LIFE + Environment Policy and Governance

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WASTEREUSE

Project: Best practices for agricultural wastes (AW) treatment and reuse in the Mediterranean countries

www.wastereuse.eu

Action 2 - Initial assessment of existing AW treatment technologies

Deliverable "Development of weight based indicators for quantitative evaluation of AW treatment technologies"

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Executive summary

In the line of Action 2, all available data regarding funded projects focused on the development/ application of technologies for the treatment of agricultural waste (AW) produced in the Mediterranean region, have been collected by Technical University of Crete (TUC), through an extensive search of relevant and available databases (LIFE, Sciencedirect, Scopus, Cordis, Google etc.)

Data collection has focused on technologies developed/applied for the treatment of the most important AW produced in large quantities in Med countries (mainly in Spain, Italy and Greece), namely olive oil mill wastes (OMW), wine, swine and other animal waste, rice straw and various other AW such as waste from handling of fruits and vegetables, chicken manure, wheat straw etc. A total of 49 funded projects have been identified; 14 of the projects are ongoing while active websites are available for 32 projects.

All available technologies for AW treatment have been included in a comprehensive inventory (grouped by type of waste, level of development and coordinating country) which has been also uploaded on the web-site of the project. Details for each project (duration, funding scheme, budget, beneficiaries) as well as a short description of the developed technologies are also included. More details can be found on the websites of the projects, where available.

The quantitative weight-based evaluation of the technologies developed for AW treatment is based on technical, environmental, economical and socio-cultural indicators. The technologies were evaluated using a scale of 1 to 5 for the selected indicators considering four different scenarios. All available data, regarding the efficiency of each treatment technology, total cost, environmental benefits such as minimization of surface- and groundwater contamination as well as socio-cultural aspects and compliance with relevant environmental legislation, were taken into consideration. Best AW treatment technologies were selected and proposed to responsible Beneficiaries of Actions 3 and 4 (CEBAS-CSIC, CCIAA and CERSAA) for consideration.

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1. Introduction

In the line of Action 2, all available data regarding funded projects focused on the development/ application of technologies for the treatment of agricultural waste (AW) produced in the Mediterranean region, have been collected by Technical University Crete (TUC). Data collection has focused on AW treatment technologies developed/applied and used mainly in Spain, Italy, Greece and other Med countries.

Actions 3 - 6 are based on the outcomes of Action 2. Actions 3 and 4 include lab experiments in order to evaluate the treated wastes derived from the different technologies developed so far, regarding their suitability to improve crop production and quality as well as to assess the potential effects on soil properties. The most suitable, environment friendly, low cost technologies will be used for the development of alternative cultivation practices for the main water and nutrient consuming crops in Spain and Italy; the feasibility of the application of treated wastes in open field and greenhouse cultivations will be also demonstrated (Actions 5 and 6).

European Commission has funded so far many projects (especially LIFE) pertinent to the development/application of AW treatment technologies aiming to recover useful by-products, minimize environmental impacts as well as produce “cleaner” waste for safe disposal. Also, some technologies that treat AW have been developed by private funding. All available treatment technologies have been included in a comprehensive inventory (grouped by level of development, type of waste and coordinating country) which has been also uploaded on the web-site of the project.

The quantitative evaluation of the technologies developed for AW treatment is based on selected weighted technical, environmental, economical and socio-cultural indicators. The technologies were evaluated using a scale of 1 to 5 for the selected indicators considering four different scenarios. All available data, regarding the efficiency of each treatment technology, total cost, environmental benefits such as minimization of surface- and groundwater contamination as well as socio-cultural aspects and compliance with relevant environmental legislation, were taken into consideration. Best AW treatment technologies were selected and proposed to responsible Beneficiaries of Actions 3 and 4 (CEBAS-CSIC, CCIAA and CERSAA) for consideration in the frame of WasteReuse project.

2. Agricultural waste and treatment technologies

The most important AW produced in the Med region include olive oil mill wastes (OMW), wine, swine and other animal waste, rice straw and various other AW (such as waste from handling of fruits and vegetables, horse or chicken manure, wheat straw etc). AW which can be in the form of solid, liquid or slurries depending on the nature of agricultural activities, are mainly characterized by seasonal production and should be rapidly removed from the field to avoid interferences with other agricultural activities (Sarmah, 2009). Depending on the agricultural activity, AW can be categorized as in Table 1 (Loehr, 1978).

Although the volume of wastes produced by the agricultural sector is significantly lower compared to wastes produced by other sectors, their pollution potential is usually very high. AW have usually a high content of recalcitrant compounds and may be characterized as potentially hazardous and toxic when disposed untreated on soil or in water bodies.

Application of AW such as dairy effluents or manure on crop land and pasture can result in decrease in soil permeability and also adversely affect crop growth due to inhibitory amounts of nitrite nitrogen (NO_2-N) or salts added in soil. Excess loading of nitrogen and phosphorus from AW applied on land may cause eutrophication of water bodies or contamination of drinking water (Sharpley et al., 1984; Anderson et al., 2002). Livestock wastes also contain significant amounts of steroid hormones (naturally released by animals of all species in urine) that may cause adverse effects on terrestrial and aquatic organisms (Jobling et al., 1998; Boxall et al., 2004).

Table 1. Characterization of AW depending on the agricultural activity (Loehr, 1978)

Agricultural activity	*Wastes*	*Method of disposal/treatment, by-products*
Crop production and harvesting	Straw, stover	Land application, burning, plowing
Fruit and vegetable processing	Biological sludges, trimmings, peels, leaves, stems, soil, seeds and pits	Landfilling, animal feed, land application, burning
Sugar processing	Biological sludges, pulp, lime mud	Landfilling, burning, composting, animal feed
Animal production	Blood, bones, feather, litter, manures, liquid effluents	Land application, fertilizer
Dairy product processing	Biological sludges	Landfilling, land spreading
Leather tanning	Fleshings, hair, raw and tanned trimmings, lime and chrome sludge, grease	By-product recovery, landfilling, land spreading
Rice production	Bran, straw, hull	Feeds, mulch/soil conditioner, packaging material for glass and ceramics
Coconut production	Stover, cobs, husk, leaves, coco meal	Feeds, vinegar, activated carbon, coir products

However, if AW are treated and reused, valuable by-products can be produced such as compost, treated liquid waste for fertilization and irrigation as well as energy. Other benefits include reduction of raw materials use (eg. phosphate ores for fertilizers), carbon footprint and environmental risk.

So far, many projects aiming at the development of AW treatment technologies have been funded within European funding schemes and especially LIFE, as seen in Table 2. A total of 49 funded projects have been traced (14 of the projects are ongoing) while active websites are available for 32 projects. TUC has searched all relevant and available databases (LIFE, Sciencedirect, Scopus, Cordis, Google etc.) to collect data.

All projects have focused on the development of innovative technologies for AW treatment as well as on the recovery of useful by-products and energy, minimization of the environmental adverse impacts and production of “cleaner” wastes for safe disposal. Apart from European research/scientific communities, some technologies that treat AW have been developed through private funding, aiming at improving quality of the final products, minimizing waste volume and thus environmental degradation caused by their disposal.

All available technologies for AW treatment have been included in a comprehensive inventory which has been presented in detail in the deliverable entitled “Inventory of all available technologies for AW treatment, grouped by level of development (lab, pilot, full scale)” in the frame of Action 2, WasteReuse project; the inventory has been also uploaded on the web-site of the project. Details for each project (duration, funding scheme, budget, beneficiaries) as well as a short description of each developed technology are also included. More details can be found on the websites of the projects, where available.

Table 2. Number of funded projects per type of AW (by March 2012)

Waste	*Number of funded projects (funding scheme)*
Olive oil mill wastes (OMW)	20 (11 by LIFE, 3 by FP5, 3 so far by FP7, 1 by ERDF Innovative Actions 2000-2006, 1 by SME, 1 by FAIR)
Wine waste	4 (by LIFE)
Swine waste	7 (by LIFE)
Other animal waste	7 (6 by LIFE, 1 by FP7)
Rice straw	2 (by LIFE)
Various other AW	9 (by LIFE)

Treated wastewaters or composted waste produced by these technologies could potentially be used for irrigation and/or fertilization of crops after evaluation of specific terms and conditions regarding their suitability to support plant growth, without causing phytotoxicity and environmental problems. It is mentioned that AW treatment technologies, solely aiming at energy production are outside the scope of Action 2 of WasteReuse.

3. Technical, environmental, economical and socio-cultural indicators

Indicators can be used to manage complex information in a simple and clear way so that future actions regarding AW treatment and reuse can be critically assessed and communicated to decision makers and stakeholders. According to EPA (1996), indicators can present information, measure pressures or stressors that degrade environmental quality and can evaluate society's response at improving environmental conditions. When selecting the most appropriate indicators, decision makers are enabled to assess progress towards the achievement of specific objectives and outcomes (Azapagic et al., 2003; Arendse and Godfrey, 2010).

Appropriate indicators should be selected and comply with the following general criteria in order to be used for various purposes, such as evaluation of AW treatment technologies (OECD, 2001):

- ✓ be simple, easy to interpret and able to show trends over time
- ✓ be responsive to changes in the environment and related human activities
- ✓ provide a representative view of environmental/technical/economical conditions and pressures
- ✓ provide a basis for international comparisons
- ✓ be theoretically well founded in technical and scientific terms
- ✓ be based on international standards and international consensus about its validity
- ✓ provide a threshold or reference value so that users can assess the significance of the values and compare

Indicators used in the present study are categorized as technical, environmental, economical and socio-cultural to assess the efficiency of AW treatment technologies and their potential use in agriculture.

3.1 Technical indicators

- By-products production
  - Compost (kg/m^3 waste)
  - Treated liquid waste for irrigation (m^3/m^3 waste)
  - Energy (thermal kJ/m^3 waste, electrical kWh/m^3 waste)
  - Purified polyphenols (g/m^3 waste)
- Co-utilization of a specific AW with other agricultural or industrial wastes
- Ease of application of the technology that treats AW
- Potential of treatment technology in terms of transferability/flexibility
- Long-term sustainability of the proposed treatment technology

  Long-term sustainability contributes among others to the reduction of disposal cost and enhancement of the beneficiary's competitiveness on a global market leading to the production of a marketable product with additional income.

3.2 Environmental indicators

- Prevention of soil/water/air contamination
  - Prevention of soil contamination
  - Prevention of water contamination
  - Prevention of air contamination
- Phytotoxicity minimization

  Phytotoxicity is defined as a delay of seed germination, inhibition of plant growth or any adverse effect on plants caused by specific substances (phytotoxins).
- Ecotoxicity minimization, %

  Ecotoxicity refers to the potential of biological, chemical or physical stressors to affect ecosystems (kg 1,4-dichlorobenzene eq (DB_{eq}) per year). Such stressors might occur in the natural environment at densities, concentrations or levels high enough to disrupt the natural biochemistry, physiology, behaviour and interactions of the living organisms in the ecosystem.
  - Fresh water aquatic ecotoxicity minimization
  - Marine aquatic ecotoxicity minimization
  - Terrestrial ecotoxicity minimization
- Human toxicity minimization, %

  Human toxicity potential (kg 1,4-dichlorobenzene eq (DB_{eq}) per year) is calculated by adding the releases which are toxic to humans in air, water and soil.
- Biodiversity preservation

  Biodiversity is a measure of the health of ecosystems and refers to the degree of variation of life forms within ecosystems, eg. bird index may be used to define relative changes in the population of individual bird species in specific locations (Hak et al., 2012). Pressures on biodiversity can be physical (eg. habitat alteration and fragmentation through changes in land use and land cover conversions), chemical (eg. pollution from human activities) or biological (eg. alteration of population dynamics and species structure) (OECD, 2001).
- Global warming mitigation, %

  Global warming potential (GWP) (kg CO_{2eq} per year) is calculated as the sum of emissions of the greenhouse gases (CO_2, N_2O, CH_4 and volatile organic compounds) multiplied by their respective GWP factors. The values of GWP depend on the time horizon over which the global warming effect is assessed. GWP factors for short periods (20 and 50 years) provide an indication of the short-term effects of greenhouse gases on the climate, while GWP for longer periods (100 and 500 years) are used to predict the cumulative effects of these gases on the global climate. Burning of fossil fuels is a major contributor to a number of environmental problems such as global warming, eutrophication, acidification etc.

- Eutrophication minimization, %

  Eutrophication potential (kg PO_{4eq} per year) is defined as the potential to cause over-fertilization of water and soil, which can result in increased growth of biomass.

- Acidification minimization, %

  Acidification potential (kg SO_{2eq} per year) is based on the contributions of SO_2, NO_x, HCl, NH_3 and HF to the potential acid deposition, i.e. on their potential to form H^+.

- Ozone depletion minimization, %

  The ozone depletion potential (kg $CFC11_{eq}$ per year) indicates the potential of emissions of chlorofluorohydrocarbons (CFCs) and chlorinated hydrocarbons (HCs) for depleting the ozone layer. The release of certain man-made substances containing chlorine and bromine into the atmosphere endangers the stratospheric ozone layer, which shields the earth's surface from ultraviolet radiation. The depletion of the ozone layer has major effects on sustainable development due to the impacts of increased UV-B radiation on human health, crop yields and the natural environment (OECD, 2001).

- Global energy depletion minimization, %

  - Non-renewable energy depletion minimization, eg. fossil fuel (toe), mineral fertilizers (kg/ha of farmland), pesticides (kg/ha of farmland)
  - Renewable energy depletion minimization, eg. % of total available renewable freshwater resources

- Water consumption minimization, m^3/y

- Cultivated land requirement minimization, %

  Involves the management and modification of natural environment into cultivated areas, pastures and settlements (cultivated hectares).

- Crop yield increase, %

  In agriculture, the crop yield is a measure of the grains or dry matter quantity per unit of cultivated land and is usually expressed in kilograms (or ton) per hectare. Crop yield is affected by various factors such as temperature, water, oxygen and available light.

- Photochemical oxidation minimization, %

  A common photochemical oxidation example is photochemical smog caused by the reaction of hydrocarbons and NO_x under the effect of UV light (units kg C_2H_{4eq}/y).

- Radioactivity minimization, %

  The level of radioactivity is estimated by the detection of objects, foodstuffs and construction materials contaminated by radioactive elements (Bq/m^3 waste).

- Odours minimization

  Refers to the unpleasant smells caused usually by volatile chemical compounds, such as in the case of disposal of olive mill wastewaters in lagoons, streams, lakes etc.

- Noise minimization %

  Refers to excessive, displeasing human, animal or machine-created environmental noise that disrupts the activity or balance of human or animal life (units dB).

3.3 Economical indicators

- Capital investment cost, €

  The cost necessary for the implementation of a treatment technology is known as capital investment cost. This investment can be made through in-house capital, credit from financing agencies and suppliers. The total capital required for the implementation of a technology is composed of two parts: *a) fixed capital*, which is the cost needed for the construction of a processing plant with auxiliary services (mainly refers to the cost of all the assets of a plant eg. machinery, buildings, equipment and auxiliary installations etc.) and *b) working capital*, which includes the capital resources necessary for the installation and operation of a plant according to the technical and economic studies. Capital investment cost varies within very wide limits, depending on the market for which the products are intended, the characteristics of the process and the availability of raw materials (FAO, 1995).

- Operating (production) cost, €/m^3 treated waste

  Includes the expenses necessary for the plant operation, eg. electricity, fuel and water supply. In a healthy company the difference between income (from sales and other sources) and operating cost indicates the gross profit (FAO, 1995).

  - Management cost (€/y), includes management and administrative cost for the implementation of a technology
  - Transport cost (€/m^3 treated waste)
  - Waste treatment cost (€/m^3 treated waste)
  - Disposal cost (€/m^3 treated waste)

- Payback period, y

  Is the estimated time needed for the revenues and other economic benefits to recover the initial investment and stated rate of return.

- Direct revenues, $€\cdot t^{-1}\cdot y^{-1}$

  By-products from agricultural activities could improve rural economies e.g. sale of compost, pellets and briquettes from OMW residues etc.

- Indirect revenues, $€\cdot ha^{-1}\cdot y^{-1}$

  e.g. savings due to use of compost instead of chemical fertilizers

- Contribution to sectoral growth and Gross Domestic Product, %

3.4 Socio-cultural indicators

- Compliance with relevant environmental legislation, %
- Public acceptance of treatment technology, %

  In different cultures, people have a different perception of waste and management, thus innovative management concepts may encounter socio–cultural difficulties during their implementation.

- Public behaviour including awareness, participation and responsibility, %
- Compatibility with institutional requirements, %

  Different wastewater treatment systems require different regulations and control mechanisms. These requirements should fit in the existing institutional infrastructure of the country or region (Balkema et al., 2002).

- Employment growth and development, %

  Employment indicators reflect the overall health of an economy or business cycle, eg. creation of new jobs

- Expertise of personnel, high/medium/low

  The application of a technology may require a certain level of expertise for installation and operation. If the expertise is not locally available it may be gained through import or training (Balkema et al., 2002).

- Socio-economic risk, high/medium/low

  e.g. limiting farmers' independence and welfare

- Equity concern (high/medium/low)

  Involves policies, practices and programs pertinent to AW management that may raise legitimate concerns about equity.

- Modernization level, high/medium/low

4. Evaluation of AW treatment technologies

4.1 General issues

The efficiency and potential use of a treatment technology in agriculture may be evaluated by taking into consideration various parameters such as the quality and quantity of the final products, the environmental benefits, the cost for the implementation of the technology as well as the public acceptance of the technology and various other socio-cultural parameters. Also, a complete evaluation should ensure the compatibility of the technology with related physical and functional requirements, such as the life cycle of the products, effectiveness, reliability and recyclability (Fabrycky and Blanchard 1991; Asiedu and Gu, 1998).

The interaction between technology and environment is shown in Figure 1, where functional criteria should be fulfilled so that the technology complies with the end user demands. During the implementation of a technology, the physical, economic, social and cultural environments are affected. For example, when raw materials are extracted from the physical environment, capital and labour are related to the economic environment to which benefits return, while socio-cultural environments are affected by compliance with legislation and public acceptance of the technology. As far as cost is concerned, the estimated accuracy is very essential for the sustainability of a technology as well as for external (e.g. contract bidding) and internal use (e.g. cost control, budgeting). When the cost estimation for a treatment technology is unrealistically low (underestimated) or high (overestimated), financial loss and risk may occur (Daschbach and Apgar, 1988).

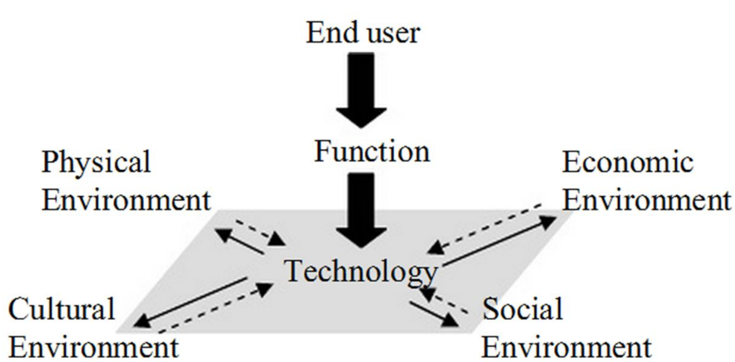

Figure 1. Interaction between technology and environment (Balkema et al, 2000)

In order to select the best or most suitable treatment technologies, adequate data/information and a well structured decision making process are required. All important aspects, such as the technology itself, the input material, the output of the technology, the recovery process, the disposal of wastes etc. should be taken into consideration.

For example, in Germany, two different methodologies - the UVP (Environmental Impact Assessment) and the EPA (Environmental Profile Analysis) - have been developed in order to evaluate products, production processes and technical facilities in terms of their environmental effects; comparison between waste treatment technologies may be also carried out. The UVP includes the investigation, description and evaluation of the effects of a technology on humans, animals, plants, soil, water, air, climate and landscape. The scientific evaluation is carried out based on standards according to environmental laws and guidelines; when no standards exist, an efficient system to allow the evaluation of the effects should be developed. The EPA methodology aims to detect and evaluate the impacts on the environment during the life-cycle of the products by identifying the flow of mass and energy; environmental adverse effects are also taken into consideration (Schunke and Mabin, 1999).

4.2 Weighted indicators

In order to evaluate the technologies considered for the treatment of AW in the frame of WasteReuse, data available regarding the efficiency of each treatment technology, total cost, environmental benefits such as contribution to the minimization of surface- and groundwater contamination as well as socio-cultural aspects and compliance with relevant environmental legislation, were taken into consideration. Indicators discussed in section 3 were weighted using a scale between 1 and 5 according to Table 3. Where no data is available, mainly for older technologies or for ongoing projects, no values were assigned. It is mentioned that an evaluation scale between -3 and +3, was initially proposed according to the methodology of Action 2. However, it is believed that it is quite risky to assign negative values for indicators since, in several cases, limited data are available.

Table 3. Scale corresponding to % improvement of the respective indicator

Scale	*% improvement of the respective indicator*
1	<10
2	11-30
3	31-50
4	51-75
5	75-100

For the evaluation of the technologies four different scenarios were considered, as seen in Table 4. According to scenario 1, all indicators are equally weighted by 25% each. In scenarios 2-4 various weight percentages are considered. Technical indicators which significantly contribute to the evaluation of the AW treatment technologies in order to assess the suitability of treated AW for crop cultivation are weighted by the highest percentages of 30 and 40% in scenarios 2 and 3, respectively. Economical indicators are weighted by the highest percentage of 40% in scenario 4. Socio-cultural indicators are represented by the lowest weight 10-20% in scenarios 2-4.

Table 4. The four different weighted scenarios considered for the evaluation of AW treatment technologies

% weight for indicators	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*
Technical (W_T)	25	30	40	20
Environmental (W_E)	25	30	20	30
Economical (W_F)	25	30	20	40
Socio-cultural (W_S)	25	10	20	10

The total evaluation score (R) was obtained after assigning values between 1 to 5, to all indicators, according to the following equation [1]:

$$R = 100 * \left(W_T * \frac{\Sigma(W_{Tij} * T_{ij})}{\Sigma T_{i(max)}} + W_E * \frac{\Sigma(W_{Eij} * E_{ij})}{\Sigma E_{i(max)}} + W_F * \frac{\Sigma(W_{Fij} * F_{ij})}{\Sigma F_{i(max)}} + W_S * \frac{\Sigma(W_{Sij} * S_{ij})}{\Sigma S_{i(max)}}\right) \quad [1]$$

where W_T, W_E, W_F, W_S is the % weight used for technical, environmental, economical and socio-cultural indicators, respectively, according to scenarios 1-4 shown in Table 4; W_{Tij}, W_{Eij}, W_{Fij}, W_{Sij} is the % weight used for each indicator (eg. by-products production) and sub-indicator (eg. compost, treated liquid for irrigation); T_{ij}, E_{ij}, F_{ij}, S_{ij} is the value between 1 and 5 assigned for each indicator and sub-indicator; $T_{i(max)}$, $E_{i(max)}$, $F_{i(max)}$, $S_{i(max)}$ is the maximum value assigned for each indicator, ie. 5 in the present study.

4.3 Best AW treatment technologies

The best technologies were selected as shown in Table 5, for the treatment of OMW, wine, swine, other animal waste, rice straw and various other AW (10 out of 20, 2 out of 4, 3 out of 7, 3 out of 7, 2 out of 2 and 3 out of 9, respectively). Evaluation scores based on scenarios 1-4 are also shown in Table 5 and correspond to % improvement obtained by each technology compared to the worst scenario of no AW treatment implementation. It is seen that the ranking varies according to the objective of each technology eg. treatment of waste for irrigation, compost or energy production, safe disposal etc.

Lower evaluation scores were obtained for the other AW treatment technologies (not shown in Table 5) since their objectives were not related to the scope of WasteReuse (eg. production of material for animal feed) or for ongoing projects for which results are not yet provided or no data is available (eg. no website is active). Table I in Annex I, shows score for each weighted scenario 1 to 4 for all available technologies for AW treatment grouped by type of waste.

In the following sections 4.3.1 – 4.3.6 a short description of the best treatment technologies per waste is provided.

4.3.1 Olive mill waste

ENVIFriendly project aimed at the development of environment friendly technologies to minimize diffuse pollution and treat wastewater and solid waste from local production of olive oil as well as orange juice. The technology is implemented in three stages: 1) OMW filtration and degradation by phyto-remediation using poplar trees, 2) liming for solid/liquid (S/L) separation, 3) electrolysis of OMW and orange juice wastewater (OJW). Treated OMW was applied on agricultural land (irrigation of crops and subsurface disposal in a field with poplar trees) and the solid part was composted. The technology may be transferred in other parts of Greece or in other countries; contamination of soil, surface- and groundwater could be substantially reduced and river ecology could be greatly improved with significant indirect economic benefits for the olive mill owners due to the long-term sustainability of their operation.

Table 5. Best technologies for AW treatment grouped by waste type

Waste	*Project acronym*	*Evaluation score % based on scenario 1*	*Evaluation score % based on scenario 2*	*Evaluation score % based on scenario 3*	*Evaluation score % based on scenario 4*
OMW	ENVIFriendly	58.1	62.3	70.5	55.8
	OLEICO	47.0	49.7	57.6	41.1
	Eco Olive Cleaner	48.1	50.3	54.5	46.9
	NAIAS	42.8	47.7	48.7	45.3
	PROSODOL	41.1	45.7	50.8	40.2
	OLIVEWASTE	37.5	39.8	44.6	35.5
	TIRSAVplus	38.2	39.2	45.2	34.9
	RESOLIVE	33.5	36.5	38.1	34.2
	WAWAROMED	32.5	36.7	40.9	30.7
	TIRSAV	40.1	44.4	49.4	40.1
Wine waste	DIONYSOS	39.9	42.6	43.2	41.8
	GRAPE TANNINS	31.1	32.8	32.9	31.5
Swine waste	Ecodiptera	35.2	38.5	42.8	32.5
	ZNP	30.7	32.4	37.9	26.5
	PIGS	29.8	33.5	37.1	28.9
Other animal waste	DUCK SLURRY	30.8	33.2	37.3	29.5
	ECOREGA	27.7	31.0	34.8	26.3
	ENERWASTE	24.5	26.4	25.4	27.1
Rice straw	ECORICE	31.3	33.9	41.1	26.4
	BIOCOMPOST	28.9	30.9	36.4	25.4
Various other AW	ECOFILTER	39.8	44.9	51.9	37.1
	INTER-WASTE	35.4	38.8	46.3	31.5
	INTEGRASTE	30.3	32.6	34.2	30.9

The *OLEICO* project designed and established a demonstration plant which uses a cost-effective and innovative approach for OMW management. A quite simple technology was involved, using the natural treatment technique of phyto-depuration; this process is based on the interaction between plants, soil and micro-organisms. A pilot plant was successfully constructed in the area of an Italian olive oil mill and the technique was granted a European patent (No EP1216963, 2002). Main environmental benefits include low energy consumption due to OMW pumping, no adverse impact on the landscape where poplars may fit, no sludge and odours generation. In the case of phyto-depuration, little energy is required, medium investment cost as well as limited disposal, construction and management cost is foreseen.

Eco Olive Cleaner technology was developed in North Greece by an individual olive oil mill owner and achieved S/L separation by using a vibrating sieving system during primary oil production. Solids are removed by 99% along with the oil produced and no chemicals are added. Clean coloured wastewater without solids and oils is produced and can be reused in the decanter or for irrigation. Removal of solids enhances evaporation after land disposal as well as eliminates problems due to high organic load and oil content. In addition, soil permeability decreases and no odours are expected after disposal. Since 2007, Eco Olive Cleaner technology is patented (Patent No 1007252, Industrial Property Organization, 2011) and used in industrial scale in Averis olive oil mill in North Greece.

The objective of *NAIAS* was to select integrated olive mill wastewater management systems and set up pilot plants for three olive mills in Lesvos island, Greece. The OMW management system is a phase separation tank (PST), where OMW remain for five days and is separated into three fractions by natural settling. The light fraction (floating grease and oils) is periodically removed from the PST and returns to the olive mill to obtain a low quality industrial olive oil. The middle fraction is applied to land (subsoil infiltration field or evaporation ponds), whereas the heavy fraction (settled sludge) is periodically removed and disposed of in deep anaerobic pits. This wastewater management system was approved by the Department of the Environment (Local Authority of Lesvos Prefecture) which granted operating permits to the participating olive mills. Environmental benefits include decreased sludge volume production, spreading of the digested sludge on non-cultivated lands (for safety reasons) and even on cultivated fields (olive groves, vineyards etc.) as soil enhancer/organic fertilizer and recycling of the decanter water. The total investment cost is estimated at 72.000-140.000 € and the operating cost at 2.000-4.000 €/y (for the production of approximately 3.000 m^3 of OMW/y).

The *PROSODOL* project aims to develop and implement protective/remedial technologies that can be used to remove or significantly limit the presence of pollutants or other stressing factors in soils and water bodies affected, directly or indirectly, by the disposal of OMW. Technologies being tested/applied include bioremediation and use of low-cost porous materials as soil additives. Also, prior to waste disposal, a waste pre-treatment methodology using low-cost additives, is being developed in order to reduce some of the toxic load and thus, enhance the efficiency of soil remedial/protective techniques that follow. Composting techniques with low operating and production cost, that can be applied by individuals in their own disposal lands are being developed and implemented in field scale. The design and implementation of a monitoring system to assess soil and water quality at areas where disposal of untreated OMW takes place for many years, aims to develop methodologies and procedures suitable to identify soil/water quality parameters and extent of pollution over time as well as to provide national authorities with an effective monitoring tool for eliminating environmental risks. Pilot scale tests are being carried out in the Municipality of Rethymno, Crete, Greece and in Liguria Region, Italy.

The *OLIVEWASTE* main goal was to demonstrate the environmental advantages, as well as the economic and technical viability of a new system for treating waste from olive oil production. This innovation was based on the implementation of a treatment process involving the three following phases: 1) accelerated S/L separation, 2) evaporation-condensation and 3) final treatment of water. After treatment three main by-products are obtained: clean water for irrigation, solid and liquid organic fertilizers. A pilot plant, located in the municipality of Baena, Córdoba, Spain, was built primarily to process waste from the '3-Phase' olive oil production; also a new treatment system was adapted for wastes generated by '2-Phase' olive oil production. Environmental benefits include among others self-supply of energy, biomass availability and reduction of toxic components (benzopyrens) due to decreased temperature for drying the solid waste in the plant. Liquid waste treatment cost is estimated at 4.42 €/t of olives, while total benefit is estimated at 6.53 €/t of olives due to income anticipated from sale of solid and liquid fertilizers.

The *TIRSAVplus* project, based on the results of TIRSAV project (see below), addresses the issue of cost-effectiveness of an innovative technology at oil-mill level through planning and construction of a centralized recycling pilot plant. The unit will also be able to recycle other organic wastes to produce organic fertilizers that are easy to use and acceptable by farmers. Finally, the project will promote the harmonization of legislation at European level regarding the oil-mill wastes.

The *RESOLIVE* project, explored various processes such as solar distillation, composting etc. to treat olive mill residues. The project aimed at defining the needs for the implementation of renewable energy solutions in olive oil industry and test in practice their performance; to create a comprehensive set of guidelines that will advice olive oil producers to select best available renewable energy technologies; to summarize the existing knowledge in olive waste valorisation and transfer this knowledge to its end users supporting them for further implementation. An increase of the sustainability of European olive oil sector is anticipated by implementing solutions which result in valorization of its waste. Also a prototype gasification system combined with a 30 kW microturbine was build and operated in pilot scale, for biogas production.

The *WAWAROMED* project aimed at developing a concept for the efficient and cost effective treatment of OMW in Mediterranean countries. Purification methods are adapted to the regional climatic conditions and optimized in order to ensure reduction of toxic load below acceptable limits with low investment and operating cost. OMW was treated aerobically and anaerobically. A new biological sedimenter, which combines the advantages of aerobic and anaerobic treatment was developed and resulted in good removal rates for COD and phenolic compounds. Diluted treated wastewater was used for irrigation of plants that absorbed all nutrients from wastewater, while the solids were concentrated at their roots operating as natural filters. In anaerobically treated OMW using the “Epuvalisation technology” the reduction of COD reached 98%, after 5-9 days of effluent circulation mainly due to sludge settlement. Treated waste may be reused for irrigation or as a fertilizer in agriculture and for direct plant production. The separated solid residuals may be used as biomass (valorization of waste). A treatment pilot plant was constructed in an olive mill in the municipality of Mousouron, Crete, Greece and treated wastewater was reused in agriculture.

The aim of the *TIRSAV* project was to significantly reduce the environmental impact of the disposal of olive mill processing by-products by developing a co-blending strategy to combine, in a recycling plant, olive oil wastewaters, fresh olive pomace and other natural organic by-products. The final products (integrated use of different bio-wastes from the agro-food industry and agricultural production), comply with the reference limits set by Italian regulations for simple vegetal non-composted amendments or for mixed composted amendments (Law 748/84) or for Organic Agriculture (Reg 2092/91 and MiPAF Circular n. 8 of 13 September 1999). The beneficiaries have carried out a cost/benefit analysis regarding the plant and 12 scenarios were taken into account; results have shown that considerable increase in profits can be obtained through only slight variations in the price of the compost. The TIRSAV technology has been patented (patent number RM2004A000084 “Method and apparatus for olive mill residues treatment”).

4.3.2 Wine waste

The overall goal of *DIONYSOS* project was the development of an economically feasible process for the integrated management of the waste generated by the winemaking industry in Greece. The treatment system consists of the following four main successive individual steps: a) extraction-filtration of grape pomace, b) selective adsorption of polyphenols through a series of resins, c) thermal treatment-solvent recovery and d) purification of resveratrol by FCPC (Fast Centrifugal Partition Chromatography). The implementation of the technology results in the production of enriched polyphenolic extract (1 kg per 100 kg of grape pomace) and pure polyphenols (eg. resveratrol) to be used as raw material in various applications such as production of medicines, cosmetics, food supplements etc. Also high nutritional value animal food and natural organic fertilizer (compost) are produced. Phenols recovery procedure is environment friendly, while compost produced may be used to enrich soil with organic matter, increase its water holding capacity as well as the capacity for nutrient absorbency and assimilation. Also soil aeration is improved, soil erosion and need for chemical fertilization is decreased. A prototype composting unit has been installed in the Agricultural University of Athens and a pilot plant for the treatment of winery waste was designed, installed and operated. The capital cost for a treatment of 2,500 kg of winery wastes per day is approximately 1,100,000 € (construction cost is not included) while the operating cost per month is estimated at 53,000 €. Considering that mean polyphenols concentration is ranging between 7-10 g/kg and the market price for selling the final extract is estimated to be 0.5-1 €/g, it is estimated that the total depreciation of the central unit equipment can be achieved within the first nine years of operation.

The aim of the *GRAPE TANNINS* project was to minimize deforestation of some species of trees, such as quebracho, mimose, chestnut, mirabolan, valonea and tara and replace vegetable tanning agents, extracted from these species and are commonly used in leather tanning, by a wine tanning extract which is obtained from wine waste. In order to extract tannins in aqueous medium, the oil content was removed from crushed pips with hexane, tannin extraction took place in autoclave and thereafter tannin content was analyzed by the filter-bell method. The developed process is environment friendly due to contribution to the reduction of excess of wine waste, valorization of a low profitable by-product, minimization of deforestation of some tree species as well as reduction of energetic cost necessary for the concentration of vegetable tannins. A semi-industrial prototype was built for the production of adequate quantities of “grape” tannin for industrial trials in two participating tanneries. This demonstration prototype includes an extraction plant, a concentration plant (including an ultrafiltration section and a nanofiltration section with four membranes) as well as a wastewater treatment plant. According to beneficiaries’ economical evaluation of the process (obtaining tannins at industrial scale), the system would produce a grape tannin extract with 35% dry matter content at a cost of approximately 450 €/t, which is competitive with the current price of commercial tannins. This cost would be reasonable if the process is implemented in an industrial scale for grape waste in the most important European wine-producing countries (France, Italy and Spain).

4.3.3 Swine waste

The main objective of *Ecodiptera* project was to demonstrate a novel method of treating pig manure using selected species and varieties of diptera order flies in their larval stage. The treatment methodology consists of the following phases: a) transfer of pig manure from the farm, b) pre-treatment, c) mass-rearing fly larvae phase and d) biodegradation phase. A completely stabilized, non-polluting substance was obtained as an end product with great potential for use in agriculture as a high-quality fertilizer, complying with European legislation. Application of treated waste to corn and sunflower crops showed results comparable with four commercial fertilizers, eg. intensified growth and positive influence on the phytomass weight. A prototype plant was built in Slovakia (the technology for mass-rearing Diptera flies was developed in a semi-industrial test) and a pilot plant in Valencia, Spain (a pilot biodegradation plan for pig manure was established on a semi-industrial scale in a pig farming area). Environmental benefits include minimization of surface- and groundwater contamination (the nitrogen content of the pig manure is reduced to 2.45%), minimization of offensive odours and risk of transferring diseases, control of fly proliferation in municipalities, reduction in electricity consumption during treatment as well as of CO_2 emissions and fuel consumption. Biodegradation cost is estimated according to beneficiaries at 10 €/t, which is higher compared to the cost of systems in use (3 €/t) involving direct application of pig manure in the field. It could be though reduced by mechanizing various stages of the process and revaluing the by-products obtained.

The *ZNP* project aimed to develop and demonstrate a pig slurry management approach through combination of several existing techniques into a single system, according to the following phases: a) fresh slurry management, b) preliminary S/L separation by centrifuge, c) biological treatment by activated sludge and d) composting system using centrifuge residue. The ZNP process adapts well to European climate, while the flushing system does not require intensive technical and maintenance support, thus the technology may have good transferable benefits throughout Europe and for different livestock producers. Using the ZNP system, suspended solids and total chemical oxygen demand are eliminated by 100 and 95%, respectively, nitrogen is transformed into nitrates by 94% and greenhouse gases and atmospheric pollution are mitigated. It is also estimated that widespread use of the new treatment technology in France could reduce national ammonia emissions from pig production by approximately 18,000 t per year (currently around 60,000 t) as well as water consumption providing savings up to 40% compared with conventional systems. A prototype was installed in the experimental station at Guernévez, in Finistère (France). Total cost for manure treatment is estimated at 15-19 €/m^3 and is expected to be reduced significantly by technical adaptations in future commercialized versions.

The *PIGS* projects' objectives include the development and implementation of a set of instruments, tools and best practices for the management and treatment of solid and liquid wastes from pig farms as well as study of the viability of composting process. The solid part of waste may be re-used and recycled for compost production along with green waste and the solid part of urban waste. Main environmental benefits include long-term protection of groundwater and improvement of their quality, minimization of noise levels and odours, re-use and recycling of material through composting, minimization of pig farm waste production and discharge, water savings in pig farms, potential for transferability and reproduction of tools and instruments developed (eg. Local Pig-Farming Regulation etc.)

4.3.4 Other animal waste

The aim of the *DUCK SLURRY* project was to develop a sustainable, cost-effective methodology for the treatment of duck slurry into a solid fertilizer thus eliminating environmental problems. Duck slurry treatment involves maceration and homogenization of waste, S/L separation, drying of the solid, dissolved air flotation and anaerobic digestion of the dewatered liquid blend, capture and utilization of biogas and safe discharge of the effluent. The methodology is implemented in Silver Hill Foods, a fully integrated family owned Duck Company in Ireland, which produces approximately 3 million ducks a year and around 80,000 t of duck slurry. Prior to the LIFE project, waste was spread on agricultural land, with obvious implications on nitrate loading and leaching and associated high transport cost. The biogas produced after anaerobic digestion of slurry can be used to heat and run the plant. Also, the long-term sustainability of the process reduces the disposal cost which severely inhibits the beneficiary's competitiveness on a global market.

The aim of *ECOREGA* project is to demonstrate good practices in the management of agricultural organic waste that can contribute to the reduction of the environmental impact of cattle farms and reduce their greenhouse gas emissions. An innovative system is proposed for mixing liquid manure from cattle farms with other types of organic waste (swine, bird) to produce a natural fertilizer (compost) and methane. The cattle waste management methodology will be adopted by farms of Galicia, Extremadura and other regions in Spain. Environmental benefits include greenhouse gas emissions minimization as well as elimination of the use of inorganic or synthetic fertilizers at the farms.

The objective of the *ENERWASTE* project was to improve the management of slaughterhouse waste through anaerobic digestion which is a process very similar to the one taking place in the digestive track of the animals. After treatment biogas and fertilizer are generated. It is mentioned that 38,820 Nm^3/y of natural gas are substituted by biogas at MFN (coordinator premises), while 1,800,000 kWhe/y are produced avoiding the use of fossil fuels thus reducing CO_2 emissions by 370,000 kg every year. Income foreseen, not including self supply income, is estimated at ~108,000 €/year (0.06 €/kWh). It is also noted that a cost of 10 €/t is required for the treatment of waste in a biogas plant compared to 33 €/t required for its disposal.

4.3.5 Rice straw

For the treatment of rice straw only two LIFE projects have been funded within European Funding schemes (ECORICE and BIOCOMPOST); methodology developed in BIOCOMPOST was used in ECORICE.

The objective of the *ECORICE* project was to eliminate air pollution caused by rice straw incineration in the area of Albufera Nature Reserve, Spain, using the methodology proposed in BIOCOMPOST project (see below). 1,350 t of rice straw were collected from the fields of the Valencia municipality and prototypes developed by BIOCOMPOST were used to store the straw, which was then transferred to the centre for waste reuse and recycling (straw blankets production). The use of straw to make blankets or rolls is a simple and economic method of stabilizing land, by establishing a cover or substratum to enhance vegetation growth and retain ground humidity. Results from the application of the straw blankets in pilot-site fields showed that the agronomic yield of the area was improved. The ECORICE technique may be adopted and developed by rice farmers elsewhere in Spain and across Europe or transferred to other agricultural sectors. Also contributes to the reduction of greenhouse gas emissions by 74.6 t CO_2/y by avoiding the burning of 1,350 t of rice straw, to the saving of water and increase of arid crop yield through the use of straw blankets as well as to the improvement of public acceptability regarding traditional rice cultivation.

The *BIOCOMPOST* project aimed to establish an operating system for collecting rice straw. Two treatment methodologies were proposed: a) mixing of rice stalks with organic material and composting in heaps, b) grinding of rice stalks and mixing with sludge, organic material and pruning waste and finally composting in silos. The gathering system has been demonstrated for the removal of rice stalks from fields in regions characterized by swampy cultivations or cultivations where flooding occurs. The stalks gathered were used for composting (pilot scale) in the Waste Treatment Plant FERVASA (Quart de Poblet, Spain). Using the BIOCOMPOST process, sustainable solution to the problems of incineration of rice straw after harvesting (reducing the smoke produced) and of the direct application of the muds in agricultural land (contributing to the protection and improved management of resources in the area of Valencia) is achieved. The high cost for gathering of rice straw is an issue to be solved.

4.3.6 Various agricultural waste

The *ECOFILTER* project developed an environment friendly technology for composting in the agricultural sector. Composting steps include: a) pre-wetting and pre-fermentation of the mixture (horse or chicken manure, straw, water and gypsum etc.) in completely closed and floor aerated indoor tunnels, b) pasteurization of compost in tunnels, c) the spawn runs through the compost. The innovation of the project is the implementation of a closed technology, by which smell and ammonia emissions can be reduced by 95% (no addition of chemicals) while the efficiency of the technology, may be still improved. Environmental benefits include the production of environment friendly compost (I, II and III phases), energy-saving as well as recycling of the water used, avoiding leakage on soil through management and fermentation of the raw materials on concrete surface. The technology is implemented in the coordinator's facilities (Bio-Fingi Mushroom growing & Compost producer Ltd), where 3 indoor tunnels, a pipe- system to collect and remove air, an integrated bio-filter and bio-washer were constructed.

The *INTER-WASTE* project is focusing on the development and demonstration of a sustainable conversion technology for the management of biodegradable organic waste and wastewater through the construction of an innovative integrated Membrane Bioreactor System (MBR) based on anaerobic process. The proposed MBR system which will be able to treat at least 1 m^3/d of wastewater, consists of the following components: (1) Aerobic reactor for the oxidation of the organic matter and nitrification (i.e. conversion of ammonium to nitrate), (2) anoxic reactor for the denitrification process (ie. the conversion of nitrate to gaseous nitrogen) and (3) membrane tank where the filtration process will take place for the separation of the final effluent from the sludge.

The biogas obtained is scrubbed to obtain pipeline quality gas. After digestion is completed, the residue slurry is removed, the water content is filtered out and re-circulated to the digester and the filter cake is treated aerobically to form compost. Environmental benefits include energy gain for different types of feedstock, assessment and minimization of the environmental impact of the process (GHG emissions) and reduction of chemical fertilizers usage. All these result in protection of sensitive water bodies from eutrophication, adoption of the priorities of the EU concerning the recovery and reuse of materials as well as utilization of waste for energy production (waste-to-energy) and minimization of energy loss through electricity transportation to distant locations.

The *INTEGRASTE* project, has as main objective to utilize and manage agro-wastes (agricultural plant residues) and agro-industrial wastes (eg. from olive mills, piggeries etc.) and develop a facility for the management of AW in Achaia region, Greece, using anaerobic digestion to produce electrical and thermal energy as well as compost for crops fertilization and valorization of the residuals. Anaerobic digestion has a great number of advantages such as 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. In the frame of INTEGRASTE project, an existing pilot plant built at the Industrial Zone of Patras, Greece, was upgraded for the treatment of both liquid AW (existing process) and solid AW (enhanced process). Total investment cost is estimated at 5.008.775 €, total operating and maintenance cost at 630.000 €/year, total revenues from exploitation of energy and materials at 2.190.030 €/year (in case of subsidy) while the payback period will be 3-4 years, according to a preliminary cost analysis for the management of around 105.000 t waste/year.

5. Conclusion

In the present deliverable, AW treatment technologies mainly funded by Framework Programs of the European Commission and also developed by private funding, were evaluated based on available data and according to selected technical, environmental, economical and socio-cultural indicators, using a scale between 1 and 5. Four different weighted scenarios were also considered.

According to the evaluation score obtained after considering the different scenarios, the best AW treatment technologies were selected for OMW, wine, swine and other animal waste, rice straw and various other AW eg. waste from handling of fruits and vegetables, chicken manure, wheat straw etc. (10 out of 20, 2 out of 4, 3 out of 7, 3 out of 7, 2 out of 2 and 3 out of 9, respectively). It is mentioned that when scenarios 1-4 are considered the ranking varies according to the objective of each technology eg. treatment of waste for irrigation, compost or energy production, safe disposal etc.

All these technologies are being considered by the responsible Beneficiaries of Actions 3 and 4 (CEBAS-CSIC, CCIAA and CERSAA) for the evaluation of treated and untreated waste to be used in lab experiments and therefore the assessment of their suitability to improve crop production and quality as well as the identification of the potential effects on soil properties.

ENVIFriendly, *OLEICO* and *Eco Olive Cleaner* have focused on the development of environment friendly and innovative technologies for OMW management and also minimization of water and soil contamination. The goal of *DIONYSOS* and *GRAPE TANNINS* was the development of economically feasible processes for the integrated management of wine waste as well as for the valorization of by-products such as polyphenols. *Ecodiptera*, *ZNP* and *PIGS* have demonstrated methods for the treatment of solid and liquid swine waste and the production of stabilized end products. *DUCK SLURRY*, *ECOREGA* and *ENERWASTE* have demonstrated good practices for the treatment of various other animal waste including duck slurry, cattle and slaughterhouse waste mainly for the production of fertilizers or energy. For the treatment of rice straw only two LIFE projects have been funded (*ECORICE* and *BIOCOMPOST*) aiming to eliminate air pollution caused by rice straw incineration. *ECOFILTER, INTER-WASTE* and *INTEGRASTE* focus on the treatment of various AW such as waste from handling of fruits and vegetables, wheat straw etc. usually for the production of compost.

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ANNEX I

Table I. Evaluation score based on scenarios 1-4 for all available technologies for AW treatment grouped by type of waste

Waste	Project (Acronym)	Coord. country	Technology	Level of development	Implementation of technology	Output	Cost	Environmental impacts	Score based on scenario 1	Score based on scenario 2	Score based on scenario 3	Score based on scenario 4
						Olive oil mill wastes (OMW)						
OMW & OJW	Environmental Friendly Technologies for Rural Development (ENVIFriendly)	GR	Three stages 1) OMW filtration and degradation by phyto-remediation using poplar trees, 2) liming for S/L separation, treated OMW to be used on agricultural land (irrigation of crops and subsurface disposal in a field with poplar trees), 3) electrolysis of OMW and OJW.	Pilot	–	Treated OMW for irrigation of crops (corn and maize field), composting of solid phase	–	Treatment technology may be transferred in other parts of Greece or other countries; pollution could be substantially reduced and river ecology could be greatly improved with significant indirect economic benefits to the olive mill owners due to the long-term sustainability of their operation.	58.1	62.3	70.5	55.8
OMW	A new application of phytodepuration as a treatment for the olive mill waste water disposal (OLEICO)	IT	Phyto-depuration technique: a) excavation, water proofing, placement of draining layer, planting of trees b) transfer of OMW using a hydraulic network and degradation through aerobic/ anaerobic processes.	Pilot	Implementation in an Italian olive oil mill	Treated OMW	Medium investment cost, limited disposal, construction and management cost	Low energy consumption mainly due to OMW pumping; no adverse impact on the landscape where poplars may be planted; no sludge or odour generation; health benefits for people; 30 organizations are interested in introducing similar systems e.g for farm, food or wine wastes.	47.0	49.7	57.6	41.1
OMW	Eco Olive Cleaner	GR	Separation of solid phase (olive paste) and wastewater by using a vibrating sieving system during primary oil production	Full	Industrial scale at Averis olive oil mill in North Greece	Clean coloured wastewater for reuse in the decanter or for irrigation; solid phase is considered as natural fertilizer	No transport cost, low purchase cost	Water demand during oil production can be decreased by 50% due to wastewater reuse in the decanter. Also, wastewater with minimum oil content is disposed in lagoons and no solid phase is collected at the bottom of lagoons eliminating thus odours and enhancing evaporation process. Solid phase is considered as natural fertilizer (the phytotoxicity of polyphenols must be tested though).	48.1	50.3	54.5	46.9

OMW	Innovative Olive Mill Waste Management Systems (NAIAS)	GR	The OMW management system involves a Phase Separation Tank (PST), where wastewater remains for five days and separated into three fractions (light, middle and heavy) by natural settling	Pilot	Three wastewater management pilot plants were constructed in three olive mills in Lesvos island, Greece	Low quality industrial olive oil (light fraction), soil enhancer/organic fertilizer (middle fraction)	Total investment cost is estimated at 72.000-140.000 € and the operating cost at 2.000-4.000 €/y (for production of approx. 3.000 m³ of OMW/y)	Sludge volume produced is decreased; the digested sludge is spread over non-cultivated lands (for safety reasons) and even over cultivated fields (olive groves, vineyards, etc.) as soil enhancer / organic fertilizer; decanter water is recycled at the olive mill and then is fed back to the decanter.	42.8	47.7	48.7	45.3
OMW	Strategies to improve and protect soil quality from the disposal of olive oil mills' wastes in the Mediterranean region (PROSODOL)	GR	Technologies being tested/applied include bioremediation, use of low-cost porous materials as soil additives, use of low-cost additives for OMW pre-treatment.	Pilot	Two implementation areas (Municipality of Rethymno, Crete, Greece and Liguria region, Italy)	Treated OMW for irrigation and safe disposal, use of porous materials as soil additives, compost production.	–	Soil quality improvement, biodiversity preservation as well as water bodies protection in affected and non-affected areas; reduction of wastes' toxic load by pre-treatment with abundant/low cost/harmless materials (enhancing also utilization/recycling of industrial wastes); identification of pollutant pathways and fate in aquatic bodies; soil monitoring system for parameters which will reflect the wastes' disposal activity in the area; guidelines for compost production in small scale; reduction of CO_2 footprint.	41.1	45.7	50.8	40.2
OMW	Processing plant for the integral treatment and valorization of the waste generated during the olive oil production process (OLIVEWASTE)	ES	Treatment of OMW: a) accelerated separation of solids, b) evaporation-condensation and c) final treatment of water.	Pilot	Implementation in the Municipality of Baena, Córdoba, Spain	Clean water for irrigation, solid and liquid organic fertilizers	Total benefit estimated at 6.53 € per t of olives	Management of solid and liquid waste for the production of organic solid and liquid fertilizers, irrigation water and clean water for disposal in water resources; self-supply of energy; biomass availability; reduction of toxic components (benzopyrens) due to decreased temperature for drying the solid waste in the plant.	37.5	39.8	44.6	35.5
OMW	New technologies for husks and waste waters recycling plus (TIRSAVplus)	IT	Development of a cost-effective and innovative technology to recycle OMW and other organic wastes and produce organic fertilizers	Pilot	Oil mill level - planning and construction of a recycling plant	Organic fertilizers	–	Recycling of OMW and other organic wastes, harmonisation of legislation at European level regarding OMW.	38.2	39.2	45.2	34.9

OMW	Adaptation of renewable energies technologies for the olive oil industry (RESOLIVE)	GR	Exploring of other processes (solar distillation, composting, etc) to obtain a valuable outcome from olive mill residues, eg. optimize existing techniques for biogas production	Pilot	Building and operation of a prototype gasification system combined with a 30 kW microturbine	Guidelines for olive oil producers to select best available renewable energy technologies; biogas production using optimized existing techniques	Reduction of production costs in the olive oil sector taking into consideration the scenario of constantly increasing prices of energy	Increase of the sustainability of European olive oil sector by implementing solutions which result in valorization of its waste.	33.5	36.5	38.1	34.2
OMW	Wastewater recycling of olive oil mills in Mediterranean countries - Demonstration and sustainable reuse of residuals (WAWAROMED)	DE	Purification of OMW by aerobic/anaerobic treatment using a biological sedimenter; the diluted wastewater was used for irrigation of plants.	Pilot	Implementation in an olive mill in the municipality of Mousouron, Crete; treated wastewater was reused in agriculture	Treated water may be reused for irrigation or as a fertiliser in agriculture. The separated solid residuals may be used as biomass.	–	In anaerobic treated OMW with “Epuvalisation technology” COD is reduced by 98% (mainly due to sludge settlement), after 5-9 days of effluent circulation in fields with plants. Seasonal application of 416 m^3/ha/y of raw OMW for 3 years had no negative effects on plant physiology, nutritional status, yield and soil properties, while soil K increased enhancing soil fertility.	32.5	36.7	40.9	30.7
OMW	New technologies for husks and waste waters recycling (TIRSAV)	IT	Co-blending of olive oil wastewaters, fresh olive pomace and other natural organic by-products.	–	–	Compost	–	Integrated use of different bio-wastes from the agro-food industry and agricultural production for simple vegetal non-composted or for mixed composted amendments.	40.1	44.4	49.4	40.1
OMW	Development of a solar distillation wastewater treatment plant for olive oil mills (SOLAR DIST)	DE	Combination of solar distillation and biological treatment (constructed wetland) for elimination of organic matter content.	Pilot	The SOLARDIST system and an organic waste composting process were used	Sludge generated is composted to be used as fertilizer; the condensate obtained is used for irrigation of constructed wetland	–	Elimination of organic matter content, including phenols and polyphenolic compounds by 98 %; the installation of the solar distillation system contributes to the reduction of air pollution and odours due to uncontrolled disposal in evaporation ponds; preservation of natural resources by using solar energy; production of a natural fertilizer for olive trees; reduction of CO_2 emissions.	31.2	34.5	37.2	30.4

OMW	Improvements of Treatments and Validation of the Liquid-Solid Waste from the Two-Phase Olive Oil Extraction (IMPROLIVE)	ES	The overall methodology integrates several procedures such as balanced-protein enrichment, aerobic bioremediation and nitrogen fixation, extraction by decanter centrifuge, fluidized bed, spray or drying and combustion/gasification.	Pilot	De-oiling and drying of alpeorujo	Oil of mproved quality, humidified organic substrate for agricultural use, material for animal feed and/or food additive	Fertilization of olive and orange trees shows that the process is rather simple and cost effective.	Reduced fresh water consumption in olive oil production; the phytotoxicity is eliminated and the treated end product can be used for fertilization of plants.	28.6	32.1	33.3	29.0
OMW	Establishment, operation and demonstration of an innovative closed-cycle system of oil milling waste water using the Fenton method in Sitia-Crete, and reuse of treated water and by-products in agriculture (Elaiocycle)	GR	Treatment using the Fenton method in combination with dissolved air flotation; further solid phase processing using a closed vessel co−composting reactor.	Pilot	Implementation in Eastern Crete	Fertilizer (methodology adopted by Greek Agricultural Associations)	–	Stabilized compost free of pathogens is produced and allowed to mature into a high quality organic fertilizer. Tests carried out in crops and trees have shown a positive effect of compost on plant growth; however, no tests have been performed regarding the potential effect on soil quality during cultivation.	29.7	33.4	35.7	29.4
OMW	Supporting SME driven olive industry to comply with EU directives (EnXOlive)	ES	Treatment of OMW by anaerobic digestion using a modular scalable bioreactor and an integrated plant.	Full	Industrial plant	Production of biogas, extraction of polyphenols, fertilizers and water for irrigation	Management costs are limited and the revenues from new high added value by-products surpass the operating costs	Important revenue can be obtained when selling marketable by-products instead of paying for the disposal of wastes. Moreover all these residues are converted in "cleaner" wastes preventing environmental pollution by disposal of untreated wastes in ponds with a lot of ecological impact and odours.	33.0	36.7	39.8	33.6
OMW	Process development for an integrated olive oil mill waste management recovering natural antioxidants and producing organic fertilizer (MINOS)	GR	Integrated treatment system: successive wastewater filtration, nanofiltration/reverse osmosis.	Pilot	Operation for two successive oil producing periods	Clean water for disposal, purified polyphenols, natural fertilizer (compost)	Capital cost for 50 m^3 OMW/d approx. 1.150.000€; operating cost approx. 54.000 €/month; total equipment depreciation within 2 years	Clean water for disposal in natural aquatic receivers, underground disposal, irrigation purposes as well as for the plant needs. By filtering OMW, polyphenols with high market value can be successfully extracted. Furthermore, solid waste from the olive oil processing can be combined with any remaining parts of the organic fraction of the wastewater to produce a rich soil conditioner.	31.1	35.1	37.6	32.0

OMW	Biotechnological recycle of olive mills washing water by microalgae (ALGATEC)	ES	Preliminary filtration of the washing water with a laminar settlement tank, main treatment with a photobioreactor using microalgae and post-photobioreactor treatment based on membrane filtration.	Pilot	Implementation in the DESAM facilities in Puente Genil, Andalusia, Spain and Peza, Greece	Recovery and recycle of most water used for olive washing	Treatment costs are about 12 times lower with respect to treating washing water together with vegetation water	The ALGATEC system a) provides a decentralised, safe and cost-efficient wastewater treatment and water reuse system, especially applicable for small and medium sized olive oil producers, b) reduces water consumption by 90 %, c) is adjustable, easy to control and maintain. Membrane technologies used are much more energy efficient compared to heat-driven purification (distillation) and more affordable while no addition of chemicals is required.		30.2	34.0	38.8	28.3
OMW	European awareness raising campaign for an environmentally sustainable olive mill waste management (OLEICO+)	IT	Raise awareness among olive growers and olive oil producers about environmental problems caused by OMW disposal. Identification and adoption of the best eco-friendly technologies for the recovery and recycling of OMW.	–	–	Technologies for recycling of OMW	Cost analysis for each technology	Contribution to the implementation of EU environmental legislation by improving olive waste management and thus minimization of soil, water and air contamination.		29.2	29.9	35.4	25.4
OMW	Technology for treatment and recycling of the water used to wash olives (UDOR)	DE	The proposed treatment for recycling water includes: a) preliminary aerobic treatment, b) ultrafiltration, c) reverse osmosis.	–	–	Water to be used again for the washing of olives; decreased volume of wastewater to be disposed of	Disposal cost is decreased	After treatment, the volume of water for disposal is decreased. The UDOR system complies with regulations reagrding wastewater treatment and if applied to all EU oil production units may potentially save about 4 billion liters of drinkable water per year.		28.8	30.9	37.7	23.9
OMW & manure	The condense managing system: production of novel fertilisers from manure and olive mill wastewater (CONDENSE)	GR	Condensation of nutrients contained in OMW and manure and production of fertilizers.	Pilot	Capacity of 5-10 t/y	Fertilizer for use in agriculture and horticulture	–	The fertilizer produced can be safely used in agriculture and horticulture. The new product will be evaluated in relation to the growth of various crops in southern and northern Europe, as well as in terms of compatibility with existing fertilizer application methods, tools and farmers practices.	Ongoing project (01-09-11 to 31-12-14)	-	-	-	-

OMW	Innovative demonstration facility for the treatment of waste water from olive oil presses (OMW) with material and energetic utilization of the residues (OLIVIA)	DE	Multi-stage process: a) wastewater purification (mechanical-biological pretreatment, anaerobic or membrane filtration stages), b) sludge treatment, c) biogas production	Pilot	Implementation in the island of Crete, Greece	Fertilizer, purified wastewater, biogas for thermal/ electrical energy	Operating cost 3.5-5.5 €/m3 OMW	Biogas may be converted into electrical and thermal energy; wastewater may be used for irrigation of agricultural land or as industrial process water or disposed into surface streams (purification over 95%); high quality fertilizer may be obtained from the residues	No data available	-	-	-	-
						Wine waste						
Wine waste	Development of an economically viable process for the integrated management via utilization of winemaking industry waste; production of high added value natural products and organic fertilizer (DIONYSOS)	GR	Four main successive individual steps: a) extraction-filtration of grape pomace, b) selective adsorption of polyphenols through a series of resins, c) thermal treatment-solvent recovery, d) purification of resveratrol by FCPC (Fast Centrifugal Partition chromatography)	Pilot	Prototype composting unit in the Agricultural University of Athens and pilot plant for wine waste treatment	High nutritional value animal food, natural organic fertilizer (compost), enriched polyphenolic extract and pure polyphenols	Capital cost 1.100.000 €, operating cost 53.000 €/month, market price for selling polyphenols extract 0.5-1 €/g. The total depreciation of the equipment can be achieved within the first nine years of operation.	Phenols recovery procedure is environment friendly. Compost produced may be used to enrich soil with organic matter, increase its water holding capacity as well as the capacity for nutrient absorbency and assimilation; also soil aeration is improved, soil erosion and need for chemical fertilization is decreased.		39.9	42.6	43.2	41.8
Wine waste	Saving of forest exploitation for obtaining of tanning extracts through valorisation of wine waste (GRAPE TANNINS)	ES	Removal of oil content, tannin extraction in autoclave, analysis by filter-bell method.	Full	Industrial trials in two participating tanneries in Spain (Curtidos Lancina and SARCO)	Ultrafiltration product to tan cow hides and produce sole leather; nanofiltration product to tan sheepskin and produce lining leather.	Total cost of approximately 450 €/t (competitive with the current price of commercial tannins)	Reduction of wine waste, valorisation of a low profitable by-product, minimization of deforestation of some tree species as well as reduction of energetic cost necessary for the concentration of vegetable tannins.		31.1	32.8	32.9	31.5
Wine waste	Advanced systems for the enhancement of the environmental performance of WINEries in Cyprus (WINEC)	CY	Identification of the major environmental problems associated with the operation of wineries and establishing environment friendly and effective solutions	Pilot	An Environmental Management System will be implemented for Tsiakkas Winery (CY) (Membrane Bioreactor-MBR followed by Advanced Solar Oxidation – SOLAR)	Environment friendly treatment of winery waste	–	Minimisation of solid waste disposal and maximisation of their reuse potential; reduced use of electricity, fuel and chemicals, water consumption, emissions and discharges to the environment; compliance with the relevant environmental legislation in all sectors		29.9	29.9	30.6	29.2

Wine waste	Integrated waste management and life cycle assessment in the wine industry: From waste to high-value products (HApro WINE)	ES	–	Pilot	–	Products of high added-value with reduced environmental impacts; recovery and recycling of wine waste.	–	Promotion of rational and sustainable use of natural resources (freshwater resources, land, etc.), recovery and recycling of winery wastes as well as synthesis of high added-value compounds from the different wine waste streams	Ongoing project (01-01-10 to 31-12-13)	-	-	-	-
						Swine waste							
Swine waste	Implementation of a management model for the ecologically sustainable treatment of pig manure in the Region of Los Serranos, Valencia-Spain (Ecodiptera)	ES	Biodegradation of farm waste through: a) transfer of pig manure from the farm, b) pre-treatment of the manure, c) mass-rearing fly larvae phase, d) biodegradation phase	Pilot	Semi-industrial scale: prototype plant in Slovakia (mass-rearing Diptera flies) and pilot plant in Valencia, Spain (biodegradation of pig manure in a pig farming area)	Organic fertilizer and by-products (eg. biomass for animal feed); application tests to corn and sunflower crops showed results comparable with four commercial fertilizers	Biodegradation cost is estimated at 10 €/t, which is higher compared to the cost of management systems in use (3 €/t) involving direct application of pig manure in the field. It could be though reduced by mechanizing various stages of the process and revaluing the byproducts obtained.	Development of a new system to transform pig wastes into a non-polluting resource suitable for agricultural use complying with the European legislation, minimal pollution of surface- and ground water (the nitrogen content of the pig manure is reduced to 2.45%), minimisation of offensive odours, control of fly proliferation in municipalities, reduction in electricity consumption in the treatment process, minimisation of the risk of disease outbreak, reduction of CO2 emissions and fuel consumption.		35.2	38.5	42.8	32.5
Swine waste	Zero Nuisance Piggeries (ZNP)	FR	Combination of several existing techniques into a single system: a) fresh slurry management, b) preliminary S/L separation by centrifuge, c) biological treatment by activated sludge, d) composting system using centrifuge residue	Pilot	The prototype is installed in the experimental station at Guernévez, Finistère, France	Production of organic fertilizer (compost)	Total cost estimated at 15-19 €/m^3; expected to be reduced significantly by technical adaptations in future commercialized versions.	Using the ZNP system, SS and total COD are eliminated by 100 and 95%, respectively. Nitrogen is transformed into nitrates by 94%, the outflow of ammonia and nitrous oxide is reduced up to 70%, greenhouse gases and atmospheric pollution are mitigated. It is estimated that widespread use of the new holistic treatment technology in France could reduce national ammonia emissions from pig production by approximately 18,000 t per year (currently around 60,000 t) as well as water consumption providing savings up to 40% compared with conventional systems.		30.7	32.4	37.9	26.5

Swine waste	Pig-Farm Integrated Management Project PIGS (PIGS)	PT	Development and implementation of a set of instruments, tools and best practices for the management and treatment of solid and liquid wastes from pig farms as well as study of the viability of composting process	Pilot	–	Compost form the solid part of pig manure	The efficient use of water by pig farms contributing to a reduction in treatment costs.	Long-term protection of groundwater and improvement of its quality, minimization of noise levels and odours, re-use and recycling of material through composting, minimisation of pig farm waste production and discharge, water savings in pig farms, potential for transferability and reproduction of tools and instruments developed (eg. Local Pig-Farming Regulation etc.)		29.8	33.5	37.1	28.9
Swine waste	Environmentally-friendly management of swine waste based on innovative technology: a demonstration project set in Aragón (Spain) (ES-WAMAR)	ES	Implementation of the best management techniques in order to minimize the environmental risk (transport of the waste from the farms to the plots, purification treatment, application as fertilizer)	Pilot	Implementation in three different Swine Waste Management Enterprises (SWMEs)	Production of organic fertilizer, design and development of global swine waste management tool	–	Recycling of nutrients (460,000 m3 of pig slurry per year through valorisation as fertilizer), reduction of diffuse pollution, unpleasant odour and emission of greenhouse gases (implementation of two gravity pipelines transport models), nitrogen reduction by 80% through biological treatment, encourage application in other regions by dissemination of the outcomes to the general public.		29.8	29.8	35.8	24.9
Swine waste	Guidelines to the Cyprus Competent Authorities for Policy Formulation for Sustainable Management of pig-farming wastes in Compliance with EU Practice (PIGWASTEMAN)	CY	Pilot treatment schemes: a) S/L separation, b) aerated lagoon or aerobic sequential batch reactor for the treatment of the liquid manure, c) composting or liming of solid manure, d) land spreading of treated liquid and solid manure	Pilot	Two piggery waste treatment systems	Formulation of a waste disposal policy for sustainable management of the pig-farming waste	–	Reduction of the pollution load of pig farming wastes, removal of pollutants such as ammonia, nitrogen and carbon, contribution to lower odour emission, development of environment friendly wastewater management alternatives for the pig farming industry		23.4	22.8	26.7	19.4
Swine waste	Evaluation of manure management and treatment technology for environmental protection and sustainable livestock farming in Europe (MANEV)	ES	Assessment of 13 treatment technologies and manure management systems, located in 8 regions with high pig production in Spain, Italy, Denmark and Poland following a common monitoring and assessment protocol that will be developed.	–	–	Development of a common protocol among European regions for manure treatment, production of fertilizer	–	Contribution to greenhouse gas emissions reduction, improve sustainability of pig farming by implementation of manure treatment technology in various livestock-dominated areas of Europe.	Ongoing project (01-01-11 to 31-12-14)	-	-	-	-

Swine waste	Pilot experiment: treatment and disposal of slurry from pig farming	ES	Application of techniques to treat waste from pig farms, involving homogenisation, solid press, anaerobic ponds, natural supply and aeration ponds and a maturing pond	Pilot	–	Recycled effluent for use in irrigation	–	–	No data available	-	-	-	-
						Other animal waste						
Other animal waste	Development of a Processing Plant for Recycling of Duck Slurry (DUCK SLURRY)	IE	Duck slurry treatment: maceration and homogenization, S/L separation, drying of the solid, dissolved air flotation and anaerobic digestion of the dewatered liquid blend, capture and utilisation of biogas, safe discharge of the effluent	Full	Implementation in Silver Hill Foods, a fully integrated family owned Duck Company	Dried fertilizer pellets, biogas for heating	The long-term sustainability of the process, reduces the disposal cost which severely inhibits the beneficiary's competitiveness on a global market.	The biogas produced after anaerobic digestion of duck slurry can be used to heat and run the plant; long-term sustainability of the process.		30.8	33.2	37.3	29.5
Other animal waste	Green (environmentally friendly) management of cattle farm waste and its repercussion on the GHG emissions (ECOREGA)	ES	An innovative system is proposed for mixing liquid manure from cattle farms with other types of organic waste (swine, bird)	Pilot	Adoption of the cattle waste management methodology in farms of Galicia, Extremadura and other regions in Spain	Natural fertilizer (compost) and methane	–	Greenhouse gas emissions minimization as well as elimination of the use of inorganic or synthetic fertilisers in farms.		27.7	31.0	34.8	26.3
Other animal waste	Implementation of an AD facility at a Spanish slaughterhouse for a sustainably closed energy and waste (ENERWASTE)	DE	Anaerobic digestion of slaughterhouse waste similar to the one taking place in the digestive track of the animals	Pilot	Convertion of slaughterhouse wastes into biogas	Biogas (renewable energy) and fertilizer (new resource)	Income for sale of electricity ~ 108,000 €/year (0.06 €/kWh). For the treatment of waste in a biogas plant 10 €/t is required, compared to 33 €/t required for the disposal of waste.	38,820 Nm3/y of natural gas substituted by biogas (renewable energy) at MFN (coordinator premises); 1,800,000 kWhe/y are produced avoiding the use of fossil fuels thus reducing CO2 emissions by 370,000 kg per year.		24.5	26.4	25.4	27.1

Other animal waste	Demonstration of a new concept for a safe, environmental advantageous, economical sustainable and energy effective system for handling animal by-products in Europe (BIOMAL)	SE	Animal by-products processing: crushing and grinding of raw materials and pumping into a fluidized bed boiler for combustion with a base fuel.	Full	Konvex's (coordinator) processing plant produces 85,000 t of Biomal fuel annually for use in four heat and power plants in Sweden	Biofuel for production of renewable heat and electricity	Much lower operating and investment cost compared with standard rendering processes	The risk for BSE (Bovine spongiform encephalopathy) infection or other diseases is eliminated; odour is eliminated; the water usage and the discharge of biological oxygen demanding substances are reduced; NOx emissions are reduced; minimization of global warming due to replacement of fossil fuels for the production of heat and power; Biomal has a heating value of about 7.6 – 8.3 MJ/kg fuel or about 2.2 MWh/t which is comparable to a conventional biofuel with a moisture content of 50 %.	22.6	24.2	25.4	22.2
Other animal waste	Global solutions for slaughterhouses, meat processing plants and phytosanitary sector: treatment of category 3 animal wastes and production of high value products with bio pesticide properties (APTAR)	ES	Treatment of category 3 animal by products: a) development of a cost-effective biotechnological method for by-products degradation using microorganisms, b) introduction of the derived products in the phytosanitary sector.	Pilot	Design, installation and optimization of a semi-scale pilot plant	Methodology for degradation of category 3 ABPs by using microorganisms; biopesticides for use in agriculture	Low cost process with high added value products new source of income by means of revalorization of category 3 ABPs increasing their added value after treatment, reduction or elimination of category 3 ABPs management costs.	Reduction of pollution derived from category 3 animal by products (ABPs) disposal, human and animal disease risks as well as pollution due to the substitution of conventional agrochemical by environment friendly bioproducts; compliance with the current regulation regarding ABPs management as well as phytosanitary regulation.	24.5	25.7	27.6	24.2
Other animal waste	Prevention of animal dejections related pollutions (ECOLIZ)	FR	Innovative and operational solution for the treatment of manure on the farm; the technique consists of mechanical separation of manure into two deodorized phases	Pilot	A fixed station was demonstrated at GIE, "La Pimosa", France	Liquid phase for irrigation and solid phase for fertilizer	–	Elimination of excess nitrogen and phosphorus spread in vulnerable areas. ECOLIZ tool available to stockbreeders is energy-efficient, relatively inexpensive and requires little maintenance or labour. The technology developed is reliable, safe, perfectly suited for agricultural activities and flexible to treat other types of effluents (other animal waste and industrial effluents).	25.0	27.8	34.7	21.1

Other animal waste	Demonstrative plant for manure management of a medium size exploitation by anaerobic digestion and agronomic valorisation of the digestate (UNIDIGES)	ES	Demonstration of a management scheme for manure at private livestock farms. Pilot plant based on manure anaerobic digestion, from a medium-sized farm.	Pilot	The system will be tested on different farms and on several types of manure	Commercial end product	–	Reduction of greenhouse gas emissions, offensive odours and the impact of nitrates on waters as well as improvement of the nutrient balance on soil.	Ongoing project (01-09-11 to 01-03-15)	-	-	-	-
Rice straw													
Rice straw	Sustainable management of the rice straw (ECORICE)	ES	The methodology proposed in BIOCOMPOST project was used in ECORICE project	Pilot	Application of the straw blankets in pilot-site fields	Straw blankets or rolls enhancing vegetation growth and tree cultivation	–	The ECORICE technique may be adopted and developed by rice farmers elsewhere in Spain and across Europe or transferred to other agricultural sectors; reduction of greenhouse gas emissions by 74.6 t CO_2/y by avoiding the burning of 1,350 t of rice straw; saving of water and improvement of arid crop yields through the use of straw blankets; improved public acceptability regarding traditional rice cultivation.		31.3	33.9	41.1	26.4
Rice straw	Demonstration Plant for composting municipal sewage sludges and rice straw, and evaluation of the agronomic quality of the produced compost (BIO COMPOST)	ES	Two treatment methodologies: a) mixing of rice stalks with organic material and composting in heaps, b) grinding of the rice stalks and mixing with sludge, organic material and pruning waste and composting in silos.	Pilot	The stalks gathered were used for composting in the Waste Treatment Plant FERVASA (Quart de Poblet, Spain)	High quality compost was used to amend a franco clayey soil during the cultivation of citrus fruits	High cost for gathering of rice straw/stalks. The methodology proposed in BIOCOMPOST project was used in ECORICE LIFE project which aimed to achieve a competitive price for the removal of rice straw/stalks from the field.	Sustainable solution to the problems of incineration of rice straw after harvesting (reducing smoke produced) and of the direct application of the muds in agricultural land (contributing to the protection and improved management of the resources in the area of Valencia).		28.9	30.9	36.4	25.4
Various other AW													
Various other AW	Modern and environmental friendly composting methods of agricultural waste (ECO FILTER)	HU	Composting: a) pre-wetting and pre-fermentation of the mixture (horse or chicken manure, straw, water and gypsum etc.) in completely closed and floor aerated indoor tunnels, b) pasteurization of compost in tunnels, c) the spawn runs through the compost	Full	Implementation in the company's facilities	Environment friendly compost (I, II and III phases)	–	Implementation of the technology in closed tunnels, reducing odour and ammonia emission by 95% (no addition of chemicals) and improving the efficiency of the technology; energy-saving, environment friendly composting method; recycling of the water used; avoiding leakage on soil through management and fermentation of the raw materials on concrete surface.		39.8	44.9	51.9	37.1

Various other AW	Demonstration of an integrated waste-to-energy system for energy generation from biodegradable organic waste and wastewater (INTER-WASTE)	CY	Development and demonstration of a sustainable conversion technology for the management of biodegradable organic waste and wastewater through the construction of an innovative integrated Membrane Bioreactor System (MBR) based on anaerobic process	Pilot	The system receives a variety of organic waste and biowaste (household organic waste, agricultural waste and manure)	Biogas, stabilised solid product, high quality effluent that can be safely reused in agriculture	Strengthening of local/insular communities economy and enhancing independence of the technology regarding energy sources utilisation	Energy gain for different types of feedstock, assessment and minimization of the environmental impact of the process (GHG emissions), reduction of chemical fertilisers usage thus protecting of sensitive water bodies from eutrophication, adoption of the priorities of the EU concerning recovery and reuse of materials as well as utilization of waste for energy production (waste-to-energy), minimization of energy loss through electricity transportation to distant locations.	35.4	38.8	46.3	31.5
Various other AW	Development of integrated agroindustrial waste management politics maximizing materials recovery and energy exploitation (INTEGRASTE)	GR	Utilization and management of agro-wastes (agricultural plant residues) and agro-industrial wastes (from e.g olive mills, piggeries etc) using anaerobic digestion	Pilot	Upgrade of an existing pilot plant built at the Industrial Zone of Patras, Greece, to process both liquid AW (existing process) and solid AW (enhanced process)	Electrical and thermal energy, composting for the production of fertilizer for crops and valorisation of the residuals	Preliminary cost analysis for the management of around 105.000 t waste/year: total investment cost of 5.008.775 €, total operating and maintenance cost 630.000 €/year, total revenues from exploitation of energy and materials 2.190.030 €/year (in case of subsidy), payback period 3-4 years.	Integrated solution for the management of solid and liquid AW using anaerobic digestion with a number of advantages such as low nutrient requirements, energy savings, generation of low quantities of sludge, waste stabilization and production of biogas (methane) and/or hydrogen without pre-treatment. The project is in line with the national priority for waste and natural resources and the specific national target for maximising recovery of materials and energy from waste.	30.3	32.6	34.2	30.9
Various other AW	Integrated systems to enhance sequestration of carbon, producing energy crops by using organic residues (Seq-Cure)	IT	Contribution to the reduction of CO2 atmospheric emissions and increase of carbon sequestration in soils through the production of biomass for renewable energies as well as the use of organic residues to fertilise energy crops	Pilot	Demonstration energy farms in Emilia-Romagna, Italy	Renewable energy production, use of digestates as fertilizers	a) Biogas production chain: average net income between 78.86 and 579.30 €, when 80% of the vegetable biomass is purchased on the market or produced on the farm, respectively b) Vegetable oil production chain: the net income per hectare of sunflowers in poor soils increased from 7.49 to 51.64 €, when the cake produced is used for livestock feed and at least 60% of the thermal energy produced was exploited c) Wood-fibre production chain: the average annual net income per hectare of poplar plantation varied between 51.09 and175.29 €, the income per linear metre of hedge was 0.68 €.	Development of a methodology for the calculation of GHG emissions and C sequestration to estimate their variations due to changes in soil use; limiting environmental impacts by fertilizing energy crops with organic residues; measures to predict the long term effects of the cultivation of energy crops.	31.0	35.0	40.1	29.0

Various other AW	Sustainable biomass production, processing and demonstration of alternative cropping and energy systems (Alternative Biomass4Energy)	DE	Screening of multiple feedstocks of biowaste and alternative biomass production systems for large-scale production of biomass	Pilot	Demonstration of a new carbonisation technology for the conversion of different sources of waste and digests	Biogas and biochar production	–	–	Ongoing project (01-09-11 to 31-08-16)	-	-	-	-
Various other AW	Integrated management of bio-waste in Greece – the case study of Athens (Athens-Bio-waste)	GR	Promotion of sustainable biowaste management in Greece using the municipalities of Athens and Kifissia as case study areas.	Pilot	Collection of biowaste and composting.	Composted biowaste, bio-waste management software tool	–	A practical guide for biowaste management by local authorities will be produced. Gaps in Greek policy and legislation related to biowaste will be identified and recommendations for the technical specification on waste management and other legislative issues will be drafted.	Ongoing project (01-09-11 to 31-12-14)	-	-	-	-
Various other AW	New soil improvement products for reducing the pollution of soils and waters and revitalizing the soil system (Biorewit)	PL	Use of natural fibrous wastes e.g. straw, sawdust, wool, cotton for the production of soil improvers or biodegradable soilless substrates	Pilot	Application of new fibrous soil bio-activators for the cultivation of vegetables on demonstration plots and on experimental cultivation fields.	New soil improvers and soilless substrates for greenhouse cultivation	–	Reduction of soil and water contamination through gradual replacement of mineral fertilizers with new soil eco-activators, gradual elimination of mineral nutrient emissions from drain waters of soilless cultures, gradual enrichment of soil with organic material through application of plant biodegradable matter contained in the eco-activators, reduction of the volume of disposed waste on landfills, improvement of farm products quality by avoiding the risk of over fertilizing crops with nitrogen.	Ongoing project (01-01-12 to 31-12-14)	-	-	-	-
Various other AW	Sustainable strategies for integrated management of agroindustrial fruit and vegetable wastes (AGRO WASTE)	ES	Integrated management system using fruit and vegetable wastes (FVW) in the Region of Murcia, Spain (e.g. anaerobic digestion of industrial wastewater and organic solid waste for biogas production, aerobic process for the production of mature organic soil amendments).	Pilot	–	Added value bioactive compounds for multifunctional food ingredients, biogas and mature organic soil amendment	–	–	Ongoing project (01-01-12 to 31-12-14)	-	-	-	-

Various other AW	Development and implementation of a centralized plant for the re-use and valorization of agricultural waste from intensive cultivation and handling of fruits and vegetable	ES	Development of a plant for the treatment of AW from intensive cultivation and handling of fruits and vegetables: a) initial methanization through mesophilic anaerobic digestion, b) phase separation, c) secondary methanization, d) accelerated composting for fertilizer production e) reverse osmosis for liquid fertilizer production.	Pilot	Pre-industrial scale application	Four sub-products (biogas, organic fertilizer, liquid fertilizer and water)	–	–	No data available	-	-	-	-