"Existing and emerging technologies for the treatment of olive oil mill wastewaters (OOMW)"

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Outline

- Objective of the study
- Management of OOMW
- Production of OOMW
- Characterisation of OOMW
- Treatment of OOMW
- Legislative framework in EU and Greece
- LIFE07 ENV/GR/000280 project
- Conclusions

Objective

Evaluation of the existing (physical, biological etc.) and emerging technologies for an integrated treatment of OOMW

The legislative framework regarding OOMW management is also presented; however no guidelines or specific disposal practices exist in the EU countries

Olive Oil Mill Wastewaters (OOMW)

- Slightly acidic - Associated with high BOD and COD, up to 100 and 220 g/L, respectively
- Their phytotoxic effect is partially attributed to organic fraction
- The phenolic content (phenols, flavonoids or polyphenols) along with long-chain fatty acids produce methanogenic toxicity
- Their characteristic dark brown colour is due to polymerization of low molecular weight phenolics

OOMW management

- Olive oil production is intense and seasonal; treatment processes should be flexible enough to operate in a non-continuous mode
- Olive mills are small-scale enterprises, making individual on-site treatment options unaffordable
- No treatment process developed for industrial wastewaters is suitable to be generally adopted
- OOMW management strategy should be directed towards a combination of their detoxification and by-products utilization

Production of OOMW

Olive oil production

discontinuous press method

40-60 L OOMW/100 kg of olives

continuous (2- or 3-phase) centrifugation method

10 or 100 L OOMW/100 kg of olives

- In all stages clean water is consumed and wastewaters of various quality are produced
- OOMW production is strongly dependent on the processing system
- OOMW quality depends on olive variety, olive seed maturity, cultivation method and geological-climatic conditions

Production of OOMW

- Mediterranean countries produce 97% of the total olive oil production; EU countries produce 80–84%
- Table: Estimated OOMW volumes generated from olive oil processing

Country	*OOMW, m^3/y*	*Olive cake, m^3/y*
Spain	2.8×10^6	1.6×10^6
Italy	2.4×10^6	1.6×10^6
Greece	1.4×10^6	0.8×10^6
Tunisia	0.55×10^6	0.3×10^6

Characterization of OOMW

- . . . is carried out using a number of chemical analyses (determination of BOD_5, COD, total solids, total phenols, tannins and lignins, total fats, total organic carbon, total phosphorous, total nitrogen, metals etc.)
- Polyphenols are not easily biodegradable but toxic to most microorganisms (up to 80 g/L in OOMW)

Legislative framework in EU

- EU policy has not brought into force any common guidelines for OOMW management
- Council Directive 91/271/EEC on "Urban Wastewater Treatment"

  - protection of the environment from the adverse effects of the discharge

  - effective treatment of OOMW before discharged

  - treated wastewaters should be reused

- Practices currently applied: land disposal, discharge into nearby rivers, lakes and storage/evaporation in lagoons

Maximum concentrations

- Homogenized, unfiltered and undecanted wastewaters should not exceed BOD_5 and COD of 25 and 125 mg/L O_2, respectively
- Maximum allowed concentrations
  - Phenols: 1 mg/L
  - Total suspended solids: 35 mg/L
  - Total phosphorous: 2 mg/L
  - Total nitrogen: 15 mg/L

Legislative framework in Greece

- No specific regulations regarding the discharge of OOMW
- Greek Law 1650/86 "For the Protection of the Environment":

  - olive mill owners are obliged to provide an environmental impact assessment study

  - each Prefecture is responsible for adopting proper OOMW management practices

Disposal practices in Crete

- Until 1987,OOMW were discharged uncontrolled into the environment
- Since then, local public authorities obliged mill owners to construct treatment units and evaporation lagoons with low construction, operation and maintenance costs
- To avoid potential downward OOMW leakage, a compacted clay liner should be placed at the bottom of the pond; after evaporation of OOMW, the remaining sludge may be land-filled

Treatment of OOMW

- Application of untreated OOMW on soils and crops as a fertiliser
- However, the disposal problem of OOMW is not completely solved, since the effluents produced cause adverse impacts to aquatic life, change of the colour of natural waters, toxicity and odours
- Treatment options: physical, physico-chemical, biological, thermal technologies and combinations thereof, as well as other combined approaches that could improve decontamination efficiency

Treatment of OOMW

Physical treatment

- Separation of different phases through mechanical means
  - *Dilution*
  - *Evaporation and sedimentation*
  - *Filtration and centrifugation*
  - *Dissolved-air flotation method*
- Unable to reduce alone the organic load and toxicity of the wastes to acceptable limits

Treatment of OOMW

Physico-chemical treatment

1. Neutralization: pre-treatment step for the removal of the suspended or colloidal matter from OOMW
2. Flocculation: aggregation of suspended particles
3. Precipitation: removes dissolved chemicals into an insoluble solid form
4. Adsorption: attachment to the surface of adsorbents
5. Chemical oxidation is used for OOMW purification
6. Ion exchange: removes heavy and alkali-earth metals

Treatment of OOMW

Biological treatment

- Use of microorganisms to break down biodegradable chemical species present in OOMW
- Anaerobic process is used to convert organic compounds to methane and carbon dioxide
- Aerobic process is used on lower concentration streams to further remove residual organic matter and nutrients from OOMW
- Combined biological processes are used to meet specific treatment requirements

Treatment of OOMW

Thermal treatment

- Three main treatment options are used:

  i) physico-thermal (evaporation of OOMW and drying of olive cake)

  ii) irreversible thermo-chemical (combustion and pyrolysis),

  iii) combined physical and biological, such as lagooning

Treatment of OOMW

Combined treatment

- Complete abatement of OOMW pollutants can be hardly achieved by the adoption of a single process
- The effective management of OOMW includes their pre-treatment before the application of the selected process
- I. Ultrafiltration and II. Anaerobic degradation = allows high removal of lipids and polyphenols but has poor selectivity
- I. Ozonation and II. Aerobic treatment = a total COD reduction of about 80% can be achieved

Other emerging treatment options

- Integrated systems are able to achieve a very high degree of treatment:

- Treatment of OOM effluents with sand filters
- Co-composting of olive mill sludge with poultry manure or sesame bark
- Mixing of olive mill sludge with calcareous soil and incubation under aerobic conditions

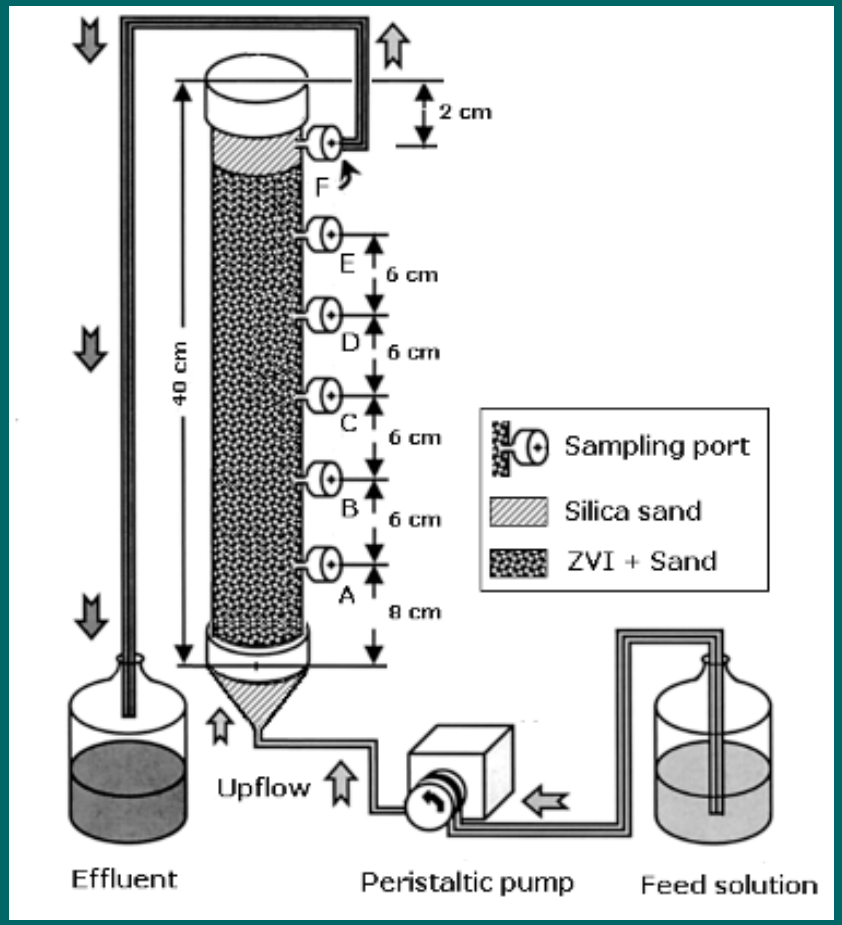
LIFE07 ENV/GR/000280 project

- Title: "Strategies to improve and protect soil quality from the disposal of olive oil mills' wastes in the Mediterranean region"
- Protective/remedial technologies will be developed to remove or significantly reduce the load of pollutants in soils and water bodies affected by the disposal of OOMW in the Municipality of Nikiforos Fokas, Rethymnon prefecture, Crete, Greece

LIFE07 ENV/GR/000280 project

- Demonstration at a pilot scale of a low-cost OOM wastes pre-treatment technique in a tank or a lagoon
- Reactive agents (metallic iron and/or limestone and/or poor lignite) will be used to add alkalinity, remove some of the toxic load and degrade organic contaminants
- Initially, laboratory work will be carried out in plexiglas columns to assess the reactivity and longevity of the media used and establish the optimum residence time

LIFE07 ENV/GR/000280 project



Column system used for pretreatment of oil mill wastes

LIFE07 ENV/GR/000280 project

- Regeneration of the reactive media used as well as toxicity of the precipitates will be studied in detail
- Implementation of a Life Cycle Analysis (LCA) for the entire olive oil production chain
- Such a pre-treatment will contribute to process optimization and will enable the establishment of an integrated strategy for the optimum management of OOMW

Conclusions

- Existing treatments for the decontamination of OOMW: physical, physico-chemical, biological and thermal technologies
- Combined or advanced alternative methods have been developed and show encouraging results
- The legislative framework of the EU does not provide specific guidelines for OOMW management, due to their production only in the Med region

Conclusions

- In most countries mill owners are responsible for the management of OOMW by using practices such as disposal into rivers or lagoons
- LIFE07 ENV/GR/000280 project: protective/remedial technologies will be developed to remove or significantly reduce the load of contaminants in soils and water resources affected by the disposal of OOMW

Thank you !

Any Questions