil mills due to the very high investment and operational costs, high energy demand and rather complex process control that requires highly qualified personnel.

E. Turano et al., 2002 [22], proposed an integrated centrifugation – Ultrafiltration (UF) system for the reduction of pollution caused by the wastes and the selective separation of some useful products, such as fats, sugars, polyphenols. In the

centrifugation step the suspended solids are removed whereas by Ultrafiltration of the centrifuge supernatant a selective separation phase is carried out. The pre-treatment step is necessary to decrease membrane fouling and to increase UF efficiency. Since centrifuge is already used in the production cycle of the olive oil, it can be economically utilized also in waste pre-treatment. Besides, the simplicity of the centrifugation process and the possibility of operating only mechanically (without any chemical change) represent an advantage of this technique with respect to other ones.

After the treatment proposed above a significant reduction of waste pollution of about 80% for ashes and suspended solids and 90% for COD took place. Oil phase concentration in the retentate from Ultrafiltration suggests an economic recovery, starting from a lower volume, with reduction in cost for extraction plant and for selective solvents. In the permeate stream, the organic fraction mainly consists of sugars and polyphenols. These compounds find different applications in pharmaceutical field and in food preserves, due to their antioxidant properties, so they can be economically recovered from the permeate starting from a low volume and without complex interferences, therefore,

with a higher selectivity of extraction. The decay of phenols content in the retentate stream, according to the decay in its phytotoxicity, allows their use as a fertilizer, after an enzymatic treatment for the production of humic substances.

In Paraskeva et al., 2007, [23, 24], the idea of using membrane technology was revisited and a new cost-effective system for complete exploitation of OMW was suggested, offering a viable solution to the problem of OMW disposal. Use of the proposed separation techniques (prefiltration), Ultrafiltration [UF], nanofiltration [NF], and reverse osmosis [RO]) produce byproducts that might include additional benefits. A pilot plant was developed in an olive mill operating in Achaia (Patras, Greece) during an olive harvesting season. Large volumes of OMW produced daily were treated systematically in a semibatch procedure to identify problems relevant to long-term behavior and reliability. Concentrate fractions obtained in membrane systems were examined as growth inhibitors of native plants (bioherbicides) in farming systems. The water—the main constituent of OMW, containing dissolved inorganic nutrients that permeate from the NF or RO system—was tested with respect to potential phytotoxic properties on cultivated plants.

In this context, it could be considered for use in irrigation or for reuse in the milling process. Finally, a feasibility-exploitation study was done to estimate if depreciation of the (indeed) expensive investment may occur in a short period of time.

#### 4.4.4 Modern Methods for Olive Mill Wastewater

Many processes for separation of gaseous or liquid mixtures use semi permeable membranes that allow one or more constituents of the mixture to pass through more readily than the others. The membranes may be thin layers of a rigid material such as porous glass or sintered metal, but more often they are flexible films of synthetic polymers prepared to have a high permeability for certain types of molecules.

##### *I) Separation of gases*

The separation of gases can be performed with porous or polymer membranes. In the first case a gas mixture is allowed to diffuse through a porous membrane to a region of lower pressure and the gas permeating the membrane is enriched in the lower molecular weight components, since they diffuse more rapidly. When polymer membranes are used, the transport of gases occurs by a solution-diffusion mechanism. The gas dissolves in the

polymer at the high-pressure side of the membranes, diffuses through the polymer phase and desorbs or evaporates at the low-pressure side.

##### *II) Separation of liquids*

There are several processes for the separation of liquid mixtures using porous membranes or asymmetric polymer membranes. With porous membranes, separation may depend just on differences in diffusivity, as is the case with *dialysis*, where aqueous solutions at atmospheric pressure are on both sides of the membrane. For *liquid-liquid extraction* using porous membranes, the immiscible raffinate and extract phases are separated by the membrane and differences in the equilibrium solute distribution as well as differences in diffusivity determine the extract composition.

With asymmetric membranes or dense polymer membranes, permeation of liquids occurs by a solution-diffusion mechanism. In *pervaporation*, one side of the membrane is exposed to the feed liquid at atmospheric pressure and vacuum or sweep gas is used to form a vapor phase on the permeate side. This lowers the partial pressure of the permeating species and provides an activity driving force for permeation. In *reverse osmosis*, the permeate is nearly pure water at about 1 atm, and very high

pressure is applied to the feed solution to make the activity of the water slightly greater than that in the permeate. This provides an activity gradient across the membrane even though the concentration of water in the product is higher than that in the feed.

### *Reverse Osmosis*

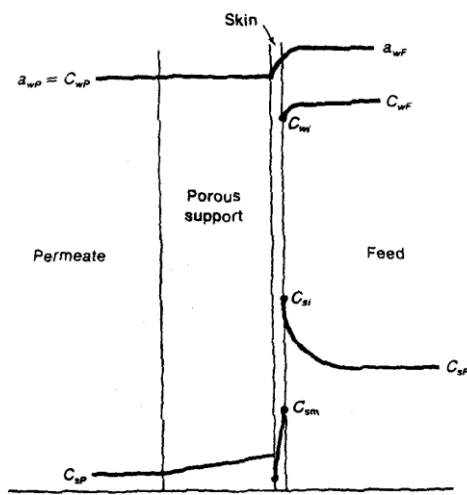
When miscible solutions of different concentration are separated by a membrane that is permeable to the solvent but nearly impermeable to the solute, diffusion of solvent occurs from the less concentrated to the more concentrated solution, where the solvent activity is lower. The diffusion of solvent is called osmosis and osmotic transfer of water occurs in many plant and animal cells. The transfer of solvent can be stopped by increasing the pressure of the concentrated solution until the activity of the solvent is the same on both sides of the membrane. If pure solvent is on one side of the membrane, the pressure required to equalize the solvent activities is the osmotic pressure of the solution  $\pi$ . If pressure higher than the osmotic pressure is applied, solvent will diffuse from the concentrated solution through the membrane into the dilute solution. This phenomenon is called reverse osmosis,

because the solvent flow is opposite to the normal osmotic flow.

Reverse osmosis is used primarily to prepare pure water from dilute aqueous solutions, though it could be used for purifying organic solvents. The main advantages of the process are that separation can take place at room temperature and there is no phase change, which would require supplying and removing large amounts of energy. The energy for the separation of salt water into pure water and concentrated brine comes from the work of pressurizing the feed and some of this energy can be recovered with a turbine, so the thermodynamic efficiency of the process is relatively high.

The mechanism of water and salt transport in reverse osmosis is not completely understood. One theory is that water and solutes diffuse separately through the polymer by a solution-diffusion mechanism. The concentration of water in the dense polymer is assumed to be proportional to the activity of water in the solution. On the low-pressure side of the dense layer the activity is essentially unity if nearly pure water is produced at 1 atm. On the high-pressure side, the activity would be slightly less than 1.0 at atmospheric pressure, 1.0 at the osmotic pressure and slightly greater than 1.0 at

higher pressures. The upstream pressure is generally set at 20 to 50 atm above the osmotic pressure of the feed solution. At these pressures the activity of the water  $\alpha_w$  is only a few percent greater than for pure water at 1 atm and the change in activity and concentration across the membrane are small, as shown in Fig. 2.



**Figure 2:** Concentration gradients for a reverse-osmosis membrane

The driving force for water transport is the difference in activity, which is proportional to the pressure difference  $\Delta P$  minus the difference in osmotic pressures of the feed and product  $\Delta\pi$ . The equation for water flux is:

$$J_w = \frac{C_w D_w u_w}{RT} \left( \frac{\Delta P - \Delta\pi}{z} \right)$$

In this equation  $D_w$  is the diffusivity in the membrane,  $C_w$  is the average water concentration in  $\text{g}/\text{cm}^3$  and  $u_w$  is the partial molar volume of water.

The flux of solute is assumed proportional to the difference in solution concentrations, the diffusivity and a solubility or distribution coefficient:

$$J_s = D_s S_s \left( \frac{\Delta C_s}{z} \right)$$

This equation shows that the water flux increases strongly with the pressure difference  $\Delta P$  and the selectivity increases also, since the salt flux does not depend on  $\Delta P$ .

The main disadvantage of this technique is known as *concentration polarization*. It's the higher concentration at the membrane surface than in the bulk solution, because of the nearly complete rejection of solute by the membrane. Concentration polarization reduces the flux of water because the increase in osmotic pressure reduces the driving force for water transport. The solute rejection decreases both because of the lower water flux and because the greater salt concentration at the surface increases the flux of solute.

### Microfiltration – Ultrafiltration

In these techniques the principle of crossflow filtration is applied in order to concentrate suspensions of fine particles or colloidal material or to fractionate solutions of macromolecules. The term *microfiltration* is generally used for particles in the size range 0.1 to 5  $\mu\text{m}$ , whereas *ultrafiltration (UF)* covers a wider size range, from 1- $\mu\text{m}$  particles down to molecules about  $10^{-3}$   $\mu\text{m}$  in size ( $M \cong 300$ ). In practice, there is not a sharp dividing line between microfiltration and ultrafiltration. For very small particles, such as 0.1- $\mu\text{m}$  spheres of polymer in a latex paint, either term could be applied.

The performance of a UF membrane can be characterized by the permeate flux, the percent rejection and the concentration of solute in the retentate system. The permeate flux often decreases with time because of membrane fouling, but fouling may increase the rejection. For a clean membrane the water is assumed to pass by laminar flow through the small pores of the selective layer and the driving force is the pressure difference  $\Delta p$  minus the difference in osmotic pressures across the membrane  $\Delta\pi$ . The permeate flux, which is the superficial permeate velocity normal to the surface, is given from equation:

$$U = Q_m (\Delta p - \Delta\pi) \frac{\mu_{H_2O}}{\mu}$$

where  $Q_m$  is the membrane permeability (incorporates the characteristics of the membrane) and  $\mu$  is the viscosity of the permeate solution.

Finally, since a membrane may have some pores that are larger than the solute molecules and the solute is only partially rejected, the rejected fraction,  $R$ , must be defined using the equation:

$$R_F = 1 - \frac{C_P}{C_F}$$

where  $C_P$  and  $C_F$  are the feed and permeate concentrations respectively.

### 4.5 Biological treatment

The biological methods are able to reduce BOD and COD concentrations and enable removal of organic and inorganic suspended solids, as well as phosphorous, nitrogen and ammonium compounds. Both aerobic and anaerobic processes can be adopted, even if anaerobic technology has clear advantages including higher removal efficiency, lower excess sludge production (the quantity of produced excess sludge is 20 times lower than in aerobic process), low space requirement. Moreover, the anaerobic process produces biogas, a valuable by-product that can be used to fulfil the mill energy demand. However, with an aerobic follow-up treatment the mentioned advantages are enhanced, making this combined solution the

preferred one for OMW treatment. On the other hand, due to high investment costs and complex process management, this technology is suited for industrial-scale oil mills or as a centralized treatment facility serving several oil mills.

The earlier studies about the aerobic-anaerobic treatment of OMW are quite interesting. Borja et al., 1992, [25], performed partial removal of some of the organic matter and phenolic compounds by aerobic pretreatment with *Geotrichum candidum*. The purified effluent, although it had the same COD level as the original OMW, was degraded anaerobically more rapidly than the original OMW as a result of the increase in methanogenic activity.

Fadil et al., 2003, [26], studied the growth and polyphenol biodegradation by three microorganisms namely *Geotrichum* sp., *Aspergillus* sp. and *Candida tropicalis*. These three microorganisms were selected for their tolerance to the polyphenols. The biodegradation process of OMW was investigated in batch regime by conducting experiments where the initial concentration of COD was varied. Furthermore, some tests were performed to determine the most important nutrients necessary for aerobic degradation of OMW. Average COD removals were 55%, 52.5% and 62.8% in wastewaters fermented with

*Geotrichum* sp., *Aspergillus* sp. and *C. tropicalis*, respectively. The maximum removal of polyphenols was 46.6% (*Geotrichum* sp.), 44.3% (*Aspergillus* sp.) and 51.7% (*C. tropicalis*). In addition, significant decolorization was evident.

Beltran-Heredia et al., 2001, [27], proposed the degradation of OMW by means of two chemical oxidation processes (Fenton's reagent and ozonation) and their consecutive treatment with aerobic microorganisms. Fenton's reagent treatment moderately reduces COD and to a greater extent the polyphenolic compounds. Ozonation contributed to low conversion of COD and moderate reduction of polyphenols, whereas the aerobic biological treatment degrades to values higher than 70% and 90% for COD and polyphenolic compounds respectively.

Finally, Fountoulakis et al., 2002, [28], investigated the capability of *Pleurotus ostreatus* to degrade phenols of OMW in different conditions such as in sterilized and thermally processed (at 100°C) wastewater, with and without dilution. According to their experimental results *P. ostreatus* removed phenols from the culture medium, under all different conditions that were examined. The degradation of phenols reached up to 78.3% for the sterilized and 50% diluted

OMW, 66.7% and 64.7% for the thermally processed OMW, with and without dilution, respectively. The effect of pre-treatment of OMW on the performance of the anaerobic digestion was also assessed, as methanogenic bacteria are seriously affected by the presence of the phenol compounds. The pre-treated wastewater was shown to be more amenable to a subsequent anaerobic digestion.

## 5. Energy production from Olive Mill Wastewater

### 5.1 Biomethanisation

The production of biogas (70-80% methane and 20-30% CO<sub>2</sub>) from the anaerobic digestion of the wastewaters of the olive mills has started many years ago. In this process the OMW are directed to an open tank and anaerobic digestion takes place in the lower layers, close to the bottom of the tank. The oily phase, which rises to the surface of the tank, omits bad smells because of its aerobical digestion.

The liquid phase is removed daily to a second tank for storage until its final disposal. The liquid wastewaters are recycled from the second tank to the first and splashed to the surface in order to create an emulsion with the surface oil and oxygenate it, so as to avoid the bad smells. The sediment from the first tank feeds a

closed heated tank (anaerobic) where the biogas is produced. The digestion of the solid wastes was performed at 55°C and the influents were directed to the first aerobic tank and enriched it with microorganisms.

Researchers from the “Instituto de la Grasa y sus Derivados” proposed the combination of bioconversion and biomethanisation for a more effective treatment of OMW. The main aim of **bioconversion** is the recovery of the olive oil emulsified with OMW and elimination of the phenolic compounds, which interfere with the biological treatment of this wastewater. Bioconversion achieves:

- The formation of a lipoprotein biomass, which “retains” practically all olive oil normally lost with the wastewater.
- The elimination of 70% of the polyphenol content.
- The elimination of the solids in suspension, colloidal substances and part of the mineral salts.

According to their study, the breakdown of the organic molecules to methane and carbon dioxide in the process of biomethanisation is performed by the symbiotic activity of 3 groups of microorganisms: hydrolytic bacteria,

acetogenic bacteria and methanogenic bacteria. From the biotechnological viewpoint, one characteristic of these bacteria is that they do not need attention during periods of digestion inactivity. This is specially relevant to the application of anaerobic treatment processes in seasonal farming-food industries. However, due to the presence in OMW of polyphenols, which inhibit microorganisms' development, hydraulic retention times in the bioreactors have to be very much higher than those for other wastewaters of the same organic load, resulting in high installation costs. During anaerobic digestion of the effluent from the lipoprotein biomass procedure (bioconversion), no inhibiting effect is observed and the process can be carried out with hydraulic retention times lower than 4 days. Therefore, biomethanisation of natural OMW needs times of the order of 36 days while the effluent (treated OMW) needs only 4 days.

If an active sludge aerobic process is used to reduce the still high COD of the previous anaerobic effluent the integral treatment has a yield of 99.6% and gives the following by-products:

- A lipoprotein, which retains all the residual oil lost in the OMW. The obtaining of this biomass could make

this phase of the process profitable or self-financing.

- During anaerobic treatment, 10 m<sup>3</sup> of biogas/m<sup>3</sup> of treated OMW is obtained. This constitutes energy of the order of 60000 kcal/m<sup>3</sup> of wastewater.
- A microbial biomass is formed during the aerobic processes, which could be used as animal feed.

## 5.2 Energy recovery from the treatment of OMW

Waste treatment technologies aimed at energy recovery represent an interesting alternative for a sustainable disposal of residues from olive oil production able to reduce the environmental impact and to generate electric energy for sale or satisfy the energy needs of oil mills. A.C. Caputo et al., 2003, [29], starting from the consideration that potential for significant energy recovery exist thanks to the nature of the treated residues, carried out a technical and economical analysis of different thermal disposal plant solutions. These plants reference to two main technologies: gasification and combustion. Thermal utilization of OMW presents many environmental advantages such as reduction of mass and volume of disposed solid, reduction of pollutants, as well as the

potential for energy recovery in order to partially fulfil the needs of oil mills or sell the produced electricity. However, a rather high technological level requiring remarkable capital investments and qualified personnel characterizes such disposal systems. Moreover, plant management is onerous and complex. Therefore, the proposed approach is cost-effective when it serves a large number of mills, gaining benefits from the economy of scale. The complexity and capital-intensive nature of such plants makes them unsuitable to small sized decentralized applications.

## 6. Industrial waste water treatment: Legislation & Methods

### 6.1 Greek legislation

The first law concerning the treatment of wastewaters in Greece was published in 1965, and is numbered as **E1b 221/65 (FEK 138/B)**, and refers to the disposal of sewage and industrial waste. This first decision was modified by two Joint Ministerial Decisions (hereinafter KYA) **KYA C1/1783/7-12-1971** και η **KYA C4/1305/2-8-1974**. These decisions are in use also today and are the basic tool for the local authorities to accept or reject a licence for the factories. Some extra terms for the disposal of final treated wastes are

being described by each local authority decisions (prefectures) taking into account the abilities of the close receptors (usually rivers or the close sea area). These decisions are modified when the conditions for the status of the receptors has been changed.

In May 1991, EU published the directive 91/271/EEC, which concerned the treatment of municipality wastewaters. This Directive anticipated that all municipalities' wastewaters shall be treated in biological stations before the rejection of the treated waters to the close receptors. Harmonization of the Greek legislation with Directive 91/271/EEC was done by the **KYA 5673/400/1997 (FEK 192/B/I 4-3-97)**' Measures and terms for the treatment of municipality wastewaters' and is the current legislation framework that valid for the treatment of municipality wastewater. With the decision 5673/400/97 the article No 10 of the **Law 1650/86 on the Protection of the Environment** is coming to force.

According to Article 3 (2) of Law 1650/86 activities that concern the environment are categorised in three lists. List A included projects and activities which because of their nature, size or extent are likely to have a serious impact on the environment. In these projects and activities, and

according to each individual case, apply, apart from the general conditions and standards, special conditions and restrictions for the protection of the environment. List B includes projects and activities which, although they have not a serious impact on the environment, have to be subject, for the protection of the environment, to general standards, conditions and restrictions as provided by law. List C includes projects and activities which have a small impact on the environment. This classification according to Art 3(3), may, for achieving in particular environmental protection, be differentiated according to the area or the natural receptor or pollution or nuisance, after taking into account the approved physical planning or control structures, the programmes and the general building plans or regulated zones of land use or other regulations concerning the protection of environment.

Articles in the decision KYA/5673/400/97 (FEK-192/B/14-3-97) 'Measures and conditions for the treatment of municipal wastewaters' are referred to the collection, treatment and disposal of municipal wastewaters. Also in the same decision there conditions and restrictions for the treatment and disposal of wastewaters in some specific manufacture sectors and are

reported in Annex III of article 16 of the same decision. These manufactory sectors are:

1. Dairy
2. Production of vegetables
3. Production and bottling and non alcoholic refreshments
4. Remaking of potatoes
5. Meat Industry
6. Brewery
7. Production of alcohol and alcoholic drinks
8. Production of animal food form vegetable products
9. Units for the production of malt
10. Remaking of fish industry

This important decision was modified according to **KYA 19661/1982/99** (FEK 181 I/B/29-9-99) and **KYA 48392/939/28-3-2002** (FEK 405/B/3- 4-2002) where a list of sensible receptors and areas for the disposal of treated wastewaters were added.

According to the Directive 76/464/EEC/May 1976 'Quality of waters and rejection of hazardous compounds' Greek legislation has encountered the following decisions.

1. **Ministerial Decision, 144/197A/1987.** Protection of the

- aquatic environment from the pollution by some hazardous compounds and more particularly is setting the limits of the quality of water in Cd, Hg and PCE's.
2. **K.Y.A. 18186/271/126B/1988.** Measures and restrictions for the protection of the environment and more particularly limits for the hazardous compounds in wastewaters.
  3. **Ministerial Decision, 73/90A/1990.** Determination of the limits of hazardous compounds for the quality of waters and for the rejection of treated wastewaters, which are included in List I of annex A, article 6 of 114/197A/1987.
  4. **K.Y.A. 55648/2210/323B/1991.** Measures and restriction for the protection of aqueous systems and more particularly setting the limits of hazardous compounds in wastewaters.
  5. **K.Y.A. 90461/2193/843B/1994.** Supplement of the Annex of article 12 of the ministerial decision 5648/2210/323B/1991 K.Y.A.
  6. **Ministerial Decision, 255/123A/1994.** Supplement of the Annex of article 6 of ministerial decisions 73/29-6-1990 Determination of the limits of hazardous compounds for the quality of waters and for the rejection of treated wastewaters, which are included in List I of annex A, article 6 of 114/197A/1987
  7. **K.Y.A. 26857/553/196B/1998.** Measures and restriction for the protection of underground waters and rejections of some specific hazardous compounds.
  8. **K.Y.A. 4859/726/253B/2001.** Measures and restrictions for the protection of aqueous environment from the rejections and more specifically determination of the limits of hazardous compounds as are described in List II of Directive 76/464/EEC, May 4<sup>th</sup>, 1976
  9. **Ministerial Decision 2/15A/2001.** Determination of the limits of hazardous compounds for the quality of waters and for the rejection of treated wastewaters, as are described in List II of Directive 76/464/EEC, May 4<sup>th</sup>, 1976
  10. **K.Y.A. 50388/2704/E103/1866B/2003.** Modification and completion of the

ministerial decision 2/1-2-2001 'Determination of the limits of hazardous compounds for the quality of waters and for the rejection of treated wastewaters, as are described in List II of Directive 76/464/EEC, May 4<sup>th</sup>, 1976 (A15)'.

**11. Ministerial Decree 15519/83 (FEK 455/B)**, concerning the conditions of waste disposal and industrial wastewater into natural receivers and set maximum allowable limits

**12. Ministerial Decision 179182/656/79 (FEK 582/B)**, concerning the disposal of liquid wastes from industrial processes of the Greater Capital region through the sewer network and streams are diverted to the CSD and supervised by the PPA to be addressed in the sea area Keratsini Piraeus

**13. Ministerial Decree 39624/2209/E103/2009 (FEK 2076/B'/25.9.2009)**, Measures conditions and restrictions on the management of waste from extractive industries, in compliance with the provisions of Directive 2006/21/EK (15 March 2006) on the management of waste from

extractive industry and amending Directive 2004

**14. Ministerial Decree/17823 (FEK 1132/B/21.12.79)**, concerning the disposal of industrial wastewater and sewage in the Saronic Gulf

**15. Ministerial Decree /19640 (FEK 1136/B/27.12.79)**, concerning the disposal of industrial wastewater and sewage in the North and South Gulf of Evia and the corresponding Gulfs Maliakos and Petalia

**16. Ministerial Decree /15549 (FEK 455/B/08.08.83) (Prefectural Decision)**, concerning the conditions of waste disposal and industrial wastewater into natural recipients and determining the maximum permissible limits of pollutants

**17. Ministerial Decree 9331 (FEK 584/B/07.10.83) (Prefectural Decision)**, conditions of waste disposal and industrial wastewater into natural receivers a) sea area Pieria, b) Aliakmonas river and setting the maximum permissible limits of pollutants

**18. Ministerial Decree 5340 (FEK 142/B/18.03.85) (Prefectural**

**Decision),** Special conditions of waste disposal and industrial waste and establish the upper class to use the waters of the river Loudias

**19. Ministerial Decree 41633/291/1984,** concerning the conditions of waste disposal and industrial waste

**20. DYG2/105452/5-8-2009,** New Instructions for the disposal of liquid waste from meat processing plants

**21. A1b/8181/88 (FEK 57/87),** concerning conditions for establishing and operating poultry facilities

*More specifically regarding the protection of waters from agro-industrial wastewaters the following legislation has been reported:*

**1. K.Y.A. 16190/1335/519B/1997.** Measures and terms for the protection of waters from nitrogen pollution because of agriculture activities.

**2. K.Y.A. 19652/1906/1575B/1999.** Determination of waters which are suffering from nitrogen pollution because of agriculture activities – List of sensible zones according to

the paragraphs 1 and 2 in article 4 of KYA/16190/1335/1997 Modification of articles 3,4,5 and 8 of the same decision.

**3. K.Y.A. 20419/2522/1212B/2001.** Completion of KYA/19652/1906/1999.

Determination of waters which are suffering from nitrogen pollution because of agriculture activities – List of sensible zones according to the paragraphs 1 and 2 in article 4 of KYA/16190/1335/519B/1997 (B1575).

### *Greek Legislation on Olive mill Wastewater treatment*

Despite the above significant problems, the legislative frame of country is exceptionally tyre so that is not achieved the reduction of level of pollution but on the contrary it is increased. Environmental protection and the reduction of pollution that is achieved through the operation of agro-industrial units and in this case, olive passes would not be feasible without state intervention and the passing of suitable regulation.

With regard to the wastewater of olive oil mills there is a decision (circular YPP&KA no YM / 5784/23-1-1992 and No 4419/23-10-1992) that reports: “...Taking into account the problems that are created in

the environment by the disposal of waste of olive oil mills, we inform you the following:

1. The treatment of olive oil mills wastewater with chemical method (neutralisation with calcium hydroxide and chemical coagulation) constitutes a method of reduction the organic and chemical pollution charge, for low however percentages. Even with complete almost attribution of installations it does not approach the desirable levels, as it is forecasted by ministerial provision E1v/221/65 YD and the relative circulars.

2. The above- mentioned method is a classic and widely widespread method of reduction of pollution, however, other variants of this method exist or even additional (e.g. various coagulants, combination with anaerobic biological treatment etc.).

Due to difficulty of handling wastewater, the selected method of treatment, except the high efficiency and functionalism, should be economical for the small enterprises (olive oil mills).

3. The final recipient of processed waste will always be determined in the framework of sanitary provision E1b/221/65 and our circular with

number YM2985/29-5-91 taking into consideration the local conditions.

The sea and more generally the aqueous recipients will be supposed to be avoided and to constitute only the inevitable solution, after exclusion of all other possibilities of final disposal (disposal to the ground, natural evaporation, etc.)...”

## 6.2 Finish legislation

Finnish legislation considering waste water treatment in industry

The environmental policies in Finland are guided, followed and organized mainly by Ministry of the Environment, Finnish Environment Institute and on regional level the Centres for Economic Development, Transport and the Environment. Furthermore, Regional State Administrative Agencies are responsible for environmental permits. (Finnish Environmental Institute 2010a) Municipals follow then the industrial activities as well as the state of the environment more in detail.

The most important laws and decrees regarding wastewaters in industry and agriculture are presented below:

**Environmental protection law (4.2.2000/86)** is a very general and overall legal framework considering all possible issues related to environment,

including naturally water systems and groundwater protection. Ministry of the Environment follows and develops this law. The basic principles are in responsibility, caution, prevention, minimizing damages, and taking BAT practices into account in every situation. Directly related to water issues; the section §8 is for example about injunction of groundwater ruination. Then again, §11 *Quality and emissions to environment* states the Council of State can make special decisions considering for example agricultural emissions, i.e. nitrates, and other water protection regarding agricultural activities. (Finlex 2010a)

Environmental protection law also sets conditions for the need of the environmental permission: when new (industrial) activity is initiated, or a change in processes applied, the actor must go through a permission procedure considering possible environmental effects. The permission includes the extent of the activity and all possible emissions, and the permission must include detailed plans for example wastewater treatment and possible effects on water systems. Activities that require environmental permission are explained more detailed in **Environmental protection decree (18.2.2000/169)**. (Finlex 2010a, b)

**Water law (19.5.1961/264)** defines water systems, groundwater, water ecology and water usage, control & wastewater conduction. For example water usage cannot cause outward change in the water system or groundwater. Irrigation (for agriculture) and industry's water use are also mentioned in this law, which is a general right as long as it does not affect to other water users. This law covers also constructions and buildings affecting to water, as well as trenching and water system adjustment. (Finlex 2010c)

Water law is supplemented with **Water decree (6.4.1962/282)** and **Water supply and sewerage law (9.2.2001/119)** (Finlex 2010d, e). Also, because the agricultural activity is typically located in rural areas in Finland, the wastewater treatment is hence connected with EU's **Urban wastewater treatment Directive (91/271/ECC)**. (European Commission 2010a)

Finally, also **Government regulation on hazardous and harmful agents in water environment (23.11.2006/1022)** deals with wastewater issues in Finland. The regulation defines the harmful agents through EU's **Water Framework Directive (2000/60/EC)** and **Directive on pollution caused by certain dangerous substances discharged into**

**the aquatic environment of the Community (2006/11/EC).** (Finlex 2010f, European Commission 2010b, Official Journal of European Union 2006)

### 6.3 Swedish legislation

Sweden's environmental work is based on the sixteen environmental quality objectives described in section 9.2. These should always be considered when working with industrial waste and stormwater management.

#### *Law and authority demands for handling of wastewater from the industry*

The Water Law and the Water Authority direct first of all the use and exploitation of the water resources not the discharge of wastewater to the different recipients.

The discharge issues to the recipient are directed in the Environmental Code and its issued directions and environmental quality norms. Diversion of wastewater from the industry to the municipal wastewater treatment plant is regulated by the local environmental boards that take care of the supervision of the handling and sewage net and the wastewater treatment plant. As general demands usually the limit values of the Swedish Water and Wastewater Association (VAV) from 1983 still are used in the industry. Many large

municipalities have established their own list or recommendations.

The ordinance for self control put demands on the activity owner to be able to show how they steer and follow as well as reports effects of the wastewaters from different processes.

In the specific case for wood floor manufacturer in the Kalmar region there are special conditions form the handling of waster from the processes.

#### *About exploitation of water*

**The Water Law (1998:808 chapter 11), Water activity (1998:1388)** the ordinance of water activities

#### **Discharge and effects on water**

**Waste water, NFS (1990:11)** – Knowledge about how water control shall be carried out

**Roles of consideration, SFS (1998:808), 2 kap. 6§** - Localization/site for ground and water areas is not allowed to create encroachment and inconvenience

**Environmentally hazardous activity, SFS (1998:899), 5§** - Permissions about environmentally hazardous activity, discharge of wastewater and landfilling of solid waste must exist.

**Measurements and sampling, NFS (2000:15)** – Measurements and sampling in order to verify must be done and documented.

**Specifically about land filling and soil pollutants**

**Solid Waste , landfilling, NFS (2004:5)** – Water related to landfilling

**Landfilling of waste, SFS (2001:512)** – The ordinance about landfilling. Leachate.

**Polluted areas, SFS (1998:808), 10 kap. 1-9§§** - Remediation and aftercare (of a water area) shall be made and payed by the activity owner.

In this particular case permission for the acitivity roles about sedimentation and adsorption for process wastewater are given.

For storm water it is just given that the authority has the right to make demands.

Concrete this means that a dialog between the municipality and the activity owner primarily about problems with high flows during heavy rainfalls. Otherwise it is assigned to effects related to environmental quality standard (See chapter 9.2)

Stormwater shall be considered as a type of wastewater. Its generation should be considered as an environmental hazardous

activity and should be handled as such and this is regulated in the Swedish **Environmental Protection Code (MB)**. Stormwater must be treated if it can't be discharged without risk for environmental nuisance. For estimation of the risk the pollutants in the wastewater and stormwater and the sensitivity of the reviewing water must be estimated/measured. Permission is needed according to the MB and an **Environmental Consequence Description (MKB)** should be made. The MKB must show that no direct or indirect effects are caused on human health, animal, vegetation, soil water or air by the planned activity or measures planned.

The **Swedish VA-law** regulates general water and wastewater facilities (**SFS 1970:244**). On the regional level the **General regulation for the water and wastewater facilities( ABVA)** includes general requirements for the use of the municipal water and wastewater facilities which also include rules about stormwater handling in the municipality. The **Plan and Construction Law (PBL, SFS 1987:10)** and the **Registration of Property Law (SFS 1970:988)** is also dealing with wastewater and stormwater as well as **Real Property Law (SFS 1970:994)** that dealing with risk of effects on surrounding

ground or property. The Swedish Transport Administration has worked a lot with the with vegetative pond systems and is consider one big stormwater actor in Sweden. Also the Swedish Road law (**SFS 1971:948**) includes stormwater.

## 6.4 EU Legislation

### 6.4.1 Legislation on Chemical pollution of surface waters - Discharge of dangerous substances

Community policy concerning dangerous or hazardous substances in European waters was introduced by *Council Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community*.

The objective of the Directive was to regulate potential aquatic pollution by thousands of chemicals already produced in Europe at that time. The Directive covered discharges to *inland surface waters, territorial waters, inland coastal waters and ground water*. In 1980 the protection of groundwater was taken out of 76/464/EEC regulated under the separate Council Directive 80/68/EEC *on the protection of groundwater against pollution caused by certain dangerous substances*.

The Directive introduced the concept of list I and list II substances, which were listed in the Annex to the Directive, and which are discussed below. The purpose of the Directive is to eliminate pollution from list I substances and to reduce pollution from list II substances.

Based on Article 6 of Council Directive 76/464/EEC, the Council set specific emission limit values and quality objectives for 18 list I substances in five specific directives, also called 'daughter' directives. The specific directives are:

- Council Directive of 22 March 1982 on limit values and quality objectives for mercury discharges by the chlor-alkali electrolysis industry (82/176/EEC).
- Council Directive of 26 September 1983 on limit values and quality objectives for cadmium discharges (83/513/EEC).
- Council Directive of 08 March 1984 on limit values and quality objectives for mercury discharges by sectors other than the chlor-alkali electrolysis industry (84/156/EEC)
- Council Directive of 09 October 1984 on limit values and quality objectives for the discharges of

hexachlorocyclohexane  
(84/491/EEC)).

- o Council Directive of 12 June 1986 on limit values and quality objectives for discharges of certain dangerous substances in List I of the Annex to Directive 76/464/EEC (86/280/EEC as amended by 88/347/EEC and 90/415/EEC).

Directive 76/464/EEC has been codified as [2006/11/EC](#).

The Council Directive 76/464/EEC will be integrated in the Water Framework Directive. Article 22 together with Article 16 of the Water Framework Directive (2000/60/EC) set out the transitional provisions for the existing Directive on discharges of certain dangerous substances (76/464/EEC).

The European Union has introduced measures to prevent or minimize any adverse effects on the environment and resultant risks to health resulting from the management of waste from the extractive industries, such as tailings and displaced material [31].

*Some other relevant Directives and Greek harmonized laws are:*

Directive [2006/21/EC](#) of the European Parliament and of the Council of 15 March

2006 on the management of waste from extractive industries

Council Directive [75/439/EEC](#) of 16 June 1975 on the disposal of waste oils [[See amending acts](#)].

**Council Directive 91/676/EEC**, concerning the protection of waters against pollution caused by nitrates from agricultural sources

**Joint Ministerial Decree E1b 221/65**, concerning night soil and industrial waste disposal

**Joint Ministerial Decree 16190/1335/97**, measures and conditions concerning the protection of waters against pollution caused by nitrates in agricultural sources

These directives are adopted by national governments through national laws, while in many cases the jurisdiction for law enforcement is transferred to local administration so as to take notice of local conditions, such as the soil, the climate etc.

#### **6.4.2 Legislation on Chemical pollution of surface waters and the Water Framework Directive**

The major part on Community strategy against pollution of surface waters control policy is set out in Article 16 of the Water Framework Directive which lays down new procedures for the identification of

substances and development of control measures. As a first step, the European Parliament and Council adopted Decision No 2455/2001/EC establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:EN:HTML>). This decision identifies a list of substances of concern (priority substances) that present a significant risk to or via the aquatic environment.

On 17 July 2006, the Commission adopted a proposed Directive setting environmental quality standards for the priority substances which Member States must achieve by 2015, to ensure "good chemical surface water status". The proposal also requires progressive reduction of emissions, losses and discharges of all priority substances, and phase-out or cessation of emissions, losses and discharges of priority hazardous substances within 20 years.

Under the Water Framework Directive, Member States shall furthermore set quality standards for river basin specific pollutants, identified in accordance with that Directive and take action to meet those quality standards by 2015 as part of ecological status (Article 4, 11 and Annex V,

WFD). For this purpose a programme of measures shall be in place by 2009, and become operational by 2012. This procedure will then replace Directive 76/464/EEC upon its repeal.

#### 6.4.3 Legislation on Management of hazardous wastes

*Council Directive 91/689/EEC of 12 December 1991 on hazardous waste.*

The Directive set up rules on hazardous waste. It supplements Directive 2006/12/EC (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006L0012:EN:HTML>) (which replaces Directive 75/442/EEC), which establishes a framework for waste management. The list of hazardous wastes covered by the Directive has been defined on the basis of the categories, constituents and properties set out in the Annexes to the Directive. The Annexes can be amended depending to scientific and technical progress.

The competent authorities must publish plans for the management of hazardous waste, to be evaluated by the Commission.

Regulation (EC) No 166/2006, which establishes a European Pollutant Release and Transfer Register (PRTR), harmonizes the rules on the regular reporting of

information on pollutants, including waste, by Member States to the Commission.

### ***Controlled management of hazardous waste (until the end of 2010)***

Council Directive [91/689/EEC](#) of 12 December 1991 on hazardous waste. The European Union lays down a framework for the management, recovery and correct disposal of waste considered to be hazardous.

#### *List of hazardous waste*

Commission Decision 2000/532/EC of 3 May 2000 replacing Decision [94/3/EC](#) establishing a list of wastes pursuant to Article 1(a) of Council Directive [75/442/EEC](#) on waste and Council Decision [94/904/EC](#) establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive [91/689/EEC](#) on hazardous waste. This Decision establishes a single Community list combining the list of dangerous waste laid down in Decision [94/904/EC](#) and [list of waste](#) established by Decision [94/3/EC](#). It repeals those two decisions with effect from 1 January 2002. This Decision has been amended by the following decisions:

Decision 2001/118/EC (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:01:EN:HTML>)

Decision 2001/119/EC, Decision 2001/573/EC

## **7. National and EU projects**

Implementation of **innovative waste treatment technologies**, are presented only through **research projects**, and some of the existed agricultural associations and local authorities (Region of Western Greece, local Prefectures, local municipalities, olive mill enterprises, etc) were involved. However, their activities and benefits of the adopted practices through the scientific projects are not wide disseminated until now, because of lack coordination by the authorities and because of the costs that accompany the adoption of the best and innovative practices are not affordable.

### **7.1 Projects by the members of the Western Greece Region**

Participants from the research team of RWG' cluster in the present project STINNO have been involved in a large number of European and National projects as described below. The members of the research group of RWG belong to FORTH/ICE-HT, University of Patras and University of Ioannina and all act under the umbrella of FORTH/ICE-HT:

*FORTH/ICE-HT*

Assistant Professor **Christakis Paraskeva** (treatment of wastewater via membrane processes, *Contact Person*). Professor **Petros Koutsoukos** (physicochemical processes in natural waters). Professor **Gerasimos Lyberatos** (*editor of the Journal of Hazardous Material*, Biochemical Engineering and Environmental Technology). Associate Scientist **George Constantinides** (head of the Laboratory of Environmental Studies). Research Director **Vasilis Burganos** (transport processes in porous media and modelling at all scales). Principal Researcher **Christos Tsakiroglou/** (determination of the microscopic and macroscopic properties of soils and rocks)

*University of Patras*

Professor **Constantinos Chrysikopoulos** (fate and transport of viruses in subsurface formations, transport of polydisperse colloids in natural fractures). Lecturer **Hrissi K. Karapanagioti** (Marine pollution, fate and transport of pollutants, and risk assessment). Assistant Professor **Michael Kornaros** (Biological processes for the treatment of municipal and industrial wastewaters). Lecturer **Ioannis Manariotis** (Wastewater reuse, river pollution, and fate and transport of pollutants in soil and water).

*University of Ioannina*

Associate Professor **Dimitris Vayenas** (biological and physico-chemical treatment of potable water, industrial wastewater treatment). Assistant Professor **Ierotheos Zacharias** (water resources management, numerical modelling of hydrodynamic processes). Associate Professor **Ioannis Kalavrouziotis** (Domestic wastewater and sludge reuse in agricultural land, heavy metal remediation in soil).

**List of Projects**

**Scientific Responsible: Assistant Professor Christakis Paraskeva (FORTH/ICE-HT)**

- ICE/HT, 1985-91: Design and optimization of depth filtration systems for the treatment of industrial wastes, ECU 60 000
- Greek Oil Refineries at Aspropyrgos S.A., 1985-88: Design and techno-economical optimization of depth filtration systems for the treatment of process water and liquid wastes, ECU 20 000
- GSRT (EPET/SPA), 1990-93: Filtration of particulate pollutants from process water and liquid wastes of oil refineries and other industrial plants, ECU 150000

- BRITE-EURAM, 1993-1995: “Development of flexible bioprocess for recycling seasonal industrial process liquid effluents”, (with Prof. G. Lyberatos)
- CEU/INCO-COPERNICUS, 1998-2001: Emulsions in Food Industry and as Contaminant in the Environment: Hydrodynamics of Filtration and Turbulence Enhanced Coalescence, Partners: U. of Sofia (BG), U. Erlangen-Nurnberg (D), Moscow State U. (RU), Kraft Jacobs Suchard R&D (D), Kalla Cosmetics Ltd (BG), Caritex Production Co. (BG). Total budget ECU 180 000, ECU 36 000
- CEU/CRAFT, 2002-2003, **PANELEA, A cost effective system development for complete exploitation of olive mill wastewater**, Euro 200 000
- “Biological treatment and management of olive mill waste water: mechanisms and applications”, Funded by: GSRT - FP66 («Research and Technological Development Consortia in Sectors of national Priority»), Budget: 2.261.160 euro (120.706 euro as coordinator)
- “Production of polyhydroxyalkanoates from olive oil mills wastewater (POLYVER)”, Funded by: European Community (COOP-CT-2005-032967), 9/2006 – 12/2008, Budget: 600.949 euro (125.660 euro as coordinator)
- “Recording environmental situation of Aitolikou and Mesologgi lagoons / proposals for protection measures and assess the potential for the development of a biotech park”, Funded by: Region of Western Greece, 10/2005 – 9/2006, Budget: 146.370 euro (35.000 euro as coordinator)

**Scientific Responsible: Professor Gerasimos Lyberatos FORTH/ICE-HT)**

- “Environmental security enhancement through a novel process for nitrogen removal from wastewater”, Funded by: NATO - Science for Peace (SfP) - No 982816, 10/2007 – 9/2010, Budget: 300.000 euro (22.000 euro as coordinator)
- “Project startup investment for the development of a model reactor for biological nitrogen removal, bypassing nitrate production”, Funded by: GSRT-02 PRAXE 210 (Spin off)», Phase A’), 12/2003 – 6/2005, Budget: 44.000 euro
- “Bioprocessing of sewage sludge for safe recycling on agricultural land - BIOWASTE”, Funded by: European

Community (QLKS-CT2002-01138), 1/2003 – 9/2005, Budget: 2.008.771 euro (288.209 euro as coordinator)

- “Ecotoxicological Assessments and Removal Technologies for Pharmaceuticals in Wastewaters (REMPHARMAWATER)”, Funded by: European Community (EVK1-2000-0048), 12/2000 – 11/2003 (Energy, Environment and Sustainable Development), Budget: 1.129.620 euro (249.280 euro as coordinator)
- “Automatic optimization of periodic batch reactor for nitrogen removal from wastewater”, Funded by: GSRT (PENED '99 – 99ED111), 1/2000 – 8/2001
- “Integrated physicochemical and biological treatment for waste management regenerated oil”, Funded by: GSRT (PAVE 99, BE – 95), 1/2000 – 6/2001
- “Technology demonstration solvent recovery and biological treatment of paints and dyes industrial waste water using combination of photocatalytic and biological processes”, Funded by: GSRT (EPET II – 98BIA-25), 12/1999 – 6/2001
- “Assessment of Operational Strategies for the Kanapaha Wastewater Treatment Plant,” Gainesville Regional Utilities
- “Integrated Chemical and Biological Treatment of Industrial Wastewaters”, EU ENVIRONMENT program
- “Industrial Wastewater Treatment”, Center for Professional Training, University of Patras
- “Treatment of Dye Industry Wastewater through the Combined use of Photocatalytic and Biological Processes”, VIOCHROM S.A.
- «Demonstration of Technologies for Solvent Recovery and Wastewater Treatment of the Dye Industry through the Combined Use of Physicochemical and Biological Processes”, GSRT EPET program
- “Development of a System for Ship Wastewater Treatment Based on SBR Technology”, GSRT PAVE program
- “Integrated Physicochemical and Biological Treatment for Motor-oil Regeneration Wastewaters”, GSRT PAVE
- “Integrated Biological Treatment and Agricultural Reuse of Olive mill Effluents with the Concurrent Recovery of Energy Sources (BIOTROLL)”, EU Quality of Life program “Ecotoxicological Assessments and Removal Technologies for Pharmaceuticals in Wastewaters”

(REMPHARMAWATER), EU Environment and Sustainable Development program

- “Bioprocessing of Sewage Sludge for Safe Recycling on Agricultural Land (BIOWASTE)”, EU Quality of Life program
- “Production of POLYhydroxyalkanoates from olive oil mills wastewater”, POLYVER, EU FP6
- “Valorization of cheese whey for the biotechnological Production of Bioenergy” PEP Western Greece (GSRT)
- “Development of a viable solution for the management of olive-mill wastewaters with emphasis on by-product valorization”, Western Greece Innovation Poles (GSRT)
- “Bioethanol Production via lignocellulosic fermentation of Olive oil residues” (Etoile), EU FP7

**Innovation Pole of Western Greece (coordinated by Prof G. Lyberatos)**

- “Development of a viable solution for the management of olive mill wastewaters with emphasis valorization of byproducts”, Gerasimos Lyberatos, Partners: Foundation for Research and Technology / Institute of Chemical Engineering and High Temperature Chemical Processes,

Environmental Protection Engineering SA, Olive Mill “PANITSAS”, ENVIO Ltd

- Infrastructure for the development of a viable solution for the management of olive mill wastewaters with emphasis on valorization of byproducts, Foundation for Research and Technology/Institute of Chemical Engineering and High Temperature Chemical Processes

**Associate Scientist FORTH/ICE-HT Constantinides George**

- “Separation techniques in various industries and environmental protection” (TEMPUS, Project No. JEP-3949, Duration: 1.9.1992-31.8.1995, Other Partners: U. of Bordeaux (F) (Contractor), U. of Sofia (BG) (Coordinator), École Normale Supérieure (F), U. Instelling Antwerpen, (B), U. of Erlangen Nürnberg (D), U. of Hull (UK), Total Budget: 497,000 ECU)
- “Purification and control of natural and waste waters” (TEMPUS, Project No. JEP-9789, Duration: 1.9.1995-31.8.1998, Other Partners: U. of Erlangen Nürnberg (D) (Contractor), U. of Sofia (BG)

(Coordinator), U. of Bordeaux I (F), U. Instelling Antwerpen, (B), Total budget: 503,500 ECU)

- “Emulsions in Food Industry and as Contaminant in the Environment: Hydrodynamics of Filtration and Turbulence Enhanced Coalescence” (INCO-COPERNICUS, 1999-2001: Contract No. ERBIC15 CT98 0911. Project Administrative Coordinator: FORTH/ICE-HT, Project Scientific Coordinator: Univ. of Sofia (BG), Partners: U. Erlangen-Nürnberg (D), Moscow State Univ. (RU), Kraft Jacobs Suchard R&D (D), Kalla Cosmetics Ltd (BG), Caritex Production Co. (BG), Total budget: 241,400 ECU, FORTH/ICE-HT: 48,000 ECU)
- “Risk assessment on the quality of water resources in the Western Achaia region from permanent and occasional pollution sources using Information and Telecommunication Technologies” (Prefecture of Achaia, Duration: 01.11.06-31.07.07, Total Budget: 100.000 €, Budget of FORTH/ICE-HT: 66,000 €)
- “Development of a Viable Solution for the Management of Olive Mill Wastewaters with Emphasis on Valorization of Byproducts ” (GSRT/ Western Greece Pole of Innovation, Partners: Environmental Protection Engineering

S.A., Olive Mill “N. Panitsas”, ENBIO Ltd., Duration: 01.11.2006-31.12.2008, Total Budget: 165.600 €, FORTH/ICE-HT Budget: 96,600 €)

- “Sustainable Innovations and Treatment in Industrial Waste Water Clusters (STInno)” (FP7-REGIONS-2009-1 CSA-CA, Partners: Lahti Science and Business Park (LSBP) (FI), Regional Council of Päijät-Häme (PHL) (FI), Lappeenranta University of Technology (LUT) (FI), Helsinki University of Technology (HUT) (FI), Sustainable Sweden South East (SSSE) (SE), Regional Council of Kalmar (RFK) (SE), University of Kalmar (HIK) (SE), Patras Science Park (PSP) (GR), Regional Council of Western Greece (RWG) (GR), FORTH/ICE-HT (GR), International Association of Mediterranean Agro-Industrial Waste (IAMAW) (IT), Lancaster Environment Centre (LEC) (UK), Duration: 01.12.2009-30.11.2012, Total Budget: 1,051,403.77 €, FORTH/ICE-HT Budget: 51,157.77 €)

### **Research Director FORTH/ICE-HT**

#### **Vasilis BURGANOS**

- “Groundwater Risk Assessment at Contaminated Sites”, GRACOS, Programme EESD, 2000-2003 Total budget: 2.540 keuros, FORTH’s Budget: 350 keuros.

- “Development of an informative system and environmental parameters from the prefecture of Achaia, 2005, Budget: 22 kEuros.
- “Risk assessment on the quality of aqueous resources in the area of prefecture Achaia, under permanent and occasional sources of contamination, using information technologies, total budget 36.9 keuros.
- “Olive Mills: Actions for popularization and dissemination of innovative and previously existing scientific and technical knowledge regarding environmentally friendly methods for their wastewater treatment - POPULAR”, Funded by: INTERREG III A/ Greece – Italy, 2000-2006, Contractor: Prefecture of Cephalonia, Budget: 473.148 euro (37.957,50 euro as coordinator)

**Professor Chrysikopoulos Constantinos (University of Patras)**

“Reduction of Environmental Pollution with the Employment of Solar Powered Combustion of Industrial Waste,” HELLENIC MINISTRY OF NATIONAL EDUCATION AND RELIGIOUS AFFAIRS: ARCHIMEDES 2, 2005 - 2007, Co-PI (75,000 €).

**Scientific Responsible: Assistant Professor Michael Kornaros (University of Patras)**

- “Integrated management of agro industrial wastewaters in the cross-boundary Greek-Italian region - AGROENERGY”, Funded by: INTERREG III A/ Greece – Italy, 2000-2006, Contractor: Prefecture of Achaia
- “Development of INTEgrated AGROIndustrial WASTE management politics maximizing materials recovery and energy exploitation (INTEGRASTE)”, Funded by: European Community, 1/2010– today (LIFE+ Environment Policy and Governance 2008), Budget: 1.156.325 euro (338.725 euro as coordinator)
- “Agro industrial waste development for bioplastic production”, Funded by: University of Patras, project “Karatheodoris 2006”, 5/2007 – 5/2010, Budget: 24.000 euro
- “Biological removal of nitrogen in CSTR by pass of nitric production”, Funded by: EPEAEK/YPEPTH – Project “PITHAGORAS I”, 4/2004 – 6/2008, Budget: 80.000 euro

- “Phytoremediation of sites contaminated with heavy metals”, Funded by: NATO/CLG - No 980493, 1/2004 - 12/2005, Budget: 15.400 euro (3.652 euro as coordinator)
- “Biotechnological Exploitation of Uzbek Saline Water Reserves using Halotolerant Microalgae”, Funded by: NATO/ESP.EAP.SFP - No 981690, 6/2005 - today, Budget: 288.000 euro (32.000 euro as coordinator)
- “Spin-off preparation for the commercial exploitation of a biological filter for potable water treatment”, 2006-2008, General Secretariat of Research and Technology, Greece, Principal Investigator, (60,000 €).
- “Development of a sustainable and integrated system for bio-diesel production from energy crops”, 2007-2009, INTERREG IIIA GREECE-ITALY 2000-2006, (40,750 €).

### **Professor Dimitris Vayenas**

- “Reformation of the undergraduate course studies of the department of Environmental and Natural Resources Management”, University of Ioannina, 2003-2008, EPEAEK II, (452,000€).
- “Development of attached growth systems for the integrated management of olive mill wastewater”, 2006-2008, General Secretariat of Research and Technology, Greece, Principal Investigator (332,440 €).
- “Study of ground water pollution by viruses through recycled water infiltration”, 2006-2008, General Secretariat of Research and Technology, Greece, (60,000 €).
- “Study of the mechanisms of biological removal of pollutants from water by the use of trickling filters”, 2002-2005, HERAKLITOS -Operational Program for Education and Initial
- “Cr(VI) reduction from industrial waste water”, 2004-2006, Hellenic Aerospace Industry S.A., (59,000 €).
- Development of a flexible bioprocess for handling and recycling seasonal industrial process liquid effluents, BRITE-EURAM, 1994-1998.
- “Pore-to-core scale-up studies of the transport properties of organic pollutants with natural attenuation”, ENVIRONMENT, 1998-2001.
- “Clean combustion of organic wastes in cement plant”, EPET 1998.

- “Theoretical and experimental study of the dynamic behavior of bacterial systems”, ICEHT/FORTH 1998.

## 7.2 Other Projects in Greece

### **Scientific Responsible: Ioanna Iliopoulou-Georgoudaki**

“Estimation of the toxicity of agro industrial waste water using tracers”, Funded by: GSRT – PENED 2003, 1/2006 – today, Budget: 154.800 euro (30.000 euro as coordinator)

### **Community Initiative INTERREG IIIA/ Greece – Italy**

- “Processing and utilization of industrial waste milk”, I3101033
- “POPULAR: Mills: Actions for popularization and dissemination of innovative and existing scientific and technical knowledge in environmentally friendly methods of waste management (I3101022)
- AGROENERGY: Integrated management of liquid waste in agro industrial border region of Greece - Italy (I3101004)
- BIOUMICA: Creation and activation of a technique for the exploitation of organics through the COMPOST (I3101035)
- CO-BIO: Scientific cooperation to broaden the investigation and the transition of expertise in industrial enterprises of local products to support their

competitiveness in the friendly land development (I2101027)

### **ELAIA- OLIVE MILL WASTE MANAGEMENT NETWORK**

#### **(Coordinated by the Aegean University)**

The creation of «ELAIA - Olive Mill Waste Management Network» is an initiative of the Waste Management Laboratory of the University of the Aegean within the framework of NAIAS Programme – “Innovative Olive Mill Waste Management Systems.

#### **Research Programmes**

##### **Biolive Programme**

Development of industrial solutions for the recycling and valorisation of the olive oil fabrication residues for biopolymers and fine chemicals

<http://www.nf-2000.org/secure/FP5/S1241.htm>

##### **EU project AIR3-CT94-1987 "BIOWARE:**

Development of a Biological Integrated Process for Purifying Olive Oil WasteWater Recovering Energy and Producing Alcohol".

<http://www.nf-2000.org/secure/Air/S193.htm>

##### **EU project FAIR CT96-1420 "IMPROLIVE:**

Improvements of Treatments and Validation of the Liquid-Solid Waste from the Two-Phase Olive Oil Extraction".

<http://www.fiw.rwth-aachen.de/improlive/improlive.html> ,  
<http://www.ucm.es/info/improlive>

EU project ICA3-CT-1999-000 "Wastewater recycling of olive oil mills in Mediterranean countries- Demonstrations and sustainable reuse of residuals".

<http://www.medaqua.org/Forum/WAWA-ROMED.html>

### *Other projects by the member of the network 'ELAIA'*

**Dr. A. Angelakis** (National Agricultural Research Foundation, Institute of Viticulture, Vegetable crops and Floriculture of Heraklion)

- EU - APAS. "Desalination of Brackish Waters". Period: 1994-1997. Budget: 20,000€.
- EU-EPET-II. Reclamation and Reuse Wastewater. Period: 1995-1998. Budget: 6,000€.
- EU-LEONARDO. "Development of a Transnational Pilot project Supporting Vocational Training on Advanced Wastewater Treatment and Reuse Technologies. Period: 1997-1999. Total budget: 80,000€ (N.AG.RE.F. is coordinator).
- Ministry of Environment and Public Works. Mapping of Wastewater Treatment plants in Greece. Period: 1998-1999. Budget: 8,800€.
- Various Fundings from National Foundation for Agricultural Research (Dimitra), "Natural Wastewater Treatment Systems", Period: 1996-1998. Budget: 38,000€.
- EU-INCO DC."Sustainability and Optimization of Treatment and Reuse of Wastewater in Agriculture". Period: 1999-2001. Budget: 81,600€.
- EU-INCO MED II. "Olive Oil Mills Wastewater Treatment and Reuse". Period: 2000-2003. Budget: 27,000 €.
- "Olive Oil Mill Wastewater Management Using Land Treatment Systems". Period: 2002-2005. Budget: 15,000€. Sponsored by Ministry of Development GSRT, Joint Research and Technology Programs Greece-Turkey.
- "Evaluation of Biofuel Production by Different Plant Species Irrigated under Controlled Conditions with Pre-treated Municipal Wastewater". Period: 2006-2008. Budget: 12,000€. Sponsored by Ministry of Development GSRT, Joint Research and Technology Programs Greece-Tunisia.

**Dr. K.S. Chartzoulakis** (NAGREF, Olive Tree and subtropical plants Institute, Chania, Crete, Hellas)

- Wastewater recycling of olive mills in Mediterranean countries- Demonstration and sustainable reuse of residuals (WAWAROMED) in INCO-MED program of EU, 2000-2003
- Technology for treatment and reuse of the water used to wash olives (UDOR), 2001-2003
- Best water use innovative practices towards a sustainable water resources management (BEWARE) in the CRINNO project of Region of Crete-EU, 2003-2005
- Biotechnological recycle of olive mills washing water by microalgae (ALGATEC) in the FP7-SME-2008-1 of EU (2009-2011)

**Prof. E. Diamantopoulos** (Technical University of Crete, Department of Production Engineering & Management, Chania, Greece)

- Training on efficient water use technologies for environment educators using virtual application sites (ED-WAVE).  
Source of Funding: European Union

(Asia-Link Curriculum Development, 2003).

- Networking perspectives of transnational co-operation and participatory planning for spatial and sustainable development at the sector of integrated water management (NETWET 2).  
Source of Funding: European Union (Programme INTERREG III B/CADSES, 2003).
- Immersed Membrane Bioreactor Technology for Municipal Wastewater Treatment in Greece (IMBioTech), Source of Funding: General Secretariat of Research and Technology (2003).
- Production of high added value products for environmental applications from agricultural by-products in India: Activated carbon production from bagasse and rice husks (HARMONICA).  
Source of Funding: European Union (Programme EU-India Cross Cultural Programme, 2003).
- New forms of territorial governance for the promotion of landscape policies in the field of water resources management at water territories (NETWET 3).  
Source of Funding: European Union (Programme INTERREG IIIB ARCHIMED, 2006).

### **Technical University of Crete**

**Prof. N. Kalogerakis** (Technical University of Crete, Environmental Engineering Department, Chania, Greece)

GSRT - EPET II – Industrial wastewaters, "*Management of Olive Mill Wastewater*

*Through Technological Upgrade of Pomace Oil Plants*" (Total project funding

131,000,000 GRD), 1991-2001

LIFE07 – INF/IT/000438 – Oleico+

"European awareness raising campaign for an environmentally sustainable olive mill waste management" (Total project funding 1.003.000 €), Amount: 95.000 €, Period: 2009-11

**Prof. D. Mantzavinis** (Technical University of Crete, Environmental Engineering Department, Chania, Greece)

- Treatment of pigments in industrial waste by combination of chemical and biological processes Funding: EPEAEK II - PYTHAGORAS Duration: 2004-2006
- Advanced treatment methods for liquid waste and immunity of gaseous pollutants Funding: GSRT / EPAN Duration: 2003-2005
- Treatment of polyphenol waste of olive mills by combination of ultrasound and biological processes Funding: E.L.K.E. of the Technical University of Crete Duration: 2003

- Catalytic ultrasonic degradation of organic pollutants in aqueous effluents Funding: The Engineering & Physical Sciences Research Council ( EPSRC , UK ) και GlaxoSmithKline , UK Duration: 2001-2004 Cooperation: University of Leeds
- Treatment of halogenated phenol-containing wastewaters by combined chemical and biological oxidation Funding: The Engineering & Physical Sciences Research Council ( EPSRC , UK ) Duration: 2000-2003 Cooperation: University of Leeds

### **Democritus University of Thrace**

**Professor A. Aivazidis**, Management and Wastewater Treatment Technology Laboratory, Department of Environmental Engineering, Democritus University of Thrace

- Optimization of the plant chemical waste dye (FANCO A.E.) under environmental management, FANCO A.E., 01/10/1998 -30/09/2001
- Study the effectiveness of combined aerobic / anaerobic treatment of wastewater from the canning of fruits on a pilot scale, VENTURE Agricultural Associations Law Aliakmona - MIDDLE - Meliki (ALMME), 01/03/2002-30/09/2003

- Support D.E.Y.A. Corfu troubleshooting process and waste water management and improved quality of drinking water DEYAK, 02/05/2003-31/12/2004

### ***National Technical University of Athens)***

**Prof. Maria Loizidou,** (Unit of Environmental Science and Technology (UEST) / National Technical University of Athens)

- “Integrated management of industrial wastewater and sewage of the greater area of Oinofita – Sximatari”, 2009-2010, Greek Ministry of Environment, Regional Planning & Public Works
- Promotion of integrated environmental and safety management practices for industry in the Kaliningrad Region, **ESMAK**, LIFE-3rd Countries, 2006–2008, European Commission (link to **Infolibrary**).
- Development and implementation of methodology for the management of industrial sludge which contains hazardous substances”, Research Promotion Foundation of Cyprus, 2001-2003.
- "Design, construction, and operation of a pilot plant for the composting of the liquid waste of oil-factory", Research Promotion Foundation of Cyprus, 2001-2003.
- "Development of a methodology for the inventory of industrial wastewater at a national level", Ministry of Environment, Regional Planning and Public Works, 1999-2001.
- “Development of an Integrated Management Scheme for Municipal and Industrial Wastes at a National Level”, Ministry of Environment, National Planning and Public Works, 1998.
- “Technical Development and Demonstration of closed-loop procedures in electroplating and metal chemistry using solar energy or waste heat to avoid wastewater and to minimize solid waste which can be utilized”, DG XII, INCO DC, 1998-2000.
- “Integrated emissions inventories for industrial wastes in Viotia region, Greece - Design of a centralized facility for waste treatment”, Ministry of Environment, Regional Planning and Public Works, 1997.
- “Development of an inventory of industrial wastewaters at a national level”, Ministry of Environment, Regional Planning and Public Works, 1996.

### 7.3 Projects by the members of Finnish Region

**Government regulation on water protection and management guidelines by 2015:** main objectives are reducing nutrient load causing eutrophication, minimizing risks caused by harmful agents, decreasing harms from civil engineering and watercourse regulation, protection of groundwater as well as biodiversity, and water management. The most important objective is seen to be preventing eutrophication especially caused by agriculture. Agriculture causes half of the nutrient load even though the fertilizer amounts are decreased remarkably, protective zones are built and modern cultivation methods cause less erosion today. The aim is to decrease nutrient load by 2015 at least one third from the average level in years 2001-2005. After this, long-term objective is to decrease nutrient load to half of the mentioned level. Other tasks to reach the objectives include for example covering the groundwater areas and creating protection plans for groundwaters, and possible changes in environmental regulation considering especially better surface water protection. Closer governmental cooperation is also mentioned as part of the water protection. (Finnish Environmental Institute 2010c, d)

**Finland's Rural Development Strategy for the period 2007-2013** focuses on (Rural.fi 2010a):

- economically, ecologically and ethically sustainable agriculture
- promoting rural enterprise
- supporting local initiatives

Developments in Finland's rural regions can be financed using national funds and support from *the European Agricultural Fund for Rural Development*. National funding comes from the budgets of the national government budget and local municipalities. Private funding represents a third source of finance. (Rural.fi 2010b)

### 7.4 Projects by the members of Swedish Region

**MOMENT Modern Water Management in the South Baltic Sea Area**



[www.momentproject.eu](http://www.momentproject.eu)

The MOMENT project aims to improve water quality in the Baltic Sea. The local and regional levels are very important for the implementation of practical measures aiming at better waters. MOMENT will – based on existing experiences from EU, HELCOM, the research society, national

authorities and other – develop local and regional methods for effective management of water with special focus on decreased outlets of nutrients and hazardous substances from small and diffuse sources. The project will test, demonstrate and develop knowledge about how to transform existing attainments and general environmental awareness from theory and general objectives to practical measures – developing an effective local work, including political involvement on the different levels.

The European Water Policy and the EU Water Framework Directive (WFD) aim at ensuring clean waters. HELCOM Baltic Sea Action Plan (BSAP) has appointed eutrophication and hazardous substances as key issues requiring action. In achieving this, the roles of local actors and citizens will be crucial.

The main idea is to test and develop a model for modern water management through Water Users Partnerships (WUP), i.e. for river basin based management with strong participation from local stakeholders. Six smaller rivers in Lithuania, Poland and Sweden will be used as pilot areas. Each pilot area will establish a Water Users Partnership which will develop a local programme of measures for decreased outlets of nutrients and

hazardous substances, and start the implementation. The pilot areas will also implement 11 selected innovative pilot measures, aiming at decreasing the outlets or combat the negative effect of the pollution. These pilot measures deal with land use (farming and forestry), waste water treatment from single houses, storm water treatment and better knowledge/communication. The results from the pilot measures will, among else, be used as input to the WUPs and local programmes of measures.



Pilot areas

MOMENT experiences will be exchanged throughout the whole project and results will be spread all over the South Baltic Area (SBA).

**Project partners:** The Regional Council in Kalmar County is Lead Beneficiary in the project. There are also 10 other project members from Sweden, 3 from Poland and

2 from Lithuania. Furthermore there are 3 associated members in the project.

**Project funder:** Interreg IVA South Baltic Programme.

**Project period:** 2009 – 2012.

### **WAB Wetlands, Algae and Biogas – A southern Baltic Sea Eutrophication Counteract Project**

Wetlands  
Algae  
Biogas



[www.wabproject.pl/en](http://www.wabproject.pl/en)

The WAB project aims to serve as a regional model for sustainable water management and integrated coastal zone management (ICZM) in the South Baltic Sea. Together with farmers, the project will show how nutrient leakage can be decreased, and algae blooms reduced through the harvesting of wetlands and the collection of algae from the coastal zone. New techniques to reduce leakage and stop nutrients reaching the sea will be tested in the project. In addition the collected biomass will be fermented into biogas and then utilized for energy generation. The nutrients in the algae will, after the biogas fermentation, be reused as fertilizers while at the same time pollutants absorbed by

the biomass will be removed from the system.

The Baltic Sea is under great environmental stress as a result of human impacts, the ecological balance has been disturbed and eutrophication is one of the main environmental problems. The South Baltic area has a strong tourism sector with high recreational values that are negatively influenced by algae accumulating along the coast. The project's concept of transforming a problem into a resource by preventing eutrophication through biogas production has several benefits for the region.

Linnaeus University is a partner in the WAB project and provides expertise on algal culture, monitoring and detoxification. Algae are very efficient bioaccumulators of a range of bioactive substances pollutants (metals, toxins). They will provide expertise on the use of algae for biogas production, algal monitoring and cultivation in wetlands and ponds.

The Southern Baltic Sea River Basin District Authority (RBDA) at the County Administrative Board in Kalmar is also a partner. The RBDA will support the project with underlying material and methods for calculating the expected nutrient retention

in wetlands from pilot studies in the same area and facilitating a better prioritization and development of wetlands which have the main goal of reducing nutrient transport from land to sea.

**Project partners:** The Municipality of Trelleborg is Lead Beneficiary in the project. Besides Linnaeus University there are also 2 other project members from Sweden and 6 from Poland.

**Project funder:** Interreg IVA South Baltic Programme.

**Project period:** 2010 – 2012.

### **WATERMIM Water Treatment by Molecularly Imprinted Materials**

## **WATERMIM Project**

<http://lpre.cperi.certh.gr/watermim/>

The WATERMIM project is focused on the advancement and optimization of the MIP technology in order to produce functional materials with well-defined morphologies with respect to pore structure and selectivity for water treatment applications. The project aims at the elimination of the random distribution and the uneven accessibility of receptor sites in the volume of the imprinted material that is crucial for its performance.

Such novel materials will immediately gain practical relevance, especially, due to their

increased selectivity and superior stability under long and harsh technical conditions. The simultaneous optimization of the imprinting efficiency, polymer membrane morphology and separation conditions will enable the development of a truly molecular selective water purification process, based on affinity interactions that would have a large application impact on the water treatment industry.

All types of synthetic organic compounds (i.e., triazines, pharmaceutical compounds and endocrine disruptors) are considered target compounds in the WATERMIM project.

Benchmark testing of the produced MIMs for water purification will be done in the project.

Linnaeus University is a partner in the WATERMIM project and provides expertise in materials science, nanotechnology, bioorganic chemistry and molecular imprinting.

**Project partners:** Besides Linnaeus University there are also 2 other project members from Sweden, 3 from Germany, 1 from United Kingdom, 1 from Norway and 1 from Greece.

**Project funder:** European Commission in the 7th Framework Programme.

**Project period:** 2009 – 2012.

**Risk analysis and development of methods and models for reduction of environmental effects caused by emission from self heating of municipal solid waste**

[www.lnu.se/eseg](http://www.lnu.se/eseg)

Biodegradation during storage is an inherent property of organic materials and solid waste fuels. It results into self heating which may ultimately lead to selfignition. Such fires pose swear environmental threats in the form of air and water pollution. There are different techniques currently in practice around the world for the storage of organic materials and solid waste fuels. It includes loose compact, hard compact, rectangular bales and cylindrical bales.

This project is a risk based study to analyze the environmental effects as a result of selfigniting fires in such storages with a particular emphasis on bailing technology. It is a continuation of earlier work at Linnaeus University. In this first year of project a preliminary study is done regarding the current situation of municipal solid waste in Sweden in a life cycle perspectiv.. In future it is planned to do some CFD computational fluid dynamic

simulations and to perform some experiments at SP Technical research institute of Sweden.

**Project partners:** Linnaeus University and SP Technical Research Institute of Sweden.

**Project funder:** The Government of Iran

**Project period:** 2010 – 2014

**Integrated Approach for Industrial Wastewater and Stormwater Management in the Wood-Industry**

[www.lnu.se/eseg](http://www.lnu.se/eseg); <http://ecotechnology.nv.hik.se/>

This project is combining biological and biomass-based treatment techniques with advanced oxidation processes in order to comply with the global sustainability policy towards zero discharge, waste utilization and natural resource conservation and to contribute to the development of onsite low-cost treatment options, protecting aquatic ecosystems.

The research aims to evaluate the sorption capacity of untreated and treated wood fly ash, activated carbon from different dead biomasses and biological treatment coupled to selected AOPs to treat the highly polluted washing/cleaning wastewater generated by the wood floor and furniture industry.



Press conference at the test plant

The specific project objectives are:

- Reach deeper knowledge about processes in coupled treatment, improving the efficiency of low-cost biomass-based sorbent treatments (sawdust, fly-ash, activated carbon);
- Select and implement advanced oxidative processes (AOPs) as pre- or post-treatment steps coupled to the low-cost options, in order to achieve high removal of COD-TOC using as little chemicals as possible, meeting the stringent EU discharge requirements;
- Establish a set of eco-toxicity tests including at least one producer

(photosynthetic algae), one consumer (crustaceans) and one decomposer (bacteria) bio-indicator to assess toxicity levels before and after treatment;

- Design and test different combined/coupled treatment systems, focusing not only on pollutants removal but also on the elimination of toxic effects;
- Perform cost analysis for different coupled treatment systems with focus on product development and patent implementation;
- Investigate the possibility of integrating wastewater treatment steps through a functional landscape to polish/treat the remaining pollution, using ecological engineering principles;
- Design and test a prototype of a treatment plant with patent deposit.

**Project partners:** Linnaeus University, AB Gustav Kährs, AKZONOBEL Casco Adhesives, Kalmar Energi, Beckers, Acroma, Anlager Svenska AB

**Project funder:** The Knowledge Foundation and above mentioned companies

**Project period:** Phase I 2008 – 2010

## Landfill mining

[www.lnu.se/eseg](http://www.lnu.se/eseg)

In earlier days the economics of landfill reclamation have often been considered to depend on the depth of the stored waste material and the soil to waste ratio, because the deeper the waste is buried, the more expensive per hectare it is to reclaim a site. However, practicalities with selection of sufficient and effective machinery, excavation, choosing proper logistics, storage and management of large masses of waste, handling of hazardous waste and health and safety in the working environment and for the public, are also essential for the economy of a project.

From the economic point of view, landfill mining must be considered in the context of integrated solid waste management economics and must deal with the waste fraction in new landfills, which in Europe means after recoverable and organic waste have been sorted. In this concept also environmental economics must be included. Enhanced Landfill Mining (ELFM) targets the integrated valorisation of materials and energy from past, present and future landfills, while meeting the most stringent ecological and social criteria.

ELFM, the EU Directive in the landfill mining perspective and related economics is studied.

**Project partners:** Linnaeus University, GLT – Waste Norway

**Project funder:** No funder

**Project period:** 1995 – present

## Environmental Economics

[www.lnu.se/eseg](http://www.lnu.se/eseg)

A cost structure is proposed for evaluating and improving the ecological-economic efficiency of baling sub-scheme units within solid waste management schemes that end with, for example, incineration for heat and power production.

The methodology proposed employs the previously introduced Waste Managements' Efficient Decision model (WAMED) and the COmpany STATistical BUSiness Tool for Environmental Recovery indicator (COSTBUSTER). The previously introduced *equality principle* and the Efficient Use of Resources for Optimal Production Economy (EUROPE) model are applied so to in monetary terms express the emissions in case of bale related fires (sol), pollutions from leachate (liquid) and odour (gas) at a scheme. Previously, the EUROPE model has been applied to

residuals from producing industry, the construction sector and whole landfills.

A case study presents the practical application of the proposed methodology. It is concluded that the presented novel methodology for evaluation and improvement of the ecological-economic efficiency of solid waste baling management schemes simultaneously decreases the negative impact on the environment and the health of the population, provides the foundation of an investment appraisal support tool for the implementation of solid waste management projects, and enables comparative analysis of estimated, actual and prevented monetary damages from the implementation of baling plant units.

**Project partners:** Linnaeus University

**Project funder:** No funder. Governmental support for disabled person

**Project period:** 2009 – 2011.

### **Actions against phosphorus leachate from agricultural properties**

The project aims to clarify the phosphorus reduction potential and cost effectiveness for ditch ponds and ditch filters with the different soil types and modes of operation, which dominates the Swedish agricultural land.

**Project partners:** IVL Swedish Environmental Research Institute is Lead Beneficiary and Linnaeus University is the other partner.

**Project funder:** Baltic Sea 2020

**Project period:** 2009 – 2010.

### **BioGasOpt – Performance Optimization of the Växtkraft Biogas Production Plant and Surrounding System**

[http://www.mdh.se/hst/research\\_new/researchgroups/pdb/projects/biogaso](http://www.mdh.se/hst/research_new/researchgroups/pdb/projects/biogaso)

To be able to produce biogas that is commercially competitive with other types of fuels, efficiency improvements of the process are needed. In the research project BioGasOpt, performance optimization of the Växtkraft biogas production plant and surrounding systems are studied.

The Växtkraft biogas plant has been in operation since 2005 and the organic materials used for biogas production are organic wastes from households and restaurants, and ley crops. The residues from the process are then used by local farmers as fertilizers and a circulation between the farm land and the city has been created. Studies of the best use of the residues at the farms are also included in the project.

The aim of the project is to investigate critical academic problems and practical engineering issues for the implementation of a full scale biogas reactor. The project will study how to:

- \*limit the ballast of organics in process water that is recirculated to the reactor
- \*improve transport performance of gas and nutrients in the reactor
- \*treat the feed material in different ways to enhance the fermentation rate
- \*use the fermentation residue in best possible way at farms.

The first attempt to filter process water was carried out in 2008. The pilot plant has been constructed by Mercatus Engineering AB and has a ceramic filter. Results from the tests show that it is possible to reduce the content of solid material from 4% to below 2%. Now the work is focused on an economic evaluation, as well as chemical and biological analysis of the different effluents from the filtration plant.

**Project partners:** Mälardalen University , Svensk Växtkraft AB, Mercatus Engineering AB, the farm Nibble Lantbruk AB

**Main sponsor(s):** Knowledge Foundation

**Grant (MSEK):** 2,9

**Project period:** 2008 – 2011

Table 1. Estimated number of projects related to the Baltic Sea Strategy.

Priority area	Type of project	LOVA	LEADER	Interreg IVA South Baltic Programme	Baltic 2020	Structure Program	Total sum
<b>Limited nutrient effluent into the sea to acceptable levels</b>	Improve individual sewage systems	45					45
	Improve water and sewage networks, planning of storm-water management	75					75
	Plant for emptying yacht toilets	65					65
	Wetlands	20		1			21
	Growing and harvesting mussels, algae	5	2		1		8
	Bioenergy		20	2		1	23
	Measures towards diffuse pollution	10			1		11
	Local participation	10		1			11
<b>Preserve natural areas and biodiversity, including fisheries</b>	Wetlands	20					20
	Restoration Project		10		1		11
	Water management / planning	60					60
<b>Reduce use of hazardous substances</b>	Boat wash	40					40

Table 2 Implementation of the EU strategy for Baltic Sea Region – Swedish commitment to coordinate and lead strategic, collaborative and prioritized measures with environmental relevance

	<b>Flagship Projects</b>	<b>Coordinating authority</b>	<b>Other involved authorities</b>
1. To reduce nutrient inputs to the sea to acceptable levels	1.1. Remove phosphates in detergents in countries where this is not yet the case as recommended by HELCOM Baltic Sea Action Plan, i.e. to prepare a timetable of phasing-out of use of phosphates in detergents".	Swedish Chemicals Agency	Environmental Protection Agency (EPA)
	1.2. "Cleaner waste water"	EPA	The Swedish River Basin District Authorities /County Administration Boards
	1.3. "Analyze results of pilot actions"	The Federation of Swedish Farmers	EPA
	1.4 "Putting best practices in agriculture into work".		
	1.5. "Cooperate with Russia and Belarus on a comprehensive regional pollution risk assessment",	MFA/Sida	
2. To preserve natural zones and biodiversity, including fisheries	2.2. "Restrict the introduction of new alien species by ships"	Ministry of trade and industry	EPA
3. To reduce the use and impact of hazardous substances		EPA	Swedish Chemicals Agency
4. To become a model region for clean shipping	4.2. "Promote measures to reduce emissions from ships and enhance the development for shore side electricity facilities or for emission treatment in all major ports around the Baltic Sea".	Swedish Transport Agency	EPA
	4.5"Improve the waste handling on board and in ports	Region Blekinge	EPA

	<b>Flagship Projects</b>	<b>Coordinating authority</b>	<b>Other involved authorities</b>
5. To mitigate and adapt to climate change	5.1. "Anticipate regional and local impacts of climate change through research	SMHI	EPA
	5.3. Create a network of sustainable cities and villages	Swedish National Board of Housing, Building and Planning	
7. To exploit the full potential of the region in research and innovation		Swedish Meteorological and Hydrological Institute	
8. Implementing the Small Business Act: to promote entrepreneurship, strengthen SMEs and increase the efficient use of human resources	8.4. Make the Baltic Sea an Eco-efficient region"	EPA	
9 To reinforce sustainability of agriculture, forestry and fisheries	9.3. Sustainable rural development		EPA
	9.3. . "Ensure sustainable fishing"	Swedish Board of Fisheries	EPA
	9.7 Sustainable forest management in the Baltic Sea Region - EFINORD"	Swedish Forest Agency	EPA
10. To improve the access to, and the efficiency and security of the energy markets	10.2. Demonstration of coordinated offshore wind farm connection solutions		EPA
	10.3. Implement the Baltic Sea Region Bioenergy Promotion' project.	Swedish Energy Agency	EPA
11. To improve internal and external transport links			
13. To become a leading region in maritime safety and in security	13.2. Become a pilot region for the integration of maritime surveillance systems".	Swedish Coast Guard	EPA

## Research performed by the Swedish Environmental Protection Agency- an overview

### Ongoing programmes and projects

[BalticPOPs - dioxiner och andra persistenta organiska miljögifter i Östersjön](#)  
[Biodiversa - biologisk mångfald](#)  
[CIRCLE - klimatförändringar](#)  
[Effektiv miljötillsyn](#)  
[Ekonomisk värdering för miljön](#)  
[Emissioner från varor - ChEmiTecs](#)  
[Envhealth - miljö och hälsa](#)  
[Hållbar avfallshantering](#)  
[Hälsoeffekter av flygbuller på uteplats](#)  
[IWRM NET - vattenresurser](#)  
[Kartering, miljöövervakning med flygburen laserskanning och digitala bilder](#)  
[LETS 2050 - hållbara energi- och transportsystem](#)  
[Marin försurning](#)  
[SKEP - europeisk miljöforskning](#)  
[Snowman Network - europeisk forskning om mark](#)  
[Statistiska analyser](#)  
[Syresättning av Östersjön](#)  
[Vindval - ett kunskapsprogram](#)  
[Viltforskning](#)  
[Östersjöprogrammet BONUS](#)

### Programmes and projects finished after 2007

[Adaptiv förvaltning av vilt och fisk](#)  
[Bedömning av måluppfyllelse under osäkerhet](#)  
[Klimatverktyg](#)  
[Friluftsliv i förändring](#)

[Frisk luft i Sverige](#)  
[Genomdrivande av miljörett i Europa](#)  
[Hållbara hushåll](#)  
[Hållbar Sanering - ett kunskapsprogram](#)  
[Livscykelhänsyn i integrerad produktpolitik](#)  
[Miljöstrategiska verktyg](#)

## 8. Regional and National policies on the treatment of agro-industrial wastewaters

### 8.1 General policies in Greece

The disposal of sewage and wastewater industries or other facilities to surface waters and soil is allowed only by permission. Originally a study is submitted and after successful evaluation of the objectives of the study, a temporary license is provided for a six-month operation of the facility or activity. The performance targets established after inspection and consultation by the local health services and Municipality's technical service. Only then the final authorization for disposal is given by the Prefect. The limits of pollutants for each recipient are specified by Prefectural decisions.

In case of hazardous wastes the approval of environmental conditions, in accordance with Articles 1, 2 and 3 of Law

3010/2002 and delegated those articles issued regulations, approval of which is a prerequisite for granting provided by KYA 13588/725/06 license of hazardous waste management.

The licensing authority for these activities is the Directorate of Development of the Prefectures and relevant services of the Ministry of Development. Note that the Directorate of Development Services now operates as “none stop services”, as they are competent to judge permitted the creation, expansion and modernization.

The licensing authority, if deemed necessary or when submitting a written complaint named by local government, from local residents or other social agencies, conducts audits to determine the lawful operation of a business. The check can be performed with the assistance of other services. [29]

## 8.2 National policies in Greece on the treatment of olive mill wastewaters.

Greece is the third country in the world in olive oil production after Spain and Italy. There are about 108 millions of olive trees and 2800 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 the 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 see, 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 neighboring 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 Med 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 neighboring agricultural tree-lands. Wet sludge from lagoons is used as fertilizer, also. 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 sludge untreated 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.

### 8.3 General policies in Finland

Agricultural wastewaters are typically directed to general sewage system; only heavy process industry has its own wastewater treatment plants on mill sites. Finnish Water and Waste Water Works Association (FIWA) defines that industrial wastewater can be directed to the general sewage system, when they fulfill the legal

requirements and environmental permission, as well as demands from the municipal wastewater treatment plant. Actually, the actor who produces the wastewater and the operating treatment plant conclude an agreement on directing wastewater to the sewage system, and the agreement includes demands for water quality. (FIWA 2010)

In practice, the actor is given very detailed requirements in its environmental permission and from the wastewater treatment plant. These are for example pretreatment and directing of wastewater, limits for certain compounds (concentrations, load value, min. and max. pH and temperature etc.), controlling the wastewater quality (sampling), reporting and information duty (changes in production, chemical and environmental information), actions in state of emergency (fire etc.) as well as possible surcharges.

Generally, municipal wastewater treatment plant can remove only certain type of compounds from the wastewater. Primary treatment is needed, if the wastewater contains compounds that can harm either water and sewage system or

environment. This is stated in Water supply and sewerage law (119/2001), Environmental protection law (86/2000) and decree (169/2000) as well as in Government regulation on hazardous and harmful agents in water environment (1022/2006). Furthermore, wastewaters that are directed to the municipal wastewater treatment system should not cause any health risks to the employers in the wastewater treatment plant. Wastewaters can not cause any operational drawbacks in the sewage system, wastewater treatment plant or other equipment. Water should not contain any harmful compounds for the environment. Wastewater treatment plant can refuse to treat such wastewater, which does not fulfill all the requirements. Before directing any wastewater to the general sewage system, all demands should be confirmed from the operating treatment plant. Water supply and sewerage law states that operating wastewater treatment plant can refuse to treat such wastewater that could affect the treatment plant operation or the overall quality of water in the sewerage system.

As mentioned earlier in chapter 6, the Environmental protection decree enumerates those activities that require environmental permission (Finlex 2010b). Essential activities for agriculture are for example:

- treatment and manufacturing plants of potatoes or root vegetables, production capacity min. 2 000 tonnes per year
- vegetable, fruit or berry treatment plant, which has the receiving capacity for raw material min. 2 000 tonnes per year
- other vegetable based food processing or manufacturing plant, which produces complete products more than 300 tonnes per day (calculated from quarter year average)

#### 8.4 General policies in Sweden

##### The Swedish Environmental Code

The Swedish Environmental Code is the framework covering most of the legislation relevant to the environment. Most industrial and agricultural activities need environmental permission according to this code. An environmental

consequence description (MKB) should be made and the MKB must show that no direct or indirect effects are caused on human health, animal, vegetation, soil water or air by the planned activity or measures planned. Agricultural and industrial wastewaters can be directed to the general sewage system if the MKB shows that the effluent can be treated there. If the effluent cannot be treated there, the industries have to build their own waste water pretreatment plant before they can release the waste water to the municipal system. Farms in the countryside far away from the municipal sewage system build their own system for sewage treatment with e.g. some kind of septic tank and a drainage system.

##### Action programme for reducing plant nutrient losses from agriculture

The first Swedish action programme for reduced nitrogen leaching was produced as early as towards the end of the 1980s, when the eutrophication issue came to decision-makers' attention. Since then, the programme has expanded to include measures for reducing losses of phosphorus and ammonia from agriculture. The work is based on international commitments and the

Swedish environmental quality objectives. The most far-reaching or extensive measures are taken in areas deemed to be particularly vulnerable to nitrate pollution. The measures in the programme are carried out through legislation, financial means of control, extension service and information, as well as research and development. This means that the measures in the action programme consist of compulsory measures, e.g. legislation, as well as voluntary measures such as participating in environmental extension services. When the action programme was introduced, funds were also directed towards research and development. The agricultural measures based on the action programme contribute both to reach the goals decided in Sweden, like the environmental quality objectives, and to reach international agreements and directives.

Examples of the measures taken are: Introduction of environmental support for establishing wetlands. Increased and improved extension service in counties with the largest leaching of plant nutrients.

## 9. Regional and national plans or programmes

### 9.1 Regional and national plans or programmes in Region of Western Greece

The authorities of Region of Western Greece are implemented operational programs for the sustainable development of the Region of Western Greece. These programs include axes and priority areas concerning the environment, the treatment of water and wastes (solids and liquids).

#### **Program “Environment – Sustainable Development”**

In national level the Program “Environment –Sustainable Development’ is dominated almost all other operational programs and its budget will be 1.8 billions Euros.

The Program “Environment –Sustainable Development’ has as main target the protection, upgrading and sustainable management of environment in order to be the main tool for the protection of public health, the improvement of the quality of citizens and to act as a factor for the improvement of the competition in economy. Some of the interventions

which are planning to be applied through the present project are:

- The integrated management of solids and hazardous wastes and the protection of soils
- **The implementation of the Directive 2000/60 and the management of municipal wastewaters and industry wastes (solids)**
- **Management and distribution of water (potable)**
- **Management of wastewaters**
- The configuration of systems for measuring and control of sources of atmospheric pollution and the application of plans to reduce the atmospheric pollution
- Interventions for protection and management of bio systems
- Interventions for the infrastructure for the flood-preventing systems
- Other measures for the protection of environment and risk assessment

### **Program Region of Western Greece-Peloponnese- Ionian Islands**

The general objective of this operational program is the widening of the development capabilities of the region, the acceleration of the rate of economical growth and of social development, and the enhancement of the productivity of the local economy.

Three main goals are included in the present program:

- Target 1: Development of modernization of accessibility infrastructure
- Target 2: Digital convergence through the utilization of information and communication technologies and the reinforcement of entrepreneurship
- **Target 3: Sustainable development and quality of life**

The total budget for the above target are up to 914 M M€. However for Target 3 money from the operational program “Environment – Sustainable Development” will be used too.

The specific goals of the priority actions in Target 3 are the following:

Priority axis 7: Sustainable Development and Quality of life in Western Greece

- **Guarantee drinking water in adequate quantities and of good quality (e.g. by promoting best practices in drinking water treatment)**
- **Management of wastewaters**
- Development of environmental infrastructure for the treatment, management and exploitation of solid wastes and projects for the renovation of areas where garbage were illegally had been disposed.
- Management and distribution of water (potable) and creation of protection zone for the water sources
- Improve the natural and man-made environment and cultural infrastructure
- Restore ecological balance, protect the environment & biodiversity and support the rational use of water resources.
- Reduce regional isolation and social infrastructure shortages (health & welfare, education).
- Promote the socio-economic regeneration of urban areas
- Maintain populations in agricultural areas by creating a more diversified economy basis and improving socio-economic conditions
- Utilize the potential of urban, semi-urban & tourist areas in the direction of boosting the competitiveness of regional economies and rendering them hubs of activities at different levels.
- **Guard against and safeguard the environment from hazards**
- Protect and promote the region's cultural resources
- Create, strengthen and utilize supporting information

## 9.2 Regional and national plans or programmes in Finland

**Environmental protection strategy of Häme region:** general strategy for protecting environment. This programme includes wide variety of environmental protection themes on very general level, water and agriculture being only small parts of this. Water related themes and actions are for example protection and management of ground and surface waters. (Finnish Environmental Institute 2010b)

**General plan for Päijät-Häme region water supply and sewerage system 2011** aims to update each municipality's water supply (Regional Council of Päijät-Häme 2010c).

**Development plan for water supply and sewerage system in Päijät-Häme rural areas** is going on by the end of 2013. This is based on EU's **Urban wastewater treatment Directive (91/271/ECC)** (European Commission 2010a) and on **Government regulation on municipal wastewater treatment in areas outside of water supply and sewerage system (542/2003)**, latter became into force 2004 (Finlex 2010g).

## 9.3 Regional and national plans or programmes in Sweden

### National Environmental Quality Objects

The Swedish Parliament has decided that Sweden's environmental work is to set out from 16 national environmental quality objectives. A number of agencies are entrusted by the Government with responsibility for these objectives, with the Swedish Environmental Protection Agency to act in a coordinating role.

Fifteen of these were adopted by the Parliament in 1999. They define the necessary characteristics (qualities) of our natural environment and our cultural heritage environment in order to ensure environmentally

sustainable development. In November 2005 a further objective, "A Rich Diversity of Plant and Animal Life", was added to the previous fifteen. Since then, Sweden's environmental work has been based on these sixteen environmental quality objectives.

The objectives shall be reached through legislation, financial instruments, information, extension services, and training. All the quality objectives have

been broken down into interim targets in order to clarify what is needed in various areas to reach the overall objectives. Programmes and activities to fulfil the targets are scheduled.

One of the objectives is **“Zero eutrophication”**. Nutrient levels in soil and water must not be such that they adversely affect human health, the conditions for biological diversity or the possibility of varied use of land and water. There are four interim targets for this objective. Two of them are about waterborne anthropogenic emissions into water. By 2010 Swedish waterborne anthropogenic emissions of phosphorus compounds into lakes, streams and coastal waters will have decreased by at least 20 per cent from 1995 levels. At the same time waterborne anthropogenic emissions of nitrogen compounds into sea areas south of the Åland Sea will have been reduced by at least 30 per cent compared with 1995 levels.

Another objective is **“Flourishing Lakes and Streams”**. Lakes and watercourses must be ecologically sustainable and their variety of habitats must be preserved. Natural productive capacity, biological

diversity, cultural heritage assets and the ecological and water-conserving function of the landscape must be preserved, at the same time as recreational assets are safeguarded. Five interim targets are set up with plans and programmes to fulfil this objective.

**“Good-Quality Groundwater”** is a third objective that is about water. Groundwater must provide a safe and sustainable supply of drinking water and contribute to viable habitats for flora and fauna in lakes and watercourses. Three interim targets are set up with plans and programmes to fulfil this objective.

**“A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos”** is another objective that is about water. The North Sea and the Baltic Sea must have a sustainable productive capacity, and biological diversity must be preserved. Coasts and archipelagos must be characterized by a high degree of biological diversity and a wealth of recreational, natural and cultural assets. Industry, recreation and other utilization of the seas, coasts and archipelagos must be compatible with the promotion of sustainable development. Particularly

valuable areas must be protected against encroachment and other disturbance. Seven interim targets are set up with plans and programmes to fulfil this objective

### **The Swedish River Basin District Authorities**

Sweden is divided into five water districts. Five County Administrative Boards are appointed as River Basin District Authorities. They have the overall responsibility for implementing the Water Framework Directive in Sweden.

At every River Basin District Authority there is a Water District Board that makes decisions on the authority's various fields of responsibility. The Water District Board is made up of experts from different fields, and is appointed by the Government.

Sweden's municipalities and County Administrative Boards have important roles in the water management. They contribute a knowledge base to the River Basin District Authorities, and perform a great deal of the operative work on local and regional levels.

### **The Kalmarsund Commission**

The Kalmarsund Commission was appointed in spring 2006 by the City of Kalmar. The assignment was to develop a concrete plan with concrete actions to improve the environmental conditions in Kalmarsund and the coastal environment. The Commission consists of representatives from the County Board, Swedish Farmers Association (LRF), Linnaeus University and Kalmar Municipality. Industry, municipalities along the Kalmarsund and various local groups were consulted in the process.

The final report was submitted in summer 2007. The action plan is the report's central point. The proposals do not address comprehensive measures nor measures in all areas needed to establish ecological balance in Kalmarsund and the Baltic. The Commission proposal is based on the competencies and responsibilities the Commission members had. The Commission has continued as a forum for the exchange of knowledge and experience, for consensus and coordination and to initiate various actions.

## Projects

Some of the projects according to plans and programmes described in this section, can be find in section 7.3, Table 1 and 2.

### 10. Activities carried out by the public and/or private sector on the agro industrial wastewaters

#### 10.1 Activities carried out in Region of Western Greece

Unfortunately, there are not so many actions or activities on the treatment of agro-industrial carried out by local authorities (Region of Western Greece or the Prefectures of Achaia, Ileia and Aitoloakarnania). There are only some research projects in which local authorities have been involved.

#### 1. Project title (LIFE+ Environment Policy and Governance 2008):

(Coordinated by Assistant Professor Michael Kornaros, member of the FORTH/ICE-HT team)

#### SUMMARY DESCRIPTION OF THE PROJECT

**Development of INTEgrated aGRoIndustrial wASTE management politics maximizing materials recovery and energy exploitation. (Acronym : INTEGRASTE).**

#### Project objectives:

The overall objective was to produce from agro-wastes (agricultural plant residues) and agroindustrial wastes (from e.g olive mills, piggeries etc) a sustainable fuel source that can be integrated into the existing energy infrastructure in the medium term while in the longer term will also provide a safe and economical means of supplying the needs of a developing hydrogen and biogas fuel economy.

Agroindustries are major contributors to the economy of Achaia region but on the other hand they constitute a severe source of pollution for the environment of the entire area. To be more specific solid and liquid wastes from the aforementioned activities are released to riversides, along streams and in several rural places in Achaia region polluting surface and ground water supplies. Indicatively from just one sector of agro industrial activities such as olive mills it is estimated that 65.000 tones of wastes are

annually produced and released with low or minimum pretreatment in aquatic receptors of Achaia region. The main project objective is to demonstrate that it is possible to solve the problem of agricultural wastes in Achaia region by developing a facility providing an integrated solution for the management of these wastes using anaerobic digestion for producing electrical and thermal energy, composting for material recovery and valorisation of the residuals.

The project focuses on identifying the different sources of organic wastes of high strength that can be efficiently combined in anaerobic digestion (AD) plants to produce gaseous biofuels (hydrogen and methane). Increasing waste treatment and disposal costs are now gradually forcing waste abatement and byproduct recovery. Nevertheless, the ultimate goal of waste-free (clean) production still seems far away from realization. Although numerous waste and byproduct recovery processes have been introduced, anaerobic digestion has a unique and integrative potential, simultaneously acting as a waste treatment and recovery process. **Anaerobic digestion** has a great number of advantages: low nutrient

requirements, energy savings, generation of low quantities of sludge, excellent waste stabilization and production of biogas (methane) and/or hydrogen without requiring residue pre-treatment. Anaerobic digestion is a particularly attractive treatment solution for high strength wastes due to the operational economy and generation of biogas and therefore is considered as a promising solution for energy production from renewable resources (biomass).

The **INTEGRASTE** project is **in line** with the **national priority for waste and natural resources** and the *specific national target for maximising the recovery of materials and energy from waste through the development of methods of wastes exploitation*. More specifically the promotion of electricity from renewable energy sources (RES) is a high European Union (EU) and national priority for *combating climate change* and several other reasons, including the security and diversification of energy supply, environmental protection and social and economic cohesion (e.g. Directive 2001/77/EC). Furthermore, a *specific national target* also addressed

by the **INTEGRASTE** project is the ***Reuse of treated wastewaters***.

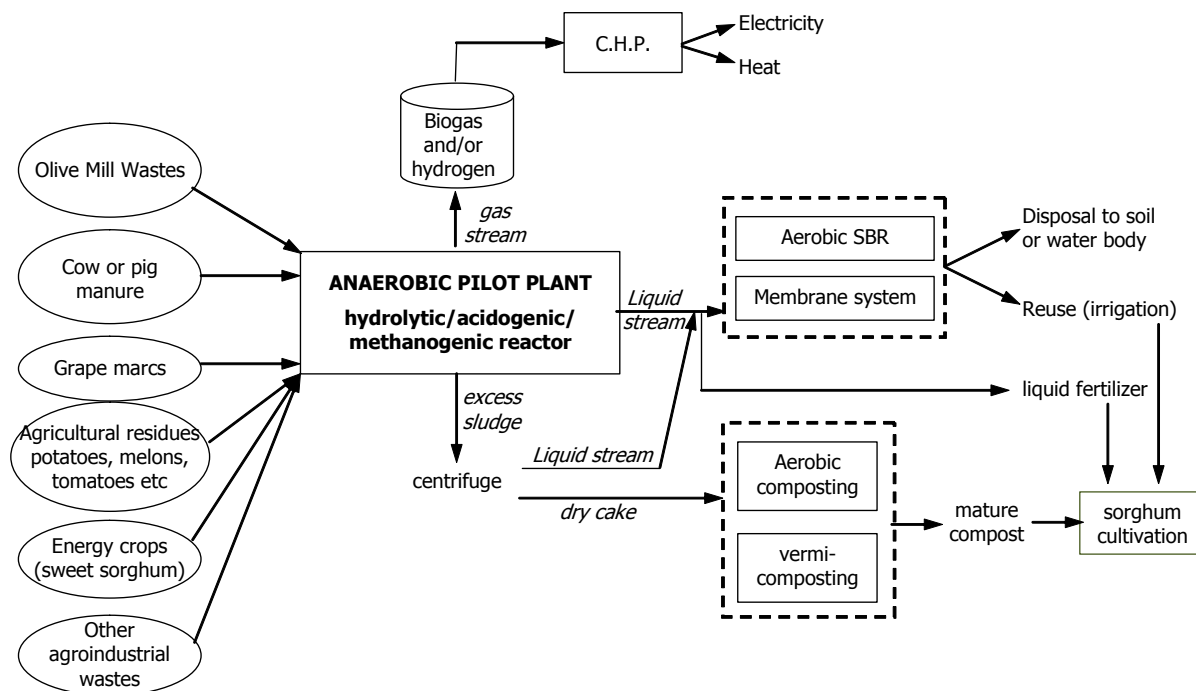
A significant number of biogas plants have been built, mainly in the Northern Europe, and now the concept is spreading all over the world. Biogas plants treat various types of organic residues including sewage sludge, food industry residues and manure. **Co-digestion of organic wastes** is a technology that is increasingly being applied for simultaneous treatment of several solid and liquid organic wastes, in which the content of nutrients can thereby be balanced, and the negative effect of toxic compounds (e.g. phenols) on the digestion process may be decreased giving thus an increased gas yield from the biomass. Moreover, co-digestion contributes to a more efficient use of AD reactors and cost-sharing by processing multiple waste streams in a single facility. This action should help in protecting the environment and will determine how the technology can best be applied to provide a versatile, low-cost, carbon-neutral biofuel in an environmentally sound and sustainable agricultural framework. After digestion the sludge is passed to a sedimentation tank where the sludge is

thickened. The thickened sludge requires further treatment prior to reuse or disposal. **Composting** of the produced sludge will also be examined in this project as an added value for the economic viability of the proposed process. Composting is an aerobic bacterial decomposition process to stabilise the sludge and produce humus (compost). The finished compost contains organic matter, nutrients including nitrogen, phosphorus and potassium, as well as sulphur, copper and boron and soil microbes. The addition of compost to the soil has a number of beneficial effects on the physical, chemical and nutrient properties of soil. Additions of compost help to improve soil structure, retain moisture, provide plant nutrients, increase organic matter and reduce disease. These properties are important in maintaining and improving soil conditions for plant growth. Composting takes place naturally on a forest floor where organic materials (leaf litter, animal wastes) are converted to more stable organic materials (humus) and the nutrients are released and made available for plant uptake. Compost will be used as a fertilizer for crops in order to achieve

full exploitation of the waste streams treated, which is the main goal of this project.

The Project goal aims at improving the sustainable agrowaste management status in Greece and EU countries and fostering renewable energy production from exploitation of their organic agrowastes. Specific project objectives include:

1. Determination of accurate energy balances for selected types and mixtures of agrowastes based on their seasonal and spatial availability
2. Determination of anaerobic degradation rates and ultimate hydrogen/methane yield of selected types of agrowastes and mixtures thereof, in pilot plant scale.
3. Prediction of biogas and hydrogen energy production per Kg (or m<sup>3</sup>) of agrowaste mixture.
4. Assessment of advantages and limitations of co-digesting different agrowastes.
5. Identification of novel process designs that will help overcome known problems of digester stability.
6. Quantification of energy usage and potential savings in a pilot-scale AD plant via testing of different mixing systems, reactor and energy integration configurations.
7. Encouraging actions (training programs, consulting services, best practices exchange, communication campaigns) aimed at supporting in Greece the development of a renewable energy culture based on gaseous biofuels from agro-wastes and other organic residues.
8. Increase access of stakeholders to pilot plant operation data and local sources of financing for Renewable Energy.



**Scheme 2.** Schematic diagram of the integrated Pilot Plant facilities.

**2. Integrated management of agroindustrial wastewaters in the cross-border Greek-Italian region – AGROENERGY INTERREG IIIA / GREECE – ITALY 2000-2006**  
(Coordinated by Assistant Professor Michael Kornaros, member of the FORTH/ICE-HT team)

**Project Partners:**

1. Prefecture of Achaia (Leader, Greece)

2. University of Patras / Dept. Chem. Eng. (Greece)
3. Prefecture of Kefalonia & Ithaca (Greece)
4. Prefecture of Lefkada (Greece)
5. Prefecture of Preveza (Greece)
6. Centro Ricerche Bonomo (CRB, Italy)
7. Prefecture of Bari (Provincia di Bari)

**Project objectives:**

The overall objective was to produce from agroindustrial wastewaters (from e.g olive mills, piggeries etc) a sustainable fuel source that can be integrated into the

existing energy infrastructure in the medium term while in the longer term will also provide a safe and economical means of supplying the needs of a developing hydrogen and biogas fuel economy. The project will determine how the existing anaerobic digestion (AD) technology can best be applied to INTERREG partners to provide versatile, low-cost carbon-neutral biofuels (hydrogen, methane) in an environmentally sound and sustainable agricultural waste management framework. AD of agro-wastes can help us to replace fossil fuels, reduce methane emissions from landfill sites and increase the efficiency of our energy system. As well as helping us to fight climate change, it can solve many of our waste management problems, reduce freshwater pollution from organic wastes, increase fuel security and reduce our dependence on chemical fertilizer.

### **Conclusion**

This study investigated the fermentative methane production treating different mixtures of OMW, Cheese Whey and Liquid Manure wastewaters in a 2-stage process. It has been proved that continuous fermentative methane

production from these kinds of wastewaters is a feasible and viable process. Co-digestion improves energy yields from the treated wastewaters.

### **3. PSP-Innovation Pole of Western Greece**

#### **Regional Innovation Pole of Western Greece**

**Greece** is a union comprised of organizations from the private and public sector, aiming at the development, promotion and exploitation of innovation in the Region of Western Greece (RWG).

**The Objective** was to organize and strengthen the bonds between the Research / Technological and Enterprise Institutions of the RWG, aiming at actions that will enhance the region's technological performance and innovation. This Union was created and organized around specific competitive markets and scientific areas and is committed to develop and promote the already existing technological and innovating mass so as to become competitive on a National and International level.

### **4. Innovation Pole of Western Greece** **Thematic Axis III: Environmental Management and Protection,**

Task A11: Development of a viable solution for the management of olive mill wastewaters with emphasis on valorization of byproducts”, Gerasimos Lyberatos, Partners: Foundation for Research and Technology / Institute of Chemical Engineering and High Temperature Chemical Processes, Environmental Protection Engineering SA, Olive Mill “PANITSAS”, ENVIO Ltd

Task C4: Infrastructure for the development of a viable solution for the management of olive mill wastewaters with emphasis on valorization of byproducts, Gerasimos Lyberatos, Partners: Foundation for Research and Technology / Institute of Chemical Engineering and High Temperature Chemical Processes, Environmental Protection Engineering SA, Olive Mill “PANITSAS”, ENVIO Ltd

**Description:**

The primary goal of the proposed task is to consider all alternative methods of olive-mill wastewaters (OMW) management that have been developed in the past, and to compare them on an environmental as well as economic basis, aiming at the development and

demonstration of suitable integrated management scenaria that combine effective OMW detoxification with the production of high additive value products and/or energy. The result of the Task, that is, the unit of integrated management of OMW will be efficient immediately, because it would be possible to be used by all olive mills in the Region of Western Greece and it will contribute to cleaner environment.

The proposed work involved:

- Detailed environmental and technoeconomic evaluation of all known integrated OMW management methods, taking into account the value of the treated byproducts
- Identification of the most promising integrated management methods and testing at a pilot scale
- testing integrated OMW management under real conditions, process optimization and selection of the most profitable technology
- result publicity and dissemination

## **Workshops**

### **FORTH/ICE-HT, Patras, Greece** **(coordinated by Assistant professor** **Christakis Paraskeva)**

"Feasible Treatment Methods and Exploitation of Olive Mill Wastewater", Project PANELEA, 17 December, 2004, Patras, Greece The Institute of Chemical Engineering and High Temperature Chemical Processes (FORTH/ICE-HT) organized a Workshop on "Feasible Treatment Methods and Exploitation of Olive Mill Wastewater (OMW)", in the framework of the EU-project: "A cost-effective system development for complete exploitation of olive mill wastewater - PANELEA (QLK5-CT-2002-71666)". In this Workshop, Research & Technology Development (RTD) performers and industrial partners in projects funded by EU were invited to attend and to present some of their results. Moreover, olive mill owners' associations (potential end-users) were invited from Spain, Italy, and Greece, as well as relevant scientists and officers from local authorities, in order to spread out at the maximum possible way the exploitation possibilities of the innovative

techniques on cost-effective utilization of OMW.

### **10.2 Activities carried out in Region of Finland**

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### 10.3 Activities carried out in Sweden Focus on Nutrients

Focus on Nutrients is the largest single undertaking in Sweden to reduce losses of nutrients to air and water from livestock and crop production. The project also focuses on the safe use of crop protection products. Focus on Nutrients is a joint venture between The Swedish Board of Agriculture, The County Administration Boards, The Federation of Swedish Farmers and a number of companies in the farming business.

**The purpose of the project is to:**

- reduce losses of the greenhouse gases; nitrous oxide, methane and carbon dioxide
- reduce losses of nitrate from farmland
- reduce ammonia emissions from manure
- reduce losses of phosphorus from farmland
- avoid losses of pesticides into surface and groundwater

In order to fulfill these objectives the project focuses on increasing nutrient management efficiency by increasing awareness and knowledge. The farmer is in focus and therefore the core of the project is education and individual on-farm advisory visits.

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