

# WASTEREUSE

Best Practices for Agricultural **Wastes** Treatment  
and **Reuse** in the Mediterranean countries



Layman's *report*



Project co-funded under the LIFE+ Program

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LIFE10 ENV/GR/594

# WASTEREUSE



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## Agricultural Waste in the Mediterranean region

In a strict sense the concept of agricultural waste (AW) refers to crops and pruning remains. In a more broad sense, the by-products of vegetal origin generated in food industries such as olive oil production, dry fruits elaboration, wine industry, etc. as well as, particular residues such as composts from mushroom cultivation, or substrates already utilized in greenhouse cultivations can also be considered as agricultural wastes. Agrarian wastes also include slurry and farmyard manure. Wastewaters are generated during washing, peeling or whitening processes and contain dissolved organic matter and suspended solids. Remaining pesticides, insects and juices can also be found. The environmental impact of this kind of residues is considered significant and a sustainable management plan is required to avoid environmental degradation and harm to human health.

Large quantities of AW are produced annually in the Mediterranean region. For example, it is estimated that the average total production of Olive Oil Mills Wastes (OMW) ranges between  $10 \times 10^6$  and  $12 \times 10^6$  m<sup>3</sup> and occurs over a brief period of the year (November-March). This highlights the necessity to develop sustainable management plans, which will include recycling and re-use in order to prevent environmental damage.



# Recycling and Reusing Agricultural Wastes

Recycling of AW through land application for plant uptake and crop production is a traditional and proven waste utilization technique. If properly done, it is an environmentally sound method of waste management resulting in economic benefits due to the reduction of commercial fertilizers use. However, although organic matter and nutrients could be beneficial for soil fertility and plant growth, potential serious soil degradation should always be considered due to very high concentrations of inorganic elements and polyphenols, sometimes near or above thresholds. Moreover, the addition of the insufficiently stable organic matter present in wastes, although it leads to the general increase in soil organic matter, may induce a number of negative effects on soil properties and plant growth, such as increase in mineralization rate of native organic carbon or release of phytotoxic substances that may have negative effects on plant growth.<sup>1,2</sup>

Although some of the up to now developed technologies for AW treatment have studied the effects of treated wastes on growth and yield parameters of a few crops, it should be noticed that in order for AW to be used safely in agriculture, specific cultivation practices should be developed after detailed study of

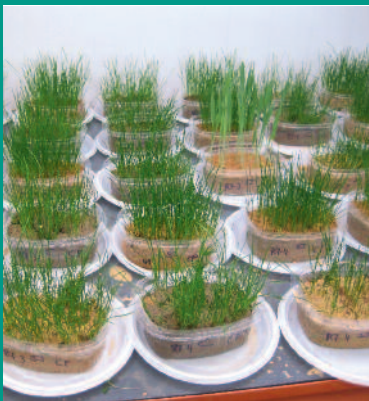


- **the effect of AW on plant growth and yield quality characteristics**
- **water and nutrients demand of the specific crops**
- **the effect of AW on soil properties**
- **the soil-climatic relations**
- **the environmental conditions**

Thus, the WASTEREUSE project proposed the development of new, alternative agricultural practices with the use of treated (or potentially untreated) AW by considering all the above factors as significant parameters, that affect, apart from the production itself, the quality of soil, water, and air.

<sup>1</sup> Cereti, C.F., Rossini, F., Federici, F., Quarantino, D., Vassilev, N., Fenice, M. Reuse of microbially treated olive mill wastewater as fertilizer for wheat (*Triticum durum* Desf.). *Biosour. Technol.* 91 (2004), 135-140

<sup>2</sup> Komilis, D.P. Karatzas, E., Halvadakis, C.P. The effect of olive mill wastewater on seed germination after various pre-treatment techniques. *J. Environ. Manag.* 74 (2005), 339-348.



## The WASTEREUSE Objectives

**WasteReuse focused on two significant environmental problems:**

- the uncontrolled disposal of agricultural wastes (olive oil mill wastes, wastes from the wine industry, etc) as well as, their uncontrolled use for crops/land fertilization.
- the excess use of nutrients and natural resources (water, phosphoric minerals used for the production of fertilizers) and the potential to increase recycling of nutrients and water with sustainable use of treated - or potentially untreated - agricultural wastes

**The main objectives of the project were:**

- The evaluation of innovative as well as, traditional technologies for agricultural wastes treatment regarding their suitability for crop cultivation.
- The development of Alternative Cultivation Practices for the most widely cultivated and water consuming crops in Mediterranean by recycling nutrients and water from AW via identification and development of Best Management
- The development of practices for waste application to main market crops aiming at maximizing yields and minimizing offsite environmental impacts.
- The protection of soil quality from the disposal of processed and unprocessed AW by developing and using cultivation practices which are suitable for representative, including degraded and vulnerable, Mediterranean soil types.
- The reduction of carbon footprint by recycling AW and minimizing the use of fertilizers. Conservation of natural resources from excessive use and uncontrolled wastes disposal.
- The increasing of competitiveness of Mediterranean agricultural products and profits via the reduction of external inputs.

# Actions and Achievements

## Initial assessment

Demonstration actions constituted a big part of the WasteReuse project and lasted in total 2.5 years. The project included two demonstration actions, one in

Spain and one in Italy, during which treated and untreated AW was used to cultivate different crops. The application included the use of wastewater for irrigation and fertilization, and the use of composts for soil quality improvement.

There were two pilot areas per country - all accessible to the public - one area for cultivation in greenhouse and one for open field cultivation. The beneficiaries provided an area of almost 2,500m<sup>2</sup> for the open field tests and a greenhouse of almost 200m<sup>2</sup> for the protected demonstrations.



**In Spain**, demonstration actions took place at CEBAS's premises, and they included:

- Open field cultivations of barley, wheat and maize
- Protected cultivations of lettuce, melon and tomato

**In Italy**, demonstration actions took place at CERSAA's premises, and they included:

- Open field cultivations of lettuce and cabbage
- Protected cultivations of basil and ornamentals

Before the start of the demonstrations, all available data regarding other EU funded projects focused on the development and application of technologies for the treatment of AW produced in large quantities in the Mediterranean region - such as olive oil mill wastes (OMW), wine, animal waste and various other AW - were collected by the Technical University of Crete, through an extensive search of relevant and available databases (LIFE, Sciadirect, Scopus, Cordis, Google etc.) A total of 49 funded projects were identified and were included in a comprehensive inventory. The relevant technologies were also quantitatively evaluated using weighted technical, environmental, economic and socio-cultural indicators and the best AW treatment technologies were proposed to the beneficiaries performing the demonstrations.

## Development of alternative agricultural practices - Lab Experiments

**In Spain**, the experiments aimed to evaluate the potential agronomic value of different treated and untreated organic wastes (OW) as derived from different technologies, regarding their suitability to promote crop production and quality and the potential effect on soil quality. Thirty-one different organic wastes as well as sixteen Spanish and Greek soils were collected and exhaustively characterized and evaluated from an agricultural point of view.

Results from this study showed that the use of OW in crop cultivation as alternative method to the traditional use of inorganic fertilizers can be a desirable strategy to replenish the losses of soil organic matter caused by successive and intensive cultivation, thus contributing to a sustainable agricultural soil management.

Land application of OW as a fertilizer not only provided essential nutrients to plants but also improved soil quality and the degree of valorization of the OW. Improvement of environmental conditions and public health as well as the need to reduce costs of fertilizing crops are also important reasons for advocating increased use of organic materials. The use of OW in ryegrass and barley crops resulted in similar, and in some cases even greater, yields than with the use of mineral N.





**In Italy**, an extensive survey carried out on around 30 wastes based on chemical analysis and laboratory assays allowed the selection of two kinds of composts with promising agronomic properties that were further investigated through pot trials using cress as indicator plant. The suitability of such composts as growing media, when mixed with natural soils and other inorganic materials (zeolite), was compared to a peat based substrate traditionally used for pot cultivation. Rates of compost (ACV or ACM) variable from 20 to 40% (v/v) mixed with natural soil characterized by a medium/high content in macro-elements, Ca and Mg, can lead to a production of biomass - at least regarding the plant species used as indicator in the trials - comparable to the one obtained with a peat based growing medium. The addition of fertilizer and zeolite to soil can further improve the production of biomass and mitigate the negative effect on biomass production deriving from the application of higher rates of compost in the mixture.

### ***Demonstrations of alternative cultivation practices***

**In Spain**, the greenhouse and open field experiments demonstrated that the use of organic materials in crop cultivation contributes to a sustainable agriculture, protecting soil from degradation processes through the improvement in soil physical chemical and microbiological properties they produce. The addition of compost has led - compared with the inorganic fertilization - to a higher increase in soil porosity, soil stable aggregates and soil water holding capacity improving soil structure and water retention, which in turn, will positively influence soil aeration and microbial growth.

It could also be asserted that the use of organic wastes (composts) in agriculture increased the levels of organic



carbon in the soil, increasing the contents of humic substances and humic acids in the soils and contributing to the increase of the soil C pool. In addition, the sustainable use of organic wastes in agriculture led to a greater positive effect on the growth and activity of soil microbial communities compared to the conventional inorganic fertilization.

**In Italy**, field and greenhouse trials were set up with different plant species in order to test the agricultural practices assessed with pot trials and verify the agronomic performance deriving from a combination of selected composts and zeolite. The trials demonstrated the possibility to exploit the unique properties of selected agricultural wastes in order to achieve a more sustainable agricultural production.

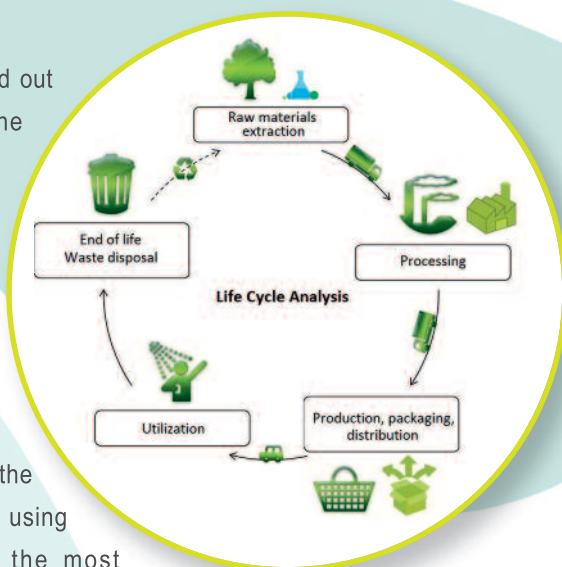
The chemical and nutritional benefits of organic matter in terms of enhancement of plant nutrient cycling determined the possibility to lower and even halve the rate of chemical fertilizer without any impairment of biomass production when compost and zeolite were added to soil substrates at defined percentages. More specifically the demonstration in Italy also proved that the use of organic waste can decrease the incidence of plant diseases caused by soil borne pathogens. Finally, the enrichment of cultivation substrates with zeolites proved to be a good agricultural practice to be adopted by farmers, against reasonable costs, in order to lower the concentration of nitric nitrogen in soils and water bodies, especially in those areas that are recognized as vulnerable to nitrates, as the Albenga plane where the trials were carried out.

### **LCA and Risk Analysis**

A Life Cycle Analysis (LCA) was carried out for the quantitative assessment of the environmental, economic and social impacts during the life cycle of AW. The assessment of the impacts of selected phases of the cycle of reused AW, contributed to the identification of the most important and successful management practices.

The risks regarding the Spanish and the Italian study areas were assessed by using the DRASTIC approach, which is the most commonly used groundwater vulnerability/risk mapping tool.

The contamination potential in the study areas was classified into five risk categories ranging from “low” to “very high”. The groundwater risk analysis was validated with available

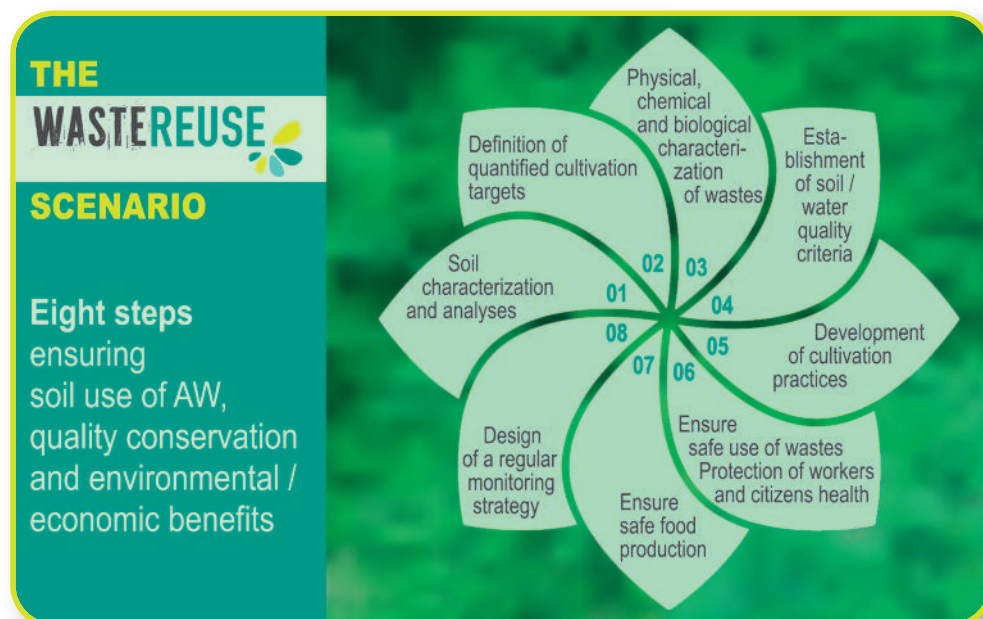


groundwater quality data obtained from Spanish and Italian public/government agencies. The results show high correlation between the DRASTIC risk mapping and the actual nitrate concentrations in both demonstration areas.

Results of the WasteReuse LCA have shown that impact categories differ for the open-field cultivations in Spain and Italy, while for the greenhouse cultivations of lettuce quite similar results are obtained for both demonstration areas. Results indicate a range of 0.171-0.243 kg CO<sub>2</sub>eq for a 1 kg of crop product (lettuce or barley), showing a higher impact for open-field compared to greenhouse cultivations. Compost production, irrigation system and greenhouse phases, have shown the highest impact contributions for the four cultivation scenarios considered.

### ***The WasteReuse Scenario and decision-making tool***

Through the study of the application and characteristics of different types of agricultural waste the project developed an integrated scenario for the use of AW including strategies to monitor soil and water bodies and to control the use of liquid/solid wastes in crop production. This scenario was also translated to specific policy recommendations for regulatory interventions and other policy measures that could facilitate the promotion and safe application of the practices for the reuse of AW.



The adoption of the proposed scenario could contribute to the environmental and economic sustainability of the agricultural sector, through a wide range of benefits including the following:



- Toxic compounds and pollution reduction
- Erosion prevention
- Healthy growth promotion
- Climate change mitigation
- Increase of water infiltration and retention
- Inhibition of pests and diseases
- Increase of soil organic matter
- Higher yields
- Inorganic fertiliser substitution
- Improvement of soil structure for better workability and better crop establishment; saving fuel and time

Furthermore, and in order to assist farmers to select the most appropriate types of AW for different crops and in order to facilitate the monitoring of AW reuse and the research on similar cultivation practices the project developed a database and an on-line tool, which includes all required details and restrictions per type of waste and crop. The tool allows for the application of multi-criteria in identifying the appropriate type of AW and is open to further development by other researchers, who would like to include the results of their experiments with more types of wastes and / or crops.

Finally, a detailed report analysing the regulatory framework, at national and at EU level, for the treatment of Agricultural Waste and proposing legislative and policy improvement was produced. This report identified the regulatory gaps and the main differences between national laws of Member States, and suggested specific EU legislative and non-legislative measures regarding agricultural waste and in particular the treatment of this kind of waste.





## Networking and Dissemination

The wider dissemination of project results included the publication, on a regular basis, of newsletters, the organization of workshops and stakeholders forums, visits of farmers, students and other stakeholders at demonstration areas in Spain and in Italy, the publication and presentation in conferences of scientific papers and the presentation of the project in local media of the countries involved. In addition a network of more than 400 representatives of waste industry and agricultural sector, local and national authorities and EU institutions, was created and was informed systematically about the research findings and the outputs of the project.

The WasteReuse Consortium organized workshops with local stakeholder in Murcia, Spain and in Albenga, Italy, where the project results, were presented and debated with practitioners in order to acquire their feedback and more practical insights and opinions from professionals in the areas of waste treatment and agriculture. In addition a multi-stakeholder forum at EU level, entitled "Towards Sustainable Use of Agricultural Waste", was organized in collaboration with the European Economic and Social Committee in Brussels. In the WasteReuse Forum experts from other projects and from organizations working on the fields of sustainable agriculture and waste treatment presented their views, experiences and best practices regarding the use and treatment of AW.



## Conclusions and Recommendations

**WasteReuse** showcased that increasing the recycling of nutrients and water with the application of sustainable methods and appropriate technologies for the reuse of AW could have various and multiplied environmental and economic benefits. On the condition that all necessary measures are taken to ensure safe and effective use of AW the potential of the tested methodologies and technologies is great, both for farmers and for the environment. In order to maximize the positive impacts of reusing AW and to mainstream its application, the research conducted in the WasteReuse project concluded that further action is needed in this field, that could be summarized in the following points:

- a** Create a coherent regulatory framework for compost, similar to sewage sludge, by harmonizing current national rules or by enacting a common legal framework on a EU level for the content, handling, storage and use of compost.
- b** Promote the use of organic wastes as alternative to mineral fertilizers and revise accordingly the European Fertiliser Regulation (463/2013) in order to align the policies on treatment of agricultural waste with the circular economy strategy of the EU and to reduce the use of fertilizer through the recycling of agricultural wastes.
- c** Foster and disseminate cultivation practices related to the circular economy and based on the recycling of different types of AW after their careful characterization.
- d** Promote the use of zeolite in improving plant growth and preserving soils and water bodies from the negative effects deriving from high nitrate concentration.
- e** Assign the ECOLABEL brand to composts.
- f** Encourage the use of plant-based composts in growing media having a peat matrix.



- g** Take into account toxicity for the characterization of AW before and after treatment with a view to i) select the most appropriate treatment technologies which should reduce the toxicity of treated AW to acceptable levels, ii) define the use of the final products and iii) define the optimum management strategy of the secondary wastes produced in order to eliminate adverse impacts on humans and environment.
- h** Reduce carbon footprint of agricultural production through proper recycling of nutrients.
- i** Promote the reduction of pesticide use by exploiting biological control of plant pathogens and suppressive properties of selected compost.
- j** Engage with all key stakeholders in Europe to disseminate successful practices for reusing AW and for receiving feedback and listening their concerns about the use of compost.
- k** Promote a renovated approach to agricultural production based on a more aware use of resources.

## Project Identity



Best Practices for Agricultural **Wastes** Treatment  
and **Reuse** in the Mediterranean countries

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### CONSORTIUM

#### Coordinating Beneficiary:



*Technical University of Crete, Greece*

#### Associated Beneficiaries



*CEBAS-CSIC Institute, Spain*



*Centro Regionale di Sperimentazione e Assistenza Agricola, Italy*



*LABCAM s.r.l., Italy*



*Signosis, Belgium*

**Project Manager: Prof. Kostas Komnitsas**, *Technical University of Crete*  
*email: komni@mred.tuc.gr*

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