LIFE Project Number

LIFE ENV/GR/000671

LIFE PROJECT NAME

MINOS

Process development for an integrated olive oil **mi**ll waste management recovering **n**atural anti**o**xidant**s** and producing organic fertilizer

Project location	Kriti
Project start date:	01/10/2001
Project end date:	01/04/2004
Total Project duration	30 months
Total budget	1,239,213 €
EC contribution:	608,561 €

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INTRODUCTION

Wastewater produced by olive oil mills constitutes a major environmental impact and a problem which cannot be easily solved by the specific agricultural industry sector. The high capital cost required for the treatment of this wastewater discourages the olive oil mill owners to change the current management practice that they use (disposal at nearby natural aquatic receivers; streams, sea etc.). The main reason for this is that most of the olive oil mills, which at their majority are small-scale enterprises, cannot afford the installation of wastewater treatment processes and consequently they persist on managing their waste with environmentally and legally not acceptable methods.

The major problem concerning this waste is their significantly high organic content, which is not easily biodegradable while the high concentrations of polyphenolic compounds result in biotoxic phenomena and degradation of the natural environment. On the other hand, recent research studies have shown that some of these olive oil originating substances are responsible for the unique nutritional value of olive oil, mainly due to their anti-oxidant and antimicrobial properties. Therefore, these substances can be used for the preparation of commercially available nutritional supplements and hence they are of considerable commercial and economic interest.

This demonstration project mainly aimed at the development of a viable high-technology process for the recovery of natural anti-oxidants from olive oil mill wastewater and to prove that the management of olive oil mill waste with the proposed integrated recovery process is economically attractive because of the financial exploitation of bioactive substances contained therein.

The project was carried out between 2001 and 2004 by a consortium of partners from the School of Pharmacy of the University of Athens, the Laboratory of Substrates and Soilless Cultures of TEI of Crete, the Goulandris Natural History Museum, the University of Crete School of Medicine and TERRA NOVA Ltd. (Environmental Consulting firm). The project was co-financed by EU with the national contribution was covered by the project participants as well as the Region of Crete and the Rouva Municipality.

A pilot plant was designed, installed and operated. Polyphenolic compounds were extracted from the Rouva Cooperative olive oil mill wastewater (hydroxytyrosol, tyrosol) as well as from the produced solid waste (oleuropeine). The demonstration

management system is integrated through the co-composting of the sludge produced by the wastewater treatment system with solid waste (olive leaves) for the production of a natural organic fertilizer.

The feasibility study that was conducted at the final phase of the project presented that the application of the developed technology at full scale comprises a considerably profitable investment that can initiate a significant development perspective.

DESCRIPTION OF THE PROBLEM

One of the most important problems of the agricultural industry sector with severe environmental impacts is the management of the wastewater produced by the olive oil mills.

EU covers 78% of the global olive oil production. The main producer countries are Spain, Italy and Greece. During the olive production period 20 million tones of water are consumed every year while 30 million tones of wastewater are produced.

Greece produces 230.000-280.000 tones of olive oil annually, corresponding to 12.5 - 15% of the total worldwide olive oil production. In Greece there are 2,500-3,000 olive oil mills of various production capacities, which cover the olive oil production needs. Of course it must be mentioned that most of the hellenic olive oil mills are small scale enterprises. The wastewater quantity generated during the operation period of the olive oil mills is exceptionally large presenting an average daily value per each mill of 15-20 tons. It is noticeable that approximately 5 kilos of wastewater are generated for each olive oil kilo produced.

The most common practice followed today for the management of olive oil mill's wastewater is its disposal in nearby aquatic receivers like streams, rivers, lakes and even the sea. More specifically, 58% of the olive oil mills dispose of their wastewater into streams, which consequently in most of the cases ends up in larger water reservoirs. 11.5% of the olive oil mills dispose of their wastewater directly into the sea while 19.5% onto soil.

The uncontrolled disposal of olive oil mill wastewater leads to:

- intense phytotoxic phenomena in flora
- quality degradation of:
  - ground water reservoirs

- surface aquatic reservoirs
- seashores and sea.

Furthermore it must be mentioned the inconvenience of the nearby living inhabitants because of the nuisance due to the unpleasant odours produced by the wastewater evaporation lagoons and the increase of the insect population in those areas.

TECHNICAL SOLUTION

The main environmental impact derived by the operation of the olive oil mills during the oil producing period (October to March) is related to the management (treatment, final disposal) of the produced wastewater (katsigaros). Katsigaros is characterized by considerably high concentrations of organic load, suspended solids and oil residues. The parameter which is mainly responsible for the severe environmental impacts derived by the katsigaros' final disposal into natural receivers is phenols. Phenols existing in katsigaros at significantly high concentrations act biotoxically. The biotoxic properties of phenols, which are in significantly high concentrations in the produced wastewater (katsigaros), constitute a significant inhibitor of the biological processes which take place in the conventional wastewater treatment methods. This is the main reason why the common methods for the biological treatment of wastewater do not present the desired performance when applied for the treatment of katsigaros.

On the other hand during the last twenty years several other treatment methods have been developed and tested. These methods either demand a significantly high capital cost for purchasing the required equipment, a cost which cannot be afforded by the majority of the small size hellenic olive oil mills, or demand a high operational and maintenance cost, a fact that combined with the production of by-products of low or medium commercial value renders the operation of these systems non-viable.

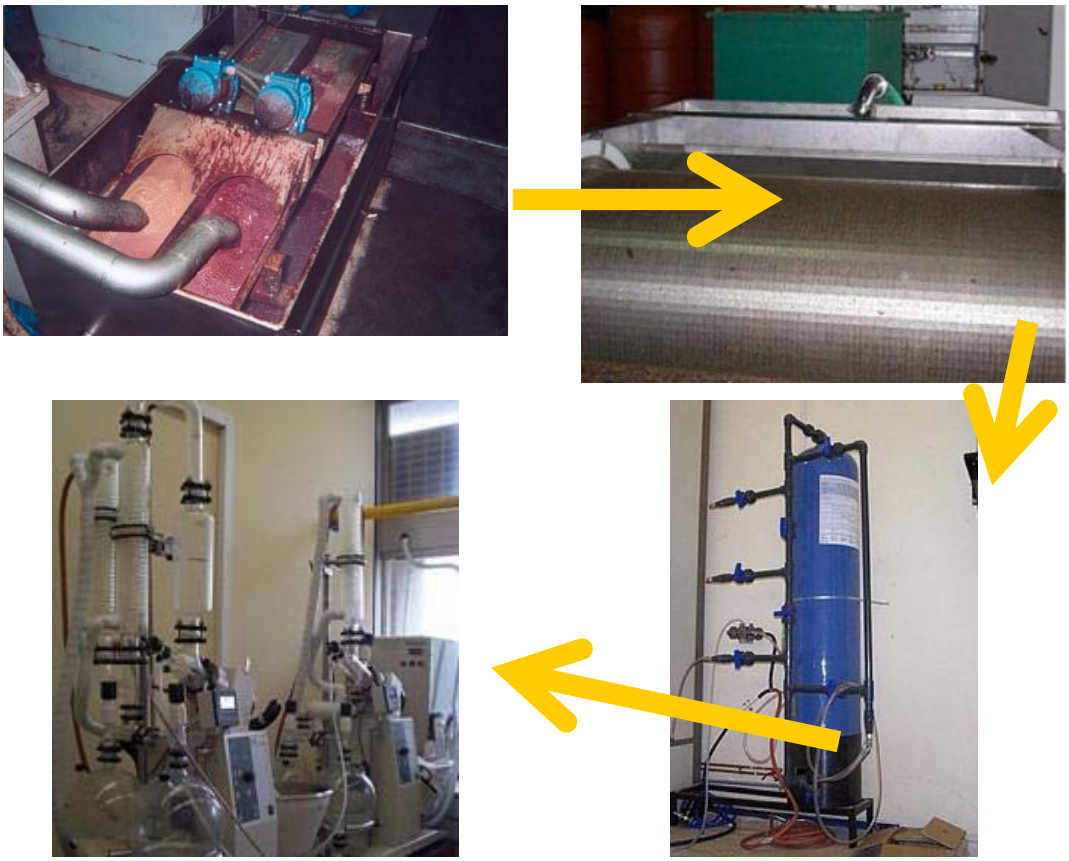
During the recent years specialised scientific studies has proved that polyphenols are substances with interesting biological activity (antioxidative, antimicrobial etc.), which can be used in numerous applications in the pharmaceutical industry, the cosmetics industry and the food industry. These substances have a significant commercial value, a fact based on which it is estimated that the viability of an investment for the development at full (industrial) scale of the specific technology will be ensured.

During the period between October 2001 and March 2004, that the implementation of the MINOS Project took place, the following actions were materialized:

- ✓ Various alternative scenarios for the management of katsigaros were designed, tested and evaluated. These scenarios aimed at the effective and integrated treatment of the specific wastewater and simultaneously at the recovery of the wastewater polyphenols content.
- ✓ The optimum management scenario was selected based on technoeconomic and environmental criteria.
- ✓ Based on the selected scenario a test plant was designed and constructed at pilot scale.
- ✓ The pilot plant operated during two successive oil producing periods. During this period continuous improvements of the pilot plant took place in order to achieve its optimum performance.

The main steps of the developed technology are the following ones:

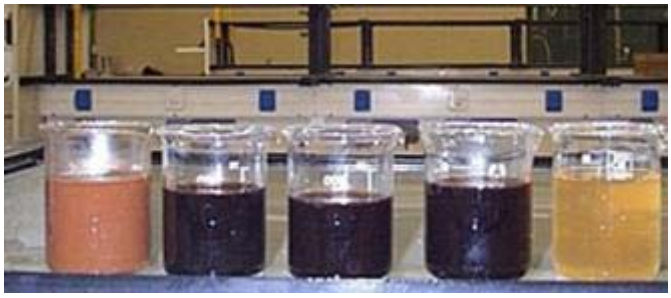
- Successive wastewater filtration stages
- Capture of the polyphenols by specialised adsorbance resin
- Treatment of the resin outflow in a nanofiltration/ reverse osmosis system
- Recovery of the polyphenols captured in the resin media by using organic solvent
- Delivery of the polyphenols mixture through thermal recovery of the organic solvent
- Chromatographic separation and purification of the polyphenols
- Composting of the sludge produced by the filtration stages and the olive leaves which are rejected as solid waste from the mills.



The basic steps of the developed technology for the polyphenols recovery (filtration, resin capture, solvent recovery)

Solid waste shreddering

Organic fertilizer production



Waste sample after the different steps of the treatment

RESULTS AND IMPACT

The application of the developed technology leads to the production of:

⇒ Clean water suitable for:
- Final disposal in a natural aquatic receiver
- Underground disposal
- Irrigation purposes
- Utilisation in the plant that will operate the developed technology in order to cover its various needs concerning water consumption

⇒ Polyphenols (e.g. hydroxytyrosol) suitable, in terms of chemical form and purity, to be used as raw material in various applications:
- production of medicines
- production of cosmetics
- production of food supplements etc.

⇒ Natural fertilizer (compost).

The full scale application of the developed technology demands the purchase and installation of specialized equipment and employment of specialized scientific personnel. These reasons render the installation of the specific technology in each individual olive oil mill non-viable due to the fact that the majority of these enterprises are small scale businesses.

Based on the aforementioned and in order to achieve the viability of the application of the developed technology, it is recommended the installation of central units in various geographical areas, which will cover the needs of the olive oil mills located in these areas. By this way the wastewater produced by each olive oil mill will be treated in the central units and thus the required capital and operational cost will be significantly lower compared to the option where the specific technology would be installed in each individual mill.

Concerning the financial data of such a central unit, it must be noted that the capital cost for a treatment capacity of 50 m^3 katsigaros per day is approximately 1.150.000€

(the building construction cost is not included) while the operational cost per month is estimated to be 54.000 €. Having in mind that the katsigaros' mean polyphenols concentration is ranging between 2-4 g/l and the market price for selling the final extract is estimated to be 0,4–1 €/g, it is concluded that based on the most moderate calculations the total depreciation of the central unit's equipment can be achieved within the first two years of operation.

Based on the aforementioned it is concluded that the application of the developed technology at full scale comprises a considerably profitable investment, which will provide a feasible solution to the so far unsolved problem of the katsigaros' management while on the other hand it will initiate a significant development perspective which will lead:

- to the development of state-of-the-art technology
- to the creation of new employment opportunities
- to the support of employment in the region
- to the development of significant commercial relations with companies located in other countries.