LIFE Project Number

LIFE05 TCY/MA/000141

TECHNICAL FINAL REPORT

Reporting Date

30/10/2008

LIFE PROJECT NAME

Design and Application of an Innovative Composting Unit for the Effective Treatment of Sludge and other Biodegradable Organic Waste in Morocco, MOROCOMP

Data Project

Project location	**El Jadida, Morocco**
Project start date:	**01/02/2006**
Project end date:	**01/02/2008 (Approved extension date: 01/08/2008)**
Total Project duration (in months)	**24 months (30 months after 6 months extension)**
Total budget	**€ 637,808**
EC contribution:	**€ 438,228**
(%) of total costs	**70**
(%) of elibible costs	**70**

Data Beneficiary

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1. LIST OF CONTENTS

2. LIST (I) KEY-WORDS AND (II) ABBREVIATIONS

Key-words: sludge, biodegradable organic waste, waste management, composting, in-vessel system, bioreactor, compost Morocco, Greece

Abbreviations:

University of Chouaib Doukkali:	UCD
National Technical University of Athens:	NTUA
Regional Office of Agricultural Development:	ORMVAD
Biodegradable Organic Waste:	BOW
Urban Wastewater Treatment	UWWT
Potable Water Refineries	PWR
Station Expérimentale de Mise en Valeur Agricole	SEMVA

3. EXECUTIVE SUMMARY

MOROCOMP is a Life-Third Countries Project co-funded by the European Community with title “Design and Application of an Innovative Composting Unit for the Effective Treatment of Sludge and other Biodegradable Organic Waste in Morocco - LIFE05 TCY/MA/000141” with benefiting country that of Morocco. The basic aim of this project is to develop and establish an innovative in-vessel composting system for the treatment of sludge and other BOW in Morocco in order to enable the operators and National Authorities to treat, control and reuse the sludge and other BOW effectively and in consistence with the European Environmental Policy.

The final technical report presents initially in section 4 an introduction to the subject of the project in which the environmental problem of sludge and BOW management in Morocco is stressed along with the activities and the expected results of the MOROCOMP project aiming to tackle the presented environmental problems in an integrated and sustainable manner.

Following the introduction, the MOROCOMP project framework is presented in section 5. In this section an overview of the project phases and the activities per phase are presented along with the organigram and the responsibilities of the beneficiary and its partners in each phase.. The project consists of eight tasks, six of which are related to its technical development, one task refers to the dissemination/training activities and one task includes all managerial and coordinating activities.

In section 6, the technology that was developed and applied through the project is described analytically. In particular, the technology that was applied for the implementation of the project involves the system’s main and auxiliary components and all the means used for the evaluation of the produced compost

In section 7, the technical progress of the project, which is divided in 6 separate Tasks, is presented and evaluated in detail, and the results that were obtained are given.

In section 8, a dissemination plan is presented covering briefly the main dissemination actions of MOROCOMP project, while analytical information related to the dissemination and training activities that were implemented throughout the duration of the project as well as their output are also presented.

In section 9, specific focus is given to the overall evaluation of the project as well as on the conclusions obtained through its implementation. The main parameters from this evaluation are presented synoptically, below:

- The technical development of the project (six technical tasks) was carried out successfully and in accordance to the proposal of the project, qualitatively and quantitatively. All the individual targets that were set per task were achieved and the outcomes and the deliverables, foreseen in the proposal, were successfully obtained.
- Concerning the management of the project, everything proceeded smoothly and the collaboration between the beneficiary – UCD - and the two partners - NTUA and OMVRAD - was efficient and productive. The project was developed according to the initial proposal and no modifications (technical, financial, project – organisation) were made.
- The reproducibility and the application of the prototype in-vessel system in large scale is feasible

- A significant number of benefits are obtained via the implementation of the project (direct/quantitative environmental benefits, positive impacts on environmentally significant issues or policy areas, long-term/qualitative environmental benefits, long-term sustainability, long-term/qualitative economic benefits, long-term/qualitative social benefits) which are pointed out in the report.
- The outcome of the project has a great impact to all the actors involved in the field of the generation and management of sludge and other BOW
- The content and the outcome of the MOROCOMP project are characterized by a high level of innovation at national and international level

In addition, in section 10 the after-LIFE plan to continue and expand the dissemination and the communication of the results and the outcome of the MOROCOMP project via the development of several actions is described, analytically.
In section 11 the actual project realization against the baseline implementation plan is given in the form of a Gantt – chart, while comments on the costs that were incurred through the project are provided in section 12. Finally the appendices of the final report are shown in section 13.

4. INTRODUCTION

The main objective of the project is to develop an innovative in-vessel composting system for the treatment of sludge generated by UWWT plants and other BOW in Morocco. This composting unit will enable the operators and National Authorities to treat, control and use sludge and other BOW effectively and in consistence with the European Environmental Policy. The project implementation will protect the water-bodies and soil from untreated and uncontrolled sludge disposal in order to promote the protection of public health and the environment. At the same time, the use of treated sludge and other BOW as ferilizers and/or soil improvers will minimize the use of chemical fertilizers and subsequently protect arable land from degredation and the surface and groundwater from contamination. This composting system will be used as a pilot-demonstration unit for further applications in large-scale in Morocco and in European geographical areas with similar characteristics that face similar problems.

Sewage sludge was selected to be the primary raw composting material since sludge treatment is an immense problem that Moroccan authorities have to cope with. More specifically, the annual volume of urban wastewater has increased from 48 million m^3 in 1960 to 500 million m^3 in 1999. It is estimated that this amount will reach 900 million m^3 by 2020. This significant increase is due to population growth, which is estimated at 5% per year. In Morocco, untreated wastewater is discharged in the water recipients. Approximately 60% is discharged in the sea which poses a real health hazard as has been shown by recent studies while the rest is either discharged in the surface waters or reused for the irrigation 7000ha of land. It should also be mentioned that EU has initiated the horizon 2020 programme for the de-pollution of the Mediterranean Sea by 2020. This means that effluents should not be discharged to sea recipients unless they are treated. So Morocco will have to cope with the continuous increase of sludge generation in a sustainable manner.

In countries with semi arid climates such as Morocco, the humidity and temperature conditions favour soil mineralization and particularly in the irrigated areas. Consequently, the absence of organic additives and/or the use of cultivation residues, entail in the long term, the reduction of the amount of organic matter in the soils. This

could be accompanied by a degradation of the structure of the soil and of a deterioration of the chemical fertility; thus affecting the durability of the production systems.

Composting process is one of the best waste management methods as far as sustainability issues are concerned, to stabilise organic waste including sewage sludge. Sewage sludge provides labile organic matter in sufficient quantities to stimulate soil microorganisms. This kind of organic residue improves the soil's physical characteristics; increasing soil sponginess, water holding capacity and the percentage of stable aggregates. They also improve the nutritional quality of soil and most importantly increase the content of the labile carbon fractions, which acts as a catalyst for the microorganisms, thus improving the soil's potential fertility and stimulating the biogeochemical cycles of the most important elements. Therefore the use of sludge as a composting material can be of significant value.

The main activities of the project are the following:

- Assessment of the existing situation in the European Union and in Morocco regarding sludge and other BOW generation and management (treatment, reuse and disposal).
- Assessment of the related legislation in the EU and in Morocco concerning sludge and other BOW.
- Review of composting success stories and best practices in the European Union and internationally.
- Design and construction of an innovative in-vessel composting system for treating sludge and other BOW.
- Development of sludge and other BOW aerobic composting processes – Optimisation of the operation of the demonstration composting system.
- Use of alternative effective additives of Mediterranean origin in the composting process.
- Determination of the most efficient compost mixture.
- Evaluation of the compost products as soil improvers in laboratory and open field applications.
- Examination of alternative uses of the end products.
- Assessment of compost market and jobs opportunities in Morocco.
- Development of specifications and guidelines covering the area of sludge and other BOW composting, characterization and use of compost as soil improver in large scale.
- Dissemination of the project progress and results (trips, conferences, workshops, meetings, website, printed material, etc).
- Training of the staff of the competent authorities and personnel that shall be involved in the compost production and distribution.
- Public information and participation.
- Management of the project and reporting to the EC.

The expected project results include:

- Development and transfer of know-how for the efficient management of sludge and other BOW in Morocco
- Development of instruments for the competent authorities in order to design and apply appropriate schemes for the management of sludge and other BOW
- Autarchy in the technology means for the management of sludge and other BOW

- Reduction of the use of chemical fertilizers and protection of sensitive water bodies from eutrophication
- Well-trained staff that can be involved in the development of the technology under examination
- Adoption of the priorities of the EU concerning the recovery and reuse of materials
- Convergence towards the existing EU legislative framework and environmental policy concerning the management of sludge and other BOW
- Solving out the problem of the disposal of sludge and other BOW
- Promotion of sustainable agricultural practices
- Utilization of Mediterranean materials as additives
- Production of compost materials that can be used as soil improvers

5. LIFE-PROJECT FRAMEWORK

The MOROCOMP project consists of 8 Tasks, 6 of them related to the technical development of the project, one to the dissemination and training activities and one to managerial and coordinating activities. The duration of the project was 30 months, after approved extension of 6 months that was given by the EC. Each task of the project is presented briefly below.

Task 1: Assessment of the existing situation in Morocco and in the EU

- Subtask 1.1: Assessment of the existing situation in Morocco regarding the production and management of sludge and other biodegradable waste
- Subtask 1.2: Assessment of the existing situation in EU in connection to sludge and other biodegradable waste and the related legislation
- Subtask 1.3: Review of best practices and success stories of composting of sludge and other BOW in the EU and internationally
- Subtask 1.4: Effective transfer of know-how concerning waste treatment technology, mainly through the conduction of site visits

Task 2: Design and construction of an innovative sludge aerobic composting system

- Design of an innovative sludge composting system
- Construction of the unit

Task 3: Development of sludge aerobic composting process - Optimisation of the operation of the pilot composting systems.

- Physicochemical analysis of sludge, and other BOW and additives.
- Development and optimisation of aerobic composting processes using sludge, individually and in combination with and other BOW.
- Optimisation of alternative aerobic composting processes using sludge and other BOW in combination with alternative additives.

Task 4: Evaluation of compost products as soil improvers

- Development of phytotoxicity tests
- Application of compost products in agriculture
- Effects on the production quantity and quality of selected cultivations

Task 5: Alternative uses of compost – Market opportunities in Morocco

- Assessment of alternative uses of compost products
- Suggestions for the development of compost market network in Morocco

Task 6: Development of guidelines and specifications covering the sludge composting process - Characterization and use of compost as soil improver

- Development of specifications concerning the optimum operation of the composting system
- Development of specifications concerning the quality of the compost products
- Development of guidelines concerning the requirements for compost uses
- Development of manuals for testing and analysis of compost

Task 7: Dissemination and training

- Dissemination of project progress and results by informing all the relevant parties and target groups
- Dissemination of project progress and results by informing the scientific community
- Continuous website updating
- Distribution of printed material
- Training session and workshop organisation
- Public information
- Organized tours to the demonstration unit
- Organisation of International Conference

Task 8: Management

- Effective management of the project and fulfilment of the activities included
- Formulation of Steering Committee
- Formulation of Management Team
- Preparation of an action plan for the project implementation
- Preparation of reports and cost statements

Responsibilities per Task

Task 1: The UCD was responsible for the successful implementation of this task, in close collaboration with NTUA.

Task 2: The NTUA team was responsible for the successful implementation of this Task, in close collaboration with the beneficiary and the Moroccan partner. NTUA working group was responsible for the design, construction, installation and start-up of the in-vessel composting system.

Task 3: The NTUA team was responsible for the successful implementation of this Task, in close collaboration with UCD. More specifically, the daily operation of the composting system was performed by UCD in collaboration with ORMVAD personnel, while NTUA provided expertise for optimizing the system's operation. The physicochemical analysis involved were performed by the UCD laboratory team while additional analysis have been carried out by NTUA members from compost samples that UCD had provided for consistency reasons.

Task 4: UCD and NTUA in close collaboration with ORMVAD were responsible for the evaluation of the suitability of the compost product for using it as soil improver. The UCD laboratory team performed the phytotoxicity tests whereas NTUA members had carried out additional analysis for consistency reasons from compost samples that UCD had provided. With respect to the open field experiments, ORMVAD provided the arable land area necessary for the cultivation tests located near the composting site in the SEMVA in Zemamra region. The performance of tests as well as the daily supervision of the site was performed by UCD in collaboration with ORMVAD personnel.

Task 5: UCD was responsible for the assessment of alternative uses of compost products and for the development of a compost market network in Morocco in collaboration with NTUA.

Task 6: The NTUA team in close collaboration with UCD developed specifications and guidelines covering the area of sludge and other BOW composting process, the characterization and the use of compost as soil improver in large-scale applications.

Task 7: UCD and NTUA were responsible for the organization of dissemination and training activities in close collaboration with ORMVAD.

Task 8: The beneficiary, (UCD) supported mainly by NTUA and by ORMVAD, is the director – coordinator of the project and has the supervision of all the work packages.

In the following Tables, analytical information is given related to the role and the responsibilities of the personnel of the beneficiary and the partner that participated in the implementation of the project.

UCD

Name	Role and responsibilities
O. Assobhei	Management and coordination of the whole project. Design of the composting unit. Installation of the composting unit. Market opportunities for the compost product. Organisation of training workshops. Conference organisation. Dissemination of results. Report preparation.
A. Aajjane	Assessment of existing situation in Morocco with regard to sludge management. Design of the composting unit. Compost evaluation and analysis. Alternative uses of compost. Market opportunities for the compost product. Standards of compost quality. Manual for compost testing and analysis. Organisation of training workshops. Conference organisation.
J. Amine	Assessment of existing situation in Morocco with regard to BOW management. Design of the composting unit. Compost evaluation and analysis. Alternative uses of compost. Market opportunities for the compost product. Standards of compost quality. Organisation of training workshops. Conference organisation. Dissemination of results. Report preparation.
K. Chedad	Assessment of existing situation in Morocco with regard to BOW management. Design of the composting unit. Quality of compost, soil analysis. Alternative uses of compost. Market opportunities for the compost product. Standards of compost quality. Organisation of training workshops. Conference organisation.
S. Etahiri	Assessment of existing situation in Morocco with regard to sludge management. Compost evaluation and analysis. Soil analysis. Alternative uses of compost. Standards of compost quality. Conference organisation.
E.M. Kabil	Assessment of existing situation in Morocco with regard to BOW management. Assessment of existing situation in Morocco with regard to sludge management. Agronomy and phytotoxicity of compost, plant physiology. Alternative uses of compost. Standards of compost quality. Conference organisation.
M. Mountadar	Chemical analysis of sludge, organic biodegradable wastes and compost. Alternative uses of compost. Guidelines for compost use. Manual for compost testing and analysis. Organisation of training workshops. Conference organisation. Dissemination of results. Report preparation.
M. Rihani	Assessment of existing situation in Morocco with regard to sludge and BOW management. Soil and compost quality analysis. Guidelines for compost use. Manual for compost testing and analysis. Organisation of training workshops.
L.A. Semlali	Assessment of existing situation in Morocco with regard to sludge and BOW management. Phytotoxicity tests on compost. Guidelines for compost use. Organisation of training workshops. Dissemination of results. Report preparation.
B. Bihaoui	Phytotoxicity tests on compost. Guidelines for compost use. Organisation of training workshops. Sludge, BOW and compost analysis.
R. Herrar	Analysis of BOW and sludge. Analysis of additives. Preparation of compost mixtures and additives. Soil analysis. Analysis of composts. Market opportunities for the compost product. Guidelines for compost use. Dissemination of results. Report preparation
W. Moustahwid	Analysis of BOW and sludge. Analysis of additives. Preparation of compost mixtures and additives. Soil analysis. Compost evaluation and analysis. Dissemination of results. Report preparation. Analysis in soil, plant and BOW.
F.E. Aboussabiq	Analysis of BOW and sludge. Analysis of additives. Preparation of compost mixtures and additives. Soil analysis. Development of composting processes. Measurements during composting processes. Process control – optimum operation of the pilot unit. Technical specifications – optimum operation of compost unit.
T. Chekroud	Development of composting processes. Measurements during composting processes. Maturation of compost. Process control – optimum operation of the pilot unit. Technical specifications – optimum operation of compost unit.
S. Moukhlissi	Development of composting processes. Measurements during composting processes. Maturation of compost. Technical specifications – optimum operation of compost unit.

Y. Salama	Development of composting processes. Measurements during composting processes. Technical specifications – optimum operation of compost unit.

NTUA

Name	Role and responsibilities
M. Loizidou	Coordination of the activities in which NTUA is involved – Supervision of their implementation – Scientific responsible – Responsible for the management
K. Haralambous	Assessment of the existing situation in European Union with regard to sludge and other BOW production and management (treatment, reuse and disposal). Physicochemical analysis of sludge and other BOW and additives. Development of phytotoxicity tests. Development of manuals for testing and analysis of compost. Participation in the management activities – Preparation of reports
A. Papadopoulos	Examination and analysis of the European Union legislative framework for waste management. Assisting in the design of the innovative sludge composting system. Development of specifications concerning the quality of the compost products. Participation in the management activities – Preparation of reports
M. Katsioti	Review of sludge and other BOW composting practices in European Union – Success stories. Performance of physicochemical analysis of sludge and other BOW and additives. Assessment of alternative uses of compost products. Development of manuals for testing and analysis of compost. Organisation of International Conference
St. Chamilakis	Review of sludge and other BOW composting practices in European Union – Success stories. Assisting in the construction of the unit and in the optimisation of alternative aerobic composting processes using sludge and other BOW in combination with alternative additives. Development of specifications concerning the quality of the compost products. Organisation of International Conference
Z. Loizos	Examination and analysis of the European Union legislative framework in connection to sludge. Assessment of the existing situation in European Union with regard to sludge. Development and optimisation of aerobic composting processes using sludge. Development of manuals for testing and analysis of compost. Participation in the management activities – Preparation of reports
K. Tsolomiti	Examination and analysis of the European Union legislative framework in connection to biodegradable organic waste (BOW). Development and optimisation of aerobic composting processes using sludge, individually. Effects on the production quantity and quality of selected cultivations. Development of specifications concerning the optimum operation of the composting system. Participation in the management activities – Preparation of reports
E. Grammatikos	Review of sludge and other BOW composting practices in European Union – Success stories. Assisting in the physicochemical analysis of sludge and other BOW and additives, in the development of phytotoxicity tests and in the development of manuals for testing and analysis of compost
M. Triantafillidi	Review of sludge and other BOW composting practices in European Union – Disposal of sludge in EU. Assisting in the setup of the innovative sludge composting system, in the development and optimisation of aerobic composting processes using sludge and in the preparation of reports
E. Doulami	Assessment of the existing situation in European Union with regard to the treatment and disposal of BOW. Review of sludge and other BOW composting practices in European Union – Success stories. Design of an innovative sludge composting system. Construction of the unit. Preparation of reports
P. Christopoulou	Review of sludge and other BOW composting practices in European Union – Success stories. Preparation of reports
D. Glekas	Assessment of the existing situation in European Union with regard to sludge and other BOW production and management (treatment, reuse and disposal). Review of sludge and other BOW composting practices in European Union – Success stories. Design of an innovative sludge composting system. Preparation of reports
St. Kokkosioulis	Examination and analysis of the European Union legislative framework in connection to sludge and other biodegradable organic waste (BOW). Review of sludge and other BOW composting practices in European Union – Success stories. Design, construction and testing of an innovative sludge composting system. Dissemination of project progress. Preparation of reports
St. Barafaka	Examination and analysis of the European Union legislative framework in connection to sludge and other biodegradable organic waste (BOW). Assessment of the existing situation in European Union with regard to sludge and other BOW production and management (treatment, reuse and disposal).Review of sludge and other BOW composting practices in European Union – Success stories. Design of an innovative sludge composting system. Construction of the unit.
N. Naoum	Review of sludge and other BOW composting practices in European Union – Success stories. Design and construction of an innovative sludge composting system. Preparation of reports
A. Kokkosiouli	Dissemination of project progress and results. Preparation of reports
P. Konstantara	EU legislation on sludge and BOW management – success stories. Preparation of reports
D. Rovas	Design and construction of an innovative sludge composting system. Preparation of reports
C. Koroneos	Design and construction of an innovative sludge composting system. Development and optimisation of aerobic composting processes using sludge, individually and in combination with and other BOW. Optimisation of alternative aerobic composting processes using sludge and other BOW in combination with alternative additives. Application of compost products in agriculture. Effects on the production quantity and quality of selected cultivations. Preparation of reports
D. Augerinos	Physicochemical analysis of sludge and other BOW and additives. Development and optimisation of aerobic composting processes using sludge, individually and in combination with and other BOW. Optimisation of alternative aerobic composting processes using sludge and other BOW in combination with alternative additives.
E. Kapetanios	Installation of the composting unit. Development and optimisation of aerobic composting processes using sludge, individually and in combination with other BOW and additives.
S. Malamis	Development and optimisation of aerobic composting processes using sludge, individually and in combination

	with other BOW and additives. Optimisation of alternative aerobic composting processes. Effects on the production quantity and quality of selected cultivations. Development of specifications concerning the quality of the compost products. Dissemination of project progress and results. Organisation of International Conference
Ph. Malamis	Physicochemical analysis of sludge and other BOW and additives. Development of phytotoxicity tests
A. Lekkas	Physicochemical analysis of sludge and other BOW and additives. Development and optimisation of aerobic composting processes using sludge, individually and in combination with other BOW and additives. Application of compost products in agriculture.Assessment of alternative uses of compost products
K. Rifouna	Optimisation of alternative aerobic composting processes using sludge and other BOW in combination with alternative additives. Development of phytotoxicity tests. Application of compost products in agriculture. Assessment of alternative uses of compost products. Development of specifications concerning the quality of the compost products
Chr. Kapetaniou	Application of compost products in agriculture. Assessment of alternative uses of compost products. Development of specifications concerning the quality of the compost products. Dissemination of project progress and results. Organisation of International Conference. Preparation of reports
K. Hapeshis	Application of compost products in agriculture. Development of specifications concerning the quality of the compost products. Preparation of reports. Dissemination of results
E. Kotsila	Development of phytotoxicity tests. Application of compost products in agriculture. Assessment of alternative uses of compost products
D. Farmakis	Application of compost products in agriculture. Effects on the production quantity and quality of selected cultivations. Assessment of alternative uses of compost products. Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses. Preparation of reports. Dissemination activity.
E. Salta	Phytotoxicity tests. Application of compost products in agriculture. Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses. Development of manuals for testing and analysis of compost. Dissemination of project progress and results
A. Theodoraki	Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses. Development of manuals for testing and analysis of compost. Preparation of reports.
M. Margaritis	Physicochemical analysis of compost and additives. Assessment of alternative uses of compost products. Development of specifications concerning the optimum operation of the composting system.
I. Poulla	Assessment of alternative uses of compost products. Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Preparation of reports. Dissemination activity. Organisation of conference
V. Dimos	Physicochemical analysis of sludge and other BOW and additives. Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses.
If. Gavriil	Development and optimisation of aerobic composting processes using sludge, individually and in combination with and other BOW. Development of phytotoxicity tests. Application of compost products in agriculture
A. Kokkalis	Physicochemical analysis of sludge and other BOW and additives. Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses.
V. Inglezakis	Physicochemical analysis. Development of phytotoxicity tests. Application of compost products in agriculture. Effects on the production quantity and quality of selected cultivations. Assessment of alternative uses of compost products. Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Dissemination of project progress and results by informing all the relevant parties and target groups
St. Gozdari	Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Preparation of reports
E. Tzempelikou	Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Dissemination activities. Conference organisation. Preparation of reports
D. Malamis	Analysis on cultivations. Effects on the production quantity and quality of selected cultivations. Assessment of alternative uses of compost products. Suggestions for the development of compost market network in Morocco. Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses. Development of manuals for testing and analysis of compost. Dissemination of project progress and results. Training session and workshops organisation and participation. Organisation of International Conference. Participation in the management activities. Preparation of reports
M. Stylianou	Analysis on cultivations and compost products. Application of compost products in agriculture. Effects on the production quantity and quality of selected cultivations. Assessment of alternative uses of compost products. Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses. Development of manuals for testing and analysis of compost
P. Tzias	Assessment of the composting uses. Standards for compost. Training session and workshop organisation. Organisation of International Conference
C. Loizou	Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products. Development of guidelines concerning the requirements for compost uses. Preparation of reports
Il. Rifounas	Development of specifications concerning the optimum operation of the composting system. Development of specifications concerning the quality of the compost products and compost analysis methods. Development of guidelines concerning the requirements for compost uses. Preparation of reports

A. Ouakka	Installation of composting unit. Development of composting processes. Process control – optimum operation of the pilot unit. Preparation of the open field experiments. Analysis on plant and soil. Dissemination activities
M. Rafrafi	Installation of composting unit. Development of composting processes. Preparation of compost mixtures and additives. Measurements during composting processes. Process control – optimum operation of the pilot unit. Dissemination activities. Phytotoxicity tests. Preparation of the open field experiments. Analysis on plant and soil. Report preparation
L. Gana	Measurements during composting processes. Phytotoxicity tests. Cultivations and measurements. Dissemination activities. Report preparation
Z. Merimi	Preparation of compost mixtures and additives. Phytotoxicity tests. Dissemination activities. Analysis on plant and soil.
F. Feniche	Installation of composting unit
El M. Ait Faria	Assisting in the design of the composting unit. Phytotoxicity tests. Cultivations and measurements.
B. Droussi	Assisting in the design of the composting unit. Development of composting processes. Installation of composting unit. Maturation of compost. Process control – optimum operation of the pilot unit. Analysis on plant and soil. Dissemination activities. Report preparation.
A. Assouli	Installation of composting unit
M. Khribech	Installation of composting unit. Development of composting processes. Preparation of compost mixtures and additives. Measurements during composting processes. Maturation of compost. Preparation of the open field experiments. Cultivations and measurements.

6. DESCRIPTION OF THE APPLIED TECHNOLOGY

The project focuses on the design, development and installation of an innovative composting system for the effective treatment of sludge and other biodegradable organic waste generated in Morocco. The technology that was applied for the implementation of the project involves the system's main and auxiliary components and all the means used for the evaluation of the produced compost.

Composition of the in-vessel composting system

Compartments for feeding the bioreactor

A shredder is used for shredding the green material and the small tree braches that are fed in the bioreactor to size less than 5mm (Figure 1). A 4m conveyor belt, show in Figure 1 was installed in order to load the input material to the supply portal.

Figure 1: Shredding device in operation and the employed conveyor belt for loading the input material to the bioreactor

Operation of the in-vessel composting system (bioreactor)

The design has taken into consideration factors such as the use of state-of-the-art in-vessel composting technology, the minimization of environmental impacts and risks to

public health, the compliance with European Union environmental legislation and policy and the production of a high quality compost that can be marketed.

The composting system is composed of the following parts: the bioreactor chamber, the support base, the supply and removal portals, the substrate agitation -stirring system, the air suction system, the substrate hydration system, the bio-filter and the leachate removal system. Each component is describe more analytically below.

Bioreactor chamber (Figure 2): The in-vessel system consists of a cylindrical in-vessel bioreactor that has a total volume of 3.979 m^3 and a workable initial volume of approximately 2.4 m^3 (60% of the total volume). The cylinder has an internal diameter of 1.3 m and an internal length of 3m. The bioreactor chamber is suspended at a height of 0.8m from the surface and it is resting on an appropriate support base. The outside bio-cylinder surface, as all other peripheral equipment have anticorrosive protection which includes sand blasting and two paint coats of epoxy paint. The inside surface of the drum has a primer anticorrosive protection.

Figure 1: Front View of Bioreactor Unit

Supply portal (Figure 3): For the supply purposes a circular 12-inch diameter opening was positioned at the top central part of the bioreactor as shown in Figure 3. The supply of sewage sludge and of shredded green material takes place through the conveyor belt which supplies the bioreactor with the required quantity of sludge and other BOW, depending on the required substrate composition.

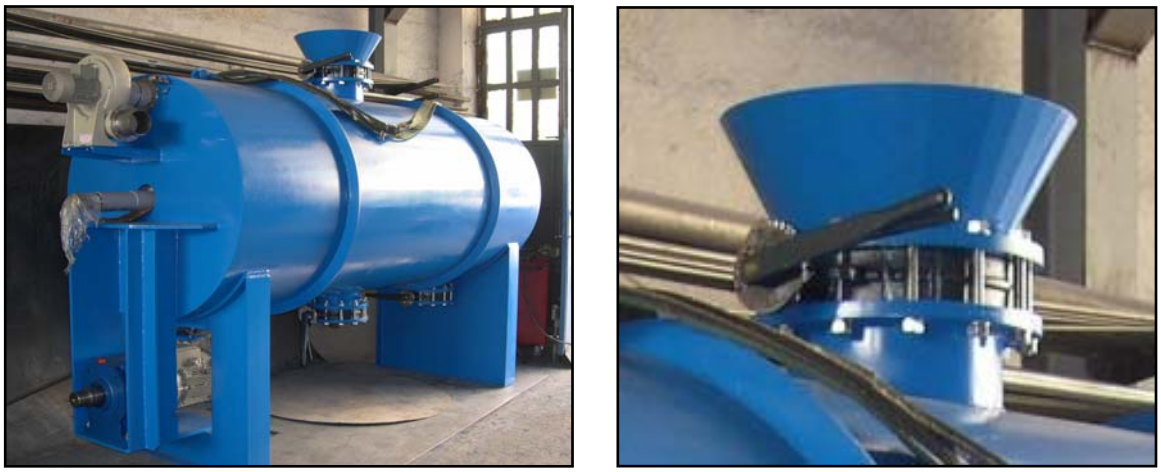

Figure 2: Supply portal for loading the input material into the bioreactor

Collection and Removal portals (Figure 4): Diametrically opposite to the supply portal three circular 10-inch diameter openings were constructed (one in the central part of the side surface and one on either side of it) for the removal of compost.

Leachate removal (Figure 4): Leachate is produced from moisture extraction of the substrate mainly due to its hydration and partly by the molecular water resulting from the bioxidation of the organic matter Leachate is removed from the bioreactor through a ½ inch pipe system where the continuous bioreactor leachate draining takes place.

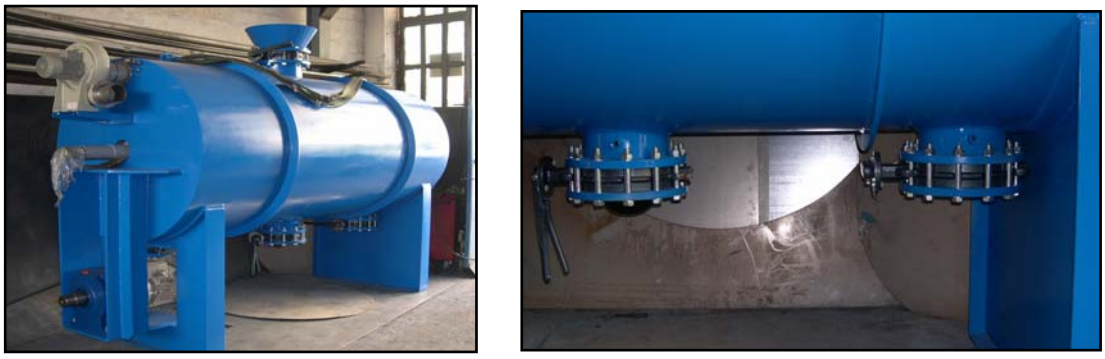

Figure 2: Compost collection portals & leachate removal system

Agitation system (Figure 5): The agitation system comprises of a steel revolving axis which runs along the bioreactor chamber. The axis carries steel blades which are distributed along its length. Therefore the agitation of the substrate is achieved through a respective arrangement which is placed along the notional cylinder axis. The design and the arrangement of the blades were performed in such a way as to provide a uniform agitation, hydration and ventilation of the substrate and preventing the substrate to aggregate. The left base of the cylinder (left hand side of the bioreactor) is removable so that the inside of the bioreactor may be accessible and at the same time allows the removal of the axle – stirrer, if required.

Figure 3: Drawing of the agitation system running along the bioreactor shell

Air suction System (Figure 6): Providing oxygen to the substrate is a very basic parameter of the composting process since oxygen is prerequisite for the aerobic biological processes to take place. For this purpose a centrifugal fan was installed in order to supply the required amount of air to the substrate. The fan sucks air from the bioreactor's interior and blows it outside while at the same time, fresh air is introduced inside the bioreactor after it has first passed through a filter. The gasses emitted during the biological processes pass through an air pipe to the **bio-filter (Figure 7)**, which is

used for the deodorization of the air. Air supply, apart from supplying with oxygen, contributes to the lowering of substrate humidity and enriching the bioreactor with oxygen by removing other gases such as carbon dioxide and ammonia. Air emissions produced during composting contain chemical compounds which have a strong and unpleasant odour. Therefore the use of a bio-filter contributes in the drastic reduction of odours. A suction fan blows air from the bioreactor, to the bio-filter, through a pipe which ends at the bio-filter, running through one side of the low wall and at a height of 100 mm from the base. The air blown passes successively through the pseudo-pavement, the geomembrane, it is diffused in the body of the mature compost bed and exits from the upper surface of the bio-filter bed, having a deodorization estimated at 82%.

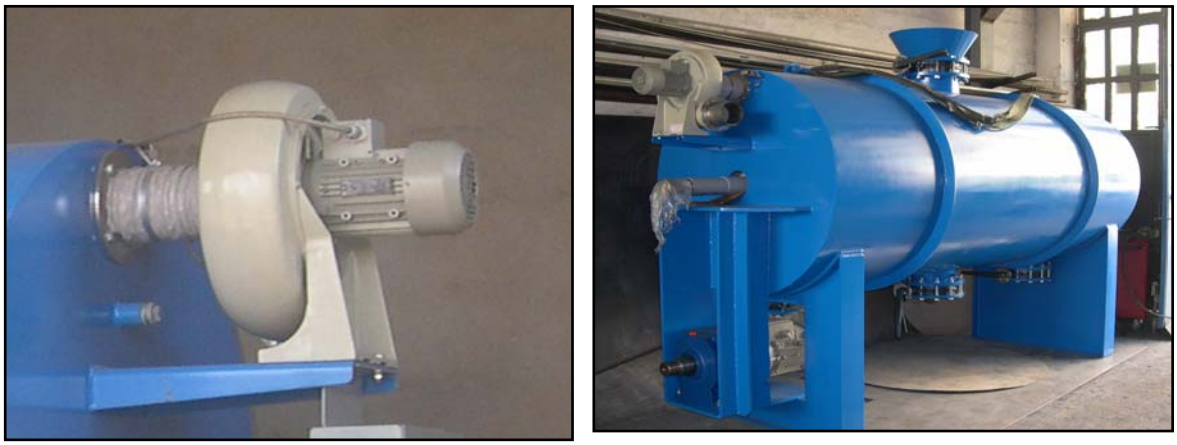

Figure 4: Image of the composting system incorporating the biofilter at the left hand side

Figure 5: Bio-filter system at the left hand side of the bioreactor

Hydration system: Moisture is essential for all living organisms since it supports their metabolic processes while water is the medium for the chemical reactions, transportation of nutrients and allows the microorganisms to move about. Therefore substrate hydration is an essential parameter in composting since it influences the system biology. Water is distributed inside the bioreactor chamber through a pipe installed at the top part of the bioreactor and runs internally through the whole length of the bioreactor. To ensure the required substrate humidity a simple time processor is installed through which water supply is controlled.

Programming Logic Controller (PLC) Figure 8: The control and monitoring of the composting processes which take place in the bioreactor is performed mainly by a PLC automatic control system which controls the agitation the aeration and the hydration system. The use of the PLC is accomplished through appropriate software designed specifically for this case.

Figure 6: Inside View of the Control Panel

Evaluation of the implementation of the composting system

The evaluation of the in-vessel composting system was implemented on three stages based on the quality of the produced compost. This involves the examination of:

- ✓ the physicochemical characteristics of the end product which constitute the basic criterion for the evaluation of the composting processes. Analyses included measurements of the water content, pH, total carbon, total nitrogen, carbon to nitrogen ratio (C:N), nitrates nitrogen (NO^-_3-N), ammonium nitrogen (NH^+_4-N), total phosphorous, total potassium, magnesium, manganese, calcium, heavy metals concentration (Cd, Cr, Cu, Ni, Pb, Zn) and biological activity.
- ✓ the phytotoxicity level of the produced compost. This was performed in order to evaluate the level of potential phytotoxic compounds incorporated in compost which may inhibit plant health and growth and seed germination.
- ✓ the field experiments to evaluate whether the derived product enhanced seed germination for specific crops. The experiments enable to evaluate the agronomic value of compost and to implement an impact assessment of compost on the physicochemical characteristics of the soil as well as on the growth and the development of cultivations in real environmental conditions.

7. TECHNICAL PROGRESS, RESULTS AND DELIVERABLES

The project was realised in an appropriate pilot scale in order to demonstrate and document the feasibility of effectively treating sewage sludge and other BOW via a prototype in-vessel composting system. The technical development of the project was materialised through the implementation of six tasks, as described analytically in the following text.

Task 1: Assessment of the existing situation in Morocco and in the EU

Subtask 1.1 refers to the assessment of the existing situation in Morocco with respect to the production and management of sludge and other biodegradable organic waste. The assessment of the Moroccan situation was based on the collaboration of UCD with ORMVAD and by contacting several relevant Moroccan authorities in order to obtain the required information. All the data and information related to the development of subtask 1.1 are included in Deliverable 1 that was submitted to the EC in the 1st progress report along with the following annexes:

- Annex 1: Production of Sludge from Wastewater Treatment Plants in Morocco

- Annex 2: Sewage Sludge production in Morocco
- Annex 3: Production of biodegradable organic waste generated by the food industry in Morocco
- Annex 4: Examination of the residues of timber processing and the waste of slaughterhouses of red meat in Morocco
- Annex 5: Evaluation of the production of agricultural residues in Morocco

Subtask 1.2 refers to the assessment of the existing situation in EU in connection to sludge and other biodegradable organic waste and the related legislation. This work was carried out by the NTUA based on the NTUA experience and prior work, based on information from the European Environmental Agency and from Eurostat and on reports of the European Commission. This was complemented by several other relevant bibliographic references and internet sites. All the data and information related to the development of subtask 1.2 are extensively presented in Deliverable 2, which assesses the existing situation and the related legislation in EU in connection to sludge management, and Deliverable 3 which assesses the existing situation and the related legislation in EU in connection to BOW management. Both Deliverables were submitted to the EC in the 1st progress report.

Subtask 1.3 refers to the review of best practices and success stories of composting of sludge and other BOW in the EU and internationally. This subtask was implemented by the NTUA. For the successful implementation of the report on success stories various operators of specific sites were contacted to provide information on their composting site. Also, well-known construction companies were contacted (i.e. GICOM, BTA, Herhof, Orgaworld and others) in order to provide information on the composting facilities that they have designed and constructed. All the data and information related to the development of subtask 1.3 are extensively presented in Deliverable 4A that was submitted to the EC in the 1st progress report (as Deliverable 4).
Under the framework of Task 1 two site visits were envisaged, one in Germany and one in Switzerland. Since Switzerland has banned the composting of sludge it was decided to perform the site visits in the plants of the company BTA at Munich (Germany) and in the plants of the company Herhof at Rennerod (100 km outside Frankfurt). The German companies Herhof and BTA were selected since their facilities focus solely on waste treatment and offer innovative technologies for organic waste treatment. Furthermore, these two companies were the only ones that could assure us that we could visit two of their plants and not just one, thus maximizing technology transfer. The site visits took place during the 11-15th of September 2006. It was decided to move the visits from the initially planed dates (April 2006) in order to allow for some time for the beneficiary and the Moroccan partner to first evaluate the generation of sludge and other organics in their country (subtask 1.1). Furthermore, more time was allowed in order to select appropriate facilities that will maximize the transfer of know-how. In total 4 waste treatment facilities were visited, 2 in Munich and 2 in Rennerod. The site visits were very successful. The participants were able to acquaint themselves with a wide range of waste treatment technologies, including composting, anaerobic digestion, mechanical separation, pre-treatment of waste. All the data and information related to the site visits are presented analytically in Deliverable 4B that was submitted to the EC in the 2nd progress report.

Task 2: Design and construction of an innovative sludge composting system
The objective of this task was to develop and implement an effective and innovative in-vessel composting system, taking into consideration factors such as local characteristics,

proven technology, environmental impacts, minimal risk to public health, compliance with European Union environmental legislation and policy, sustainable market for the end product, flexibility and use of materials of Mediterranean origin as additives. The composting system was designed in such a way as to ensure the minimization of odours and process time by controlling operational parameters such as airflow rate, temperature and agitation and to produce high quality compost. The bioreactor operates in a batch mode and comprises of the bioreactor chamber, the support base, the supply and removal portals, the substrate agitation system, the substrate air suction system, the substrate hydration system, the leachate removal system, the control equipment which monitors the agitation hydration and air suction systems, the shredder, the biofilter, the airpipe with which the air emissions from the bioreactor are transferred into the biofilter and the conveyor belt which supplies the bioreactor with the feedstock.

The prototype composting unit has been successfully designed, constructed and installed by NTUA in collaboration with UCD at the Zemamra site (Morocco) at the premises of ORMVAD located approximately 70 km away from the town of El Jadida.

Task 2 has been completed with significant delay. The design of the composting system had finished on time on the 20th of July 2006 in Greece. The construction of the system was completed at the beginning of December with a 2-month delay. This delay was due to the late arrival of certain system components (motor, fan) that were necessary in order to complete the construction of the unit. Although the materials were ordered on time, the supplier did not deliver this equipment on time. Task 2 was subjected to further delay due to a very long strike at the port of Peiraias. The system was ready to be shipped on the beginning of December; however, the personnel at the port of Peiraias (Greece) responsible for loading and unloading cargoes was on a strike that lasted the whole of December (2006), January and part of February (2007). As a result, during this period, no cargos left or entered the port of Peiraias for other destinations. This created a long delay; even after the cessation of the strike it was difficult to send the shipment as many other shipments had to leave the port. The system was finally shipped at the beginning of February and arrived at the port of Casablanca at the end of February 2007. The composting system has been successfully installed at the premises of ORMVAD. A special room has been built to house the composting system.

The 5-month delay of the implementation of Task 2 had an impact in the development of the following Tasks therefore a 6 month extension was requested and given by the EC.

For to the implementation of this task the beneficiary and the Moroccan partner performed a visit to Greece. Although it was initially planned to have two three-day trips of 4 members of the Moroccan working team to Greece a single 6-day trip took place by 8 members of the Moroccan working team. According to the proposal the trip was planned to take place on the 10th of June 2006 however the meeting had to move at a later stage of the program since at that time (9th of June 2006) a project meeting was held in Morocco within the framework of the Euro-Mediterranean project MEDAWARE. Therefore the trip of the Moroccans to Greece had been arranged for the 21st to 24th of September however the trip actually took place between the 25th and 31th of October 2006, a month later, due to the Ramadan. During this meeting, the NTUA presented to the Moroccan partners the design of the composting system. Furthermore, the details of the transportation, installation and start-up of the system were discussed among the beneficiary and the partners. Finally, the trip of the Greek team to Morocco for the system installation was performed on 14-19 of March 2007, instead of 19th of August 2006 due to the aforementioned delays in the construction and the shipping of the bioreactor.

The following Deliverables have been produced in the framework of Task 2 and have been submitted to the EC in the 2nd progress report:

- Deliverable 5A: Technical description of the in-vessel system designed by NTUA

- Deliverable 5B: Detailed drawings of the complete unit and its components
- Deliverable 5C: Pictures of the composting system and its components
- Deliverable 5D: Description of the Zemamra Site

Task 3 Development of sludge aerobic composting processes – Optimisation of the operation of the pilot composting systems

The 3rd task involves the development of aerobic composting processes using primary and secondary sludge, other BOW (green waste and manure) and effective additives (zeolite, perlite). To justify the successful implementation of the development of effective composting and co-composting processes and optimisation of the system various experiments were carried out. These experiments were focused on the compost quality characterization and on the effects of the operational conditions on the efficiency of the process, as well as on the end product quality. Extended physicochemical analyses were performed for the characterisation of the raw materials that had been used for composting. These materials included primary sewage sludge from the city of El Jadida, secondary sludge from food industry, sugar beet leaves, straw residues, sheep and cow manures in various ratios. Due to the unavailability of the UWWT plant in El Jadida at the time of the execution of the project to provide us with secondary sludge, no composting trials have been performed using secondary sludge from an UWWT plant as raw material for composting. Although there were other treatment plants operating outside the city of El Jadida that could provide us with sufficient amount of secondary sludge, the long distance as well as the high transport cost were prohibitive to apply this material into the bioreactor from those plants. Instead of secondary sludge from the UWWT plant in El Jadida it was considered appropriate to perform a composting trial using secondary sludge from a food industry. In addition it was considered appropriate not to use sludge generated from PWRs into the composting system since the high content of inert material, mainly sand and minerals, was qualitatively inappropriate for the composting process. Furthermore, due to the high moisture content of primary sludge it was considered appropriate not to use primary sludge individually but to mix it with green wastes which operate as excellent amendments and bulking agents. The high moisture content of sludge arises from the fact that there were not dewatering installations in the region where primary sludge was produced.

Green waste, that was used into the system, comprised of sugar beet leaves and straw residues provided by Moroccan farmers. Since sugar beet and wheat are the primary cultivations that are being practiced in Doukkala region, sugar beet leaves and straw residues were considered appropriate to be used as an input composting material due to their high availability and negligible cost. Manure of different origin (sheep and cow) was also used in the composting trials since the high availability and organic content, the low heavy metal content and the absence of other hazardous substances make manure excellent composting material. Furthermore manure acquires high nitrogen and phosphorous content which are basic nutrient components for plant growth.

Additives such as zeolite and perlite were obtained from Moroccan local market. Zeolite was used as additive in order to examine primarily the heavy metals removal from the substrate and secondly is its capability to adsorb the volatilized ammonia during composting. The importance of the later lies in the fact that nitrogen losses, which occur mainly during the initial stages of composting, result from ammonia volatilization. High losses of ammonia nitrogen represent a waste of a valuable resource and reduce the agronomic value of the end-product. The importance of perlite use as an additive lies in the fact that it modifies the physical properties of the substrate (e.g. structural support, porosity, aeration) to promote composting by increasing the void volume of the substrate without involving into the biochemical process of composting due to its inert properties.

To determine the optimal course of composting four different composting trials have been performed using the aforementioned waste in various ratios and under different operational conditions. The selection of the experimental set-up was determined according to the feedstock material and its characteristics while at the end of each trial valuable feedback was obtained for the optimisation of the next composting trials. The temperature, moisture and oxygen content of the substrate was closely monitored on a daily bases during composting while for the evaluation of the processes complete physicochemical analyses have been performed (i) to the substrate[1] throughout the duration of the composting processes (ii) to the derived product[2] resulting from each composting trial and (iii) to the leachates[3] produced from each composting trial. Furthermore biological and micro-biological analyses have been performed prior and after the composting processes to estimate the density reduction of pathogenic microorganisms since sludges contain great amounts of pathogens which constitute a health hazard for plant and human contamination. Finally heavy metal speciation has been performed to the produced compost in order to evaluate the potential accumulation level of heavy metals by plants when compost is applied.

The start-up of the composting process took place with the collaboration of all partners while the collection and transport of the feedstock material was performed by members of UCD and ORMVAD. The daily operation of the composting system was carried out by UCD in collaboration with ORMVAD personnel, while NTUA provided expertise for optimizing the system's operation. The required laboratory analysis took place in the premises of UCD while additional analysis have been performed by NTUA members from compost samples that UCD had provided for consistency reasons.

Task 3 was developed smoothly without any problem and it resulted in the operation of the composting unit under optimum conditions and in the production of high quality composts based on their physicochemical and biological characteristics. The activities of Task 3 have been completed successfully on the 10th of August 2007, according to the revised time schedule (6 months later than initially planned). Task 3 could only commence once the system had been installed therefore the delays occurred during Task 2 had an impact in implementing Task 3 as initially scheduled (10/04/07).

A single report was performed in the framework of Task 3 (Deliverable 13) which included the physicochemical analysis of sludge, BOW and the selected additives, the optimum conditions for the composting unit and the evaluation of the produced compost. Deliverable 13 was submitted to the EC in the 3rd progress report.

Task 4: Evaluation of compost products as soil improvers

The objective of Task 4 is to evaluate the quality characteristics and suitability of composts resulting from Task 3, as soil amendments and/or fertilizers for agricultural practices. Composts that use raw material which originates from sludges can be

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[1] Analyses included measurements of the pH, total carbon, total nitrogen, nitrates and ammonium in regular time intervals

[2] Analyses included measurements of the water content, pH, total carbon, total nitrogen, C:N ratio, nitrates nitrogen, ammonium nitrogen, total phosphorous, total potassium, magnesium, manganese, calcium and heavy metals concentration.

[3] Analyses included measurements of the pH, BOD_5, nitrates, ammonium and heavy metals in regular time intervals

potentially harmful to human health as well as to the environment when applied on land. To evaluate the suitability for agricultural application of each of the compost products, series of laboratory phytotoxicity tests have been performed to examine the effects of composts on seed germination and plant growth whereas open field experiments were implemented to examine the effects of compost application to the quantity and quality on the yield of the selected cultivations and the effects of compost on the physicochemical characteristics of the soil where compost was applied.

The laboratory phytotoxicity tests indicated that the produced compost was phytothreptic for all the composting trials that have been performed during the 3rd Task. This is evident of the absence of phytotoxic compounds that can inhibit seed germination or damage plant growth. With respect to the open field experiments three species of seeds were selected for cultivations, namely maize, wheat, sugar beet roots. The cultivation of wheat was abandoned due to plant illness caused from an external source while sugar beet and maize experiments were successfully implemented.

The experimental programme on sugar beets was successfully carried out. The experimental procedure involved the testing of mixture of equal amounts of compost from trials 2 & 3 and in different doses. According to the obtained results, the compost had no negative effect on the germination, nor on sugar beets growth at the 48th day after sowing. On the 82nd day after sowing it was confirmed that different doses of compost had positive effects on sugar beets growth. In particular biomass evolution of plants showed an exponential growth in relation to the amount of compost used confirming the stimulating effects of compost on sugar beets growth. The compost doses applied of 2.5T/ha, 5.0T/ha and 7.5T/ha presented an increase to the total plant growth of approximately 3.5%, 31.5% and 52.0% respectively. Whereas the ratio of the average weight of leaves over that of the root also increased by of 6,5%, 13,7% and 16% for compost doses of 2,5T/ha, 5T/ha and 7,5T/ha respectively.

For the maize cultivations, two different composts were used. The first compost was obtained from an equal mixture of compost resulted from trials 2 and 3, compost no (2+3), while the other one was obtained from the 4th trial compost no 4. After seeding and on selected time intervals, the height of the maize was measured. The results from maize cultivations verify the beneficial effect of compost as fertilizer. The cultivations lasted 77 days and in the initial stage, compost did not affect the growth but as time elapsed the cultivations were much affected by the presence of compost. For both composts, the cultivations using 5 T/ha show better results than the cultivations using 7,5 T/ha, or fertilizer. Comparing the two different types of compost it is shown that compost 4 shows a slightly better performance. The experimental results indicate that 32% and 42% more growth is achieved when composts no (2+3) and no4 respectively were used. Also the growth was better when using compost, than using fertilizer, the increase in growth being 21.3% and 30.4% depending on the type of compost. Also, it was observed that lower compost quantities 5 T/ha give better results than higher quantities of 7.5 T/ha.

It is worth mentioning that the experimental analysis related to soil quality and characteristics indicate a very low organic matter as well as low nutrient concentrations, parameters that affect plant growth. The addition of compost has increased the organic matter of the soil as well as the presence of nutrients, phosphorous, potassium and nitrogen. Heavy metals are in very low concentrations. This was expected due to the fact that heavy metals were found in low concentration in the produced compost as shown in Task 3 (Deliverable 13). The available metal ions that can be taken by the plants are metals obtained through sequential extraction and this amount is very low. The gradual enrichment of the soil with compost will eventually assist the improvement of its fertility and hence the plant growth while heavy metals can remain in low concentrations.

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UCD and NTUA in close collaboration with ORMVAD were responsible for the successful implementation of this Task. The UCD laboratory team performed the phytotoxicity tests whereas NTUA members had carried out additional analysis for consistency reasons from compost samples that UCD had provided. With respect to the open field experiments, ORMVAD provided the arable land area necessary for the cultivation tests located near the composting site in the SEMVA in Zemamra region. The performance of tests as well as the daily supervision of the site was performed by UCD in collaboration with ORMVAD personnel.
Task 4 was subjected to a delay since it was considered appropriate that the composts resulted from the 3rd Task had to remain outdoors for a sufficient period of time for further maturation. During the maturity phase composts were applied on an open area just outside the bioreactor site and they were subjected to regular manual agitation and aeration in order to improve furthermore their properties. The incorporated ammonium in composts was an issue of concern due to the potential toxic impact that may have on plant growth and seed germination.
Therefore Task 4 was subjected to a 3 month delay with respect to the revised time schedule (10/3/08). However the late implementation of task 4 did not change the end date of the project but it just shifted the duration of Task 4 till June 2008 instead of March 2008 (revised schedule). In regard to the initial plan (10/10/07) task 4 had an 8 month delay since Task 2 inevitably delayed the development and implementation of the task. For this reason a new report, Deliverable 14b, supplementary to Deliverable 14 was prepared to include the experimental results that were obtained after the scheduled submission date (01/04/08).

Task 5: Alternative uses of compost – Market opportunities in Morocco
The objective of Task 5 was to find and suggest possible alternative uses of compost products, the criteria needed for the development of a niche compost market in Morocco as well as possible opportunities that may arise from compost production and distribution processes. The report presents characteristics of the agro-ecological areas in Morocco and the prevailing cultivations in the country. Also the organic content of soils is given and it is clearly indicated that deterioration of soils occurs with organic matter decreasing each year. Next an analysis was performed on the current situation in terms of the use of manures and it was shown that they are under-used compared to the needs. The low level of use of manure results not only in a loss in output, but also in a continuous degradation of the Moroccan soils in nutrients as well as in organic matter and hence in lower productivity. The real need for the country is approximately 2.5 million tons on an annual basis and the consumption is less than 40%. As far as the market development is concerned it is mentioned that marketing of manure is not organized and the sales are generally done in a non controlled system. In Morocco, the country's supply with manure is assured mainly by one big company (approximately 42%), two average size companies (36%) with an annual average quantity distributed varying from 156.000 to 190.000 tons; three small to average companies (14%) and six small companies (8%).
The local distribution of manures is done through three principal networks which can be also used for the market development of compost. It should be stressed that at the moment compost market is limited since compost production results only from small scale composting units. It is estimated that the need of stable organic matter such as compost in Morocco amounts to approximately 6.25 million tons per year. To produce this amount BOW can be used such as sludge from WWTPs and agricultural and animal waste.

The Task was assessed through the use of various literature reviews, internet survey, meetings with experts, authorities and representatives of existing compost networks worldwide. The UCD was responsible for the successful implementation of this Task in close collaboration with NTUA. No difficulties were encountered during the implementation of this task since UCD has an integral view of the Moroccan market and there was also strong support from the Moroccan government through the ministry of environment. However the delays occurred during Task 2 had an impact in implementing Task 5 as initially scheduled (10/10/07). For this reason task was initiated on 10/03/08 and implemented on 10/05/08.

A single report was prepared in English as well as in French with the title "Market of compost produced from sludge and other Biodegradable Organic Waste in Morocco". The English version is attached as Deliverable 17A while the French version as Deliverable 17B, both submitted to the final report.

Task 6: Development of guidelines and specifications covering the sludge composting process - Characterization and use of compost as soil improver

Task 6 concerns the determination of the technical specifications for the optimum operation of the composting system. Moreover, this task involves the set-up of quality requirements of the compost products. The quality requirements allow the categorization of the end products derived from the treatment of sludge and other BOW. Furthermore, guidelines concerning the requirements for compost application on land (e.g. agriculture, horticulture, private gardening, covered cultures and landscaping) were appointed. Finally, test methods and analyses for compost samples were specified. Task 6 resulted (i) in the development of specification on the optimum operation of the in-vessel composting unit (ii) providing guidance to competent authorities in Morocco in the development of a set of robust and commercially beneficial compost standards and end use specifications in Morocco based on the existing worldwide experience as well as (iii) test methods for the evaluation of the produced compost. The assessment of this task was based on reference material from the related literature (national guidelines and success stories from other countries) and the experience derived from the implementation of the whole project. The NTUA team was responsible for the successful implementation of this Task, in close collaboration with UCD.

The report concerning the specifications of the optimum operation of compost units is attached as Deliverable 18A .The report on the specifications concerning the quality and compost products and their possible uses is attached as Deliverable 18B. The manual for physicochemical compost analysis is attached as Deliverable 18C. These Deliverables are submitted in the final report.

8. DISSEMINATION ACTIVITIES AND DELIVERABLES (2 PAGES)

8.1 Dissemination Plan (summary)

The dissemination plan of the project included the following activities:

- Complete set of training material and minutes from workshops
- Printed material describing the project and its results
- Website describing the project and its outcomes
- Minutes of the kick-off meeting in Morocco
- Minutes of the kick-off meeting of Life Third Countries Projects in Brussels

- English and French Leaflet
- Publications in press
- Technical papers-publications
- International conference proceedings

8.2 Activities implemented and output

Regarding the project dissemination, several efforts have been made with remarkable results during the entire implementation of the project. In particular:

Minutes of the kick-off meeting in Morocco

A launching event which took place at the kick-off meeting in order to inform all the relevant stakeholders of the project's objectives and the ways these would be achieved. The kick-off meeting and the launching event were held at the Faculty of Sciences of El Jadida of the University of Chouaib Doukkali (UCD) of Morocco on the 9th of February 2006. The events were well-attended with 15 relevant organizations participating including the Ministry of Regional Planning, Water and Environment, the Ministry of National Education, Higher Education, Managers training and Scientific Research, the Ministry of Interior, Mr. K. El Hariry who is Member of the Moroccan Parliament and two journalists.

At the kick-off meeting the project objectives and expected results were presented, as well as the activities interests and current status of the beneficiary and each partner. Emphasis was also given on the required actions, the deliverables, the responsibilities of each partner per Task and the time schedule of each task. The kick-off meeting received high publicity; three articles were published in the Internet informing the public of the kick-off meeting and the project:

- Actualities in El Jadida – Arts and Culture
- http://www.eljadida.ma/actualite_news_el_jadida/les-fauconniers-lekouassems-d-ouled-frej-s-ouvrent-sur-l-europe-a128.html
- L'Economiste http://www.leconomiste.com/article.html?a=68648
- AllAfrica http://fr.allafrica.com/stories/200602130356.html

The minutes of the kick-off meeting in Morocco are presented in Deliverable 6 which was submitted in the 1st progress report.

Minutes of the kick-off meeting of Life Third Countries Projects in Brussels

The kick-off meeting of Life Third Countries Projects in Brussels was carried out in 6-7th June 2006 and Prof Omar Assobhei (Project manager of the MOROCOMP project) and and Prof Abdelhanine Belhaj (General Secretary of the University Chouaib Doukkali, beneficiary) were attended. The meeting was a nice opportunity to explain what EC does, outline its expectations for the MOROCOMP project, provide some training on the requirements, and most importantly, answer queries to avoid potential problems during the implementation of the project. The meeting gave also the opportunity to the attendees to discuss their project with the technical and financial desk officers. The EC has shown how the project work would be evaluated and what were the main elements that the project should focus on. EC had also made use of some aspects of the 2005 selected projects and presented some 'expected results for projects' in our workshop in order to discuss appropriate indicators of performance, and the means of verifying information.

The minutes of the kick-off meeting of Life Third Countries Projects in Brussels are presented in Deliverable 7 which was submitted in the 1st progress report.

Printed material describing the project and its results

A leaflet presenting the project objectives, actions and expected results was prepared and distributed. One version was prepared in English and was distributed in Greece and one version was prepared in French and was distributed in Morocco. The leaflet was presented in Deliverable 8 and was submitted to the EC in the 1st progress report.

Publications in press

The MOROCOMP project objectives and expected results have been disseminated through 5 newspaper articles: the Moroccan Times (English), L' Economiste (French) and Liberation (French), El Jadida (French), and in the Arabic newspaper Saout Nass. Furthermore, MOROCOMP was presented in the University newspaper that is published every 6 months. All these articles are given in Deliverable 9 which was submitted to the EC in the 1st progress report.

Website describing the project and its outcomes

Two web-sites have been uploaded for the project since March 2006; one at the premises of the beneficiary (www.ucd.ac.ma/morocomp) and one at the premises of NTUA (www.uest.gr/Morocomp).These sites were regularly updated in order to accurately present the progress of the programme.

Complete set of training material and minutes from workshops

1st workshop/training session - competent authorities

The 1st training session – workshop took place on the 8th of November 2007 in Morocco and was addressed to Moroccan competent authorities in order to promote capacity building and the concept of composting of sludge and other BOW in Morocco. The topic of the 1st training session – workshop was the "Production, management and valorization of sludge from wastewater and other biodegradable organic waste" and was initiated after the welcoming speech of Prof Y. Boughaleb Dean of the Faculty of Sciences in El Jadida who referred, inter alia, on the role of this dissemination activity in the promotion of clean technologies for sustainable environmental management. The training session/workshop involved speeches from members of the NTUA and UCD while after the presentations a discussion was initiated covering a range of issues such as (i) the importance of setting demonstration systems for the promotion of solid waste technologies and sludge management in Morocco (ii) the solid waste management in Morocco and the related legislation (iii) the composting process of sludge and BOW and the use of compost as a soil improver. The participants that joint the 1st training session – workshop included researchers and students of the UCD, representatives of competent authorities (ministries, regional and local) as well as representatives of various companies and associations concerned with the management of wastewater and solid waste.

More details related to the presentations were attached in Deliverable 15A. The event's program is attached Deliverable 15B and involves speeches from members of NTUA and UCD a constructive discussion between the beneficiary, the project partners and the participants as well as a visit to the composting pilot unit. Both deliverables were attached in the 3rd progress report which has been submitted to the EC.

2nd workshop/training session - informing the farmers

The 2nd training session/workshop was carried out on the 22nd of May 2008 in which various farmer associations and individuals participated. This event was in the form of demonstration-tour to the composting facility to familiarize farmers with the concept of compost and composting and its benefits of using compost as a soil conditioner both

economically and in terms of its properties. More details related to the 2nd training session/workshop are presented in Deliverable 19 which is attached to the final report.

3rd training session/workshop - private companies and industries

The 3rd training session/workshop was held on the 14th of July 2008 for the private companies and industries that are interested in compost production and marketing in Morocco. The 3rd training session/workshop was entitled as "Compost production from sludge and BOW and the development of compost market in Morocco". The training session/workshop involved speeches from members of NTUA, UCD and ORMVAD which were related to activities such as compost quality and characteristics resulting from the MOROCOMP in-vessel composting unit, the current condition of compost market in Morocco and the potential of compost application on land as soil improver and/or fertiliser as well as ways and means of establishing and developing compost markets in Morocco based on successful case studies from countries that exercise and practice composting for many years. In the training session/workshop various private companies and representatives of the industrial Moroccan sector participated and had the opportunity to be informed about the 'systems' that are currently in place in many countries which are designed to promote composting and compost marketing in a manner which respects requirements to protect human, animal and soil health. Furthermore a constructive discussion followed up the presentations which referred inter alia (i) on the quality of compost produced from the in-vessel composting system and the applicability of the produced compost on land (ii) the commercialisation potential of the in-vessel composting unit and (iii) on the creation and development of a 'system' in Morocco for the development of compost market. A tour to the in-vessel composting system was also performed and prospective investors had the opportunity to see how the system operates, to observe end product samples. Finally a leaflet was prepared and distributed among the participants of the 3rd training session/workshop in which the composition and the characteristics of the in-vessel composting unit is described while the environmental and economic benefits of its application are also presented. The leaflet is presented as Deliverable 20B while more information on the 3rd training session/workshop are presented as Deliverable 20A. Also the programme of the 3rd training session/workshop is Deliverable 20C. All deliverables are attached in the final report.

International conference proceedings

Within the framework of MOROCOMP project an international conference on sustainable sludge management (SSM -2008) was held on the 9th and 10th of July 2008 at the Ecole National de Commerce et de Gestion, El Jadida, Morocco where the official presentation of the project took place. The main topics of the conference included (i) treatment technologies of water and sludge (ii) composting and nutrient recovery from sludge and wastewater and (iii) policy and guidelines for sludge management. The conference was promoted mainly through the official website of MOROCOMP project of UCD and NTUA while numerous emails were sent to various organizations, international associations, universities, research institutes, industrial organisations etc. well in advance. The event was implemented successfully, fact that was indicated by the high number of the participants (approximately 300) during the two day event including international research institutions and universities, various industrial organisations and international associations. Researchers from more than 12 countries from Africa Europe and Asia have participated. The conference was organized by the beneficiary (UCD) and took place under the auspices of the ministry for national and higher education, of the management training and of the scientific research and the state secretariat in charge of water and the environment, and with the support of the Hassan II academy of sciences and techniques. This conference gave the opportunity to debate about the technologies of

sludge treatment and to present the experience gained in other countries. The legislative and policy framework concerning the management of sludge was presented and there was a fruitful exchange of experiences between countries which envisaged large national programmes on sludge treatment similar to the MOROCOMP project. The conference has gathered public and private operators specializing in the domain of water management, researchers and experts from Morocco, Africa, Greece, Germany, Spain, Cyprus and France.

At the conference several presentations related to the MOROCOMP project were performed and their titles are outlined below:

- Sludge Management and guidelines, M. Zachariou-Dodou, S. Malamis, D. Malamis
- MOROCOMP: un procédé innovant pour le traitement des boues au Maroc. O. Assobhei et M. Loizidou
- Boues et Déchets Organiques Biodégradables : état de la production au Maroc, M. Rihani, A. Aajjane, J. Amine, S. Etahiri, E.M. Kabil, M. Mountadar, M. Rafrafi et O. Assobhei
- Development and optimization of the operation of in-vessel composting bioreactor, D. Malamis, Ev. Kapetanios, S. Malamis, O. Assobhei, M. Mountadar, M. Loizidou

The proceedings of international conference are presented in Deliverable 21A which is attached to the final report where also the presentations related to MOROCOMP project are included.

The international conference has also been disseminated through 5 newspaper articles namely Le Courrier Regional (French), the Doukkalia (French), Le Liberation (French), Le Matin (French), and the Arabic newspaper Assabahiya. All these newspaper articles are given in Deliverable 21B while photos of the conference are illustrated in Deliverable 21D. Both Deliverables are submitted to the final progress report.

A number of presentations and articles related to the MOROCOMP project were prepared and presented at other international conferences. More specifically:

A. "International Congress of Solid Waste Management and Sustainable Development" 27 – 30 March 2008, Hammamet, Tunisia (www.ait.org.tn/gdsdd):

- Mountadar M., Kabil Em., Malamis S., Aajjane A., Papadopoulos A., Loizidou M, Assobhei O.: «Etude comparative des législations relatives à la gestion des déchets solides au Maroc et en Union Européenne» presented as Deliverable 11 attached to the 2nd progress report.

B. Orbit 2008. "Moving Organic Waste Recycling towards Resource Management and for Biobased Economy" 6th Internation Conference in Wangeningen, the Netherlands 13th to 15th of October 2008 (https://www.orbit2008.de/frontend/index.php)

- Design of a prototype composting bioreactor for the treatment of sewage sludge and other organic waste. D. Malamis, S. Malamis, E. Kapetanios, M. Loizidou. presented as Deliverable 21C attached to the final report.

The in-vessel bioreactor, that was designed constructed and operated in the framework of MOROCOMP project, was presented by Prof. Maria Loizidou in the Horizon 2020 conference on municipal waste management in Marseille, France on the 20th November 2007 under the umbrella of an EU initiative to enhance the dissemination of composting systems internationally. Along with the in-vessel bioreactor Prof. Loizidou also presented the prototype household composting system which was developed during the implementation of the Life project COMWASTE 2006.

Finally, the NTUA set-up a stand at the Exhibition that was organized by the Committee of Environment of the Hellenic Parliament and the Municipality of Athens (Syntagma Square, Athens) from the 3rd to the 5th of June 2006 (from 9.00 a.m. until 9.00 p.m. each day) in the framework of the World Day of Environment, where the personnel of the NTUA distributed dissemination material (leaflets) and had discussions with the public related to the MOROCOMP and other European projects that are implemented by its working group (more than 5000 people visited the stand of the NTUA).

Other dissemination activities

The MOROCOMP project is mentioned in more than 30 web-sites (found through Google search). Some indicative websites are the following:

http://www.rusibis.com/eol/journal/news.asp?dir=actu&ar=2239
www.uest.gr/Morocomp/Journal%20Liberation.pdf
www.moroccotimes.com/paper/article.asp?idr=2&id=12982
www.uest.gr/Morocomp/L'economiste_2_newspaper.pdf
www.uest.gr/Comwaste
www.magharebia.com/cocoon/awi/xhtml1/en_GB/features/awi/newsbriefs/general/2006/02/20/newsbrief-03
http://www.environmentalhealthnews.org/archives.jsp?sm=fr15%3Bexposurepathway14%3B5Sewage_sludge13%3BSewage+sludgem8%3Bcoveragem8%3Bcoverage
http://www.eljadida.ma/actualite_news_el_jadida/les-fauconniers-lekouassems-d-ouled-frej-s-ouvrent-sur-l-europe-a128.html
http://www.formatiscom.com/biotech/Omar_Assobhei.htm
http://ec.europa.eu/environment/life/infoproducts/lifetcycompilation_05_lowres.pdf
http://friendsofmorocco.org/2006News/Feb06/0225News.htm
http://fr.allafrica.com/stories/200602130356.html
http://eljadidacity.africa-web.org/modules/news/article.php?storyid=117
http://www.golfteer.com/~friend5/2006News/Feb06/0225News.htm
http://pvfazzouzi.blogspot.com/2006/02/moroccos-first-composting-project-to.html
http://morocco.travel.selfip.com/report/Morocco/El%20Jadida/Zemamra
http://www.allconferences.com/conferences/20080518063710/
http://fr.allafrica.com/search.html?string=MOROCOMP
http://www.imist.ma/competences/formAfficher.php?num_cher=863&page=29&debut=800&mot=01010101
http://www.cnr.ac.ma/manifs/detailin2.php3?code=639
http://www.consulfrance-ma.org/article.php3?id_article=771
http://www.academie.hassan2.sciences.ma/fr/cv/cv.php?nom1=ASSOBHEI
http://www.leconomiste.com/article.html?a=68648
http://www.magharebia.com/cocoon/awi/xhtml1/fr/features/awi/newsbriefs/general/2006/02/20/newsbrief-03
http://www.fondationsigma.org/fr/clq_pollution_2007.html

http://www.univ-oujda.ac.ma/costeced/Programme%20Congr%C3%A8s%20Eau%20et%20d%C3%A9chets.pdf
http://www.conference-service.com/conferences/ma/water-treatment-and-reuse.html

A 5-minute presentation of the project in the national TV 2M (program Abouab Al Madida special El Jadida project) took place on Friday the 18th March 2006. The program was disseminated through the international Moroccan TV Al Maghrebia 3 times in March 2006. Also a 5 minute presentation of the project took place in the regional Radio "Radio Casablanca".

Also Deutch Welle TV prepared a reportage on the 3rd of July 2008 in which professor Assobhei presented the project. Also the TV channel prepared a documentary for the pilot system and the field experiments. Photographs are included in Deliverable 21D

1500 leaflets were distributed to ministries, companies, stockbreeders, farmers and researchers concerning the project. Four (4) billboards have been placed in the university and the Zemamra site where the system has been installed. The project have been presented to 90 students, researchers and engineers dealing with sanitation in the framework of the National seminar on wastewater treatment and it's impact on environment and human health. The Seminar was organised by Sigma Foundation for Education, culture and science and the National Office of water supply in Morocco. The Seminar was organised on the 24th January 2007 in Rabat.

Many tours have been organised by the beneficiary to the composting unit in which target groups such as competent authorities, farmers, representatives from industries and private companies had the opportunity to participate through the arrangement of appropriate training sessions/ workshops. In addition the participants of the international conference that took place in El Jadida on the 9th and 10th of July 2008 were also taken to the in-vessel composting system where a demonstration of the systems operation was carried out. Finally, tours to the composting facility were arranged for several groups that were interested in the project among which:

- ✓ participants of the 70th international institute of research on sugar beet congress (70th IIRB Congress) took place in Marrakech, Morocco.
- ✓ representatives of the Japanese international cooperation agency (JICA) which is an independent governmental agency chartered with assisting economic and social growth in developing countries, and the promotion of international cooperation.
- ✓ members of the Japan Bank for International Cooperation (JBIC) which is a Japanese governmental financial aid institution which aims to promote economical cooperation between Japan and oversea countries
- ✓ members of the Collège des Sciences et Techniques de l'Environnement, de la Terre et de la Mer of the Académie Hassan II des Sciences et Techniques

Photographs from the various visits to the demonstration composting project and field experiments are presented in Deliverable 21D attached to the final report.

9. EVALUATION AND CONCLUSIONS

Project implementation

a. The process

The technical development of the project was materialised through the implementation of six main technical tasks (each one with its individual subtasks). The six technical tasks were carried out successfully and in accordance to the proposal of the project, qualitatively and quantitatively. All the individual targets that were set per task, were achieved and the outcomes and the deliverables that were foreseen in the proposal, were obtained in a very satisfactory way.

b. The project management, the problems encountered, the partnerships and their added value

The management Task covered the whole time period of the project and its objectives were (i) to have at any time a global view on the project and on the main problems that arise, (ii) to ascertain the overall progress of the work, (iii) to manage the different priorities during the development of each task (smoothly running of project activities) (iv) to secure the optimum flow of information through the partners (v) to manage the dissemination of activities (vi) project leadership through chairmanship of technical meetings, workshops, etc (vii) to maintain communication and flow of information as required for the efficient implementation of the project. To achieve the aforementioned objectives a steering committee and a management team were formulated at the kick-off meeting.

The Steering Committee aims to promote more active stakeholder involvement during the project, resulting in the wider dissemination level of the project, in capacity building and in its successful implementation of the project. In these meetings the problems which have occurred and are related to the dissemination, training activities, proposed guidelines and proposed specifications etc, were being thoroughly discussed. During the implementation of the project two (2) steering committee meetings were carried out.

- Meeting 1: on the 9th February 2006 in El Jadida, Morocco during the kick-off meeting. The Steering Committee discussed the Action plan of the project. The Action plan was endorsed by all the institutions that participate in the Steering Committee by the end of March 2006 (Deliverable 10 submitted in EC in the 1st progress report). The minutes of the meeting and the endorsed action plan are presented in Deliverable 6 & 10 respectively and they were submitted to the EC in the 1st progress report.
- Meeting 2: on the 9th of November 2007 in El Jadida, Morocco. The minutes of the meeting are presented in Deliverable 16 which was submitted to the EC in the 3rd progress report.

The responsibility of the Management team is to discuss the progress of the project, to resolve any potential problems, to enhance communication among the participants in the project and to make sure that all deliverables and required reports are submitted on time and represent work of high standard. During the implementation of the project five (6) management committee meetings were carried out.

- Meeting 1: on the 9th February 2006 in El Jadida, Morocco during the kick-off meeting where the formulation of the management team took place.
- Meeting 2: on the 9th of June 2006 in Marrakech during the International Conference on Sustainable Water Management, Rational Water Use, Wastewater Treatment and Reuse organized in the Framework of the Euro-Mediterranean program MEDAWARE. The minutes of the meeting are presented as Deliverable 12A which was submitted to the EC in the 2nd progress report
- Meeting 3: on the 27th of October 2006 in Athens, Greece. The minutes of the management team meeting are presented in Deliverable 12B which was submitted to the EC in the 2nd progress report.
- Meeting 4: on the 15th of March 2007 at the site where the composting system has been installed (Zemamra site). The minutes of the meeting are presented in Deliverable 12C which was submitted to the EC in the 2nd progress report
- Meeting 5: on the 9th of November 2007 in El Jadida, Morocco. The minutes of the meeting are presented in Deliverable 16 which was submitted to the EC in the 3rd progress report.
- Meeting 6 on the 12th of July 2008 in El Jadida, Morocco. The minutes of the meeting are presented in Deliverable 22 which is attached in the final report.

No changes in the project's management structure have been made and everything proceeded as initially planned. Finally, in order to fulfil the reporting obligations of the project, the following material have been prepared and delivered:

- 1st Progress Report
- 2nd Progress Report
- Interim Technical and Financial Report
- 3rd Progress Report
- Final Technical and Financial Report

c. Technical and commercial application (reproducibility, economic feasibility, limiting factors)

The reproducibility and the application of the prototype in-vessel system in large scale are feasible, since:

- The technology, on which the development of the system is based, is well-documented.
- The prototype system was tested sufficiently during its manufacturing and in particular.
- The prototype system was tested intensively in practice, for sufficient time and resulted in the production of high quality compost without any environmental impact during its operation.
- When optimizing the operation of the bioreactor for specific feedstock material and ratios the capacity of the bioreactor increases since the retention time of composting process decreases.
- The retention time can be reduced even more if the maturation phase takes place outside the bioreactor. The importance of the in-vessel bioreactor lies in the fact that it controls fundamental parameters during composting and that is the oxygen, moisture and temperature conditions. Controlling these parameters during the thermophilic phase is crucial for composting development. Since after the thermophilc phase the substrate can be removed from the bioreactor and spread outside for maturity purposes. By doing that the retention time of the substrate is

minimized and thus increases the rate in which the system treats biodegradable organic waste and thus increases its capacity over time.

- The use of the in-vessel composting system is flexible in terms of its application in an area. This means that the system can be adjusted according to the quantity of sludge and BOW to be treated in a region. To do that, parallel composting systems can be constructed in order to increase the capacity of the system while at the same time reducing the capital cost[4] and the cost per tonne of treated waste[5]. Furthermore the specifications of the composting system guarantee an increased lifetime (over 20 years) while the operational cost is low since the system is fully automated and its monitoring and maintenance can be performed by a single person. For these reasons the costs (capital & operational) of the in-vessel composting system can be competitive to the costs of other systems that are available in the market.
- The in-vessel composting technology has considerable operational flexibility regarding feedstock composition.
- The environmental benefits from the use of the system are considerable and multidimensional (e.g. sludge and BOW treatment and reuse through land application of the produced compost)
- In comparison to central composing plants the in-vessel composting system is a decentralized one for in-situ treatment of sludge and other BOW. It offers the possibility for self-sufficiency with respect to BOW treatment and reuse in rural and remote areas.

Limiting factors for the application of the in-vessel composting system do not incur since:

- The use of the system is easy and simple since it was designed in such a way as to be operated by people that do not have the relevant scientific background.
- The system can have a broad range of applications since it can be installed and operated in small or large communities by adjusting the capacity of the system (single or parallel in-vessel composting system) or this system can also be applied to isolated areas e.g. insular areas or even to boats.
- It has low labour requirement and, depending on the requirements of waste treated, can be fully operated by just one individual.
- The retention time for sludge and other BOW into the bioreactor is less than a month (and it can be reduced even further as mentioned earlier) while no environmental impacts have been observed during its operation. The solid part is the produced compost, the air emissions are transferred from the bioreactor interior and through an air-pipe they are defused into the biofilter while the quantity of leachate produced is insignificant and it is collected safely disposed.

The only limiting factor is that the bioreactor can be scaled up to 30% of its initial volume since the capacity limits are strongly related to the constriction materials of each of its components (agitation system, motor etc.), but as it is mentioned above parallel systems can be installed thus increasing the capacity.

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[4] In parallel systems only the bioreactor must be purchased all the other systems (e.g. bio-filter, leachate collection pond, water reservoir) can be combined in such as to operate for all parallel bioreactors.

[5] The number of personnel needed for monitoring and operating parallel in-vessel composting systems is the same as in the case of a single in-vessel composting system

d. Comparison against the project-objectives

All the individual objectives set through the project were achieved.

A complete, clear and representative picture was given about the existing situation in Morocco with respect to the existing management schemes, systems and practices of sludge and other BOW. Also, a thorough analysis of the corresponding European Union legislative framework was performed (principles, provisions, constrains, targets and obligations set in it) with respect to sludge and other BOW generation and management (treatment, reuse and disposal). Finally a review of composting success stories and best practices in the European Union was performed.

This outcome is of great importance since it provides:

i. A representative and cohesive view of the current conditions with respect to sludge and other BOW management in Morocco and in comparison to the EU.
ii. The legislative gap between EU and Morocco with respect to sludge and BOW management.
iii. Knowledge and experience on effective practices, systems and technologies on composting

The in-vessel composting system was successfully designed, manufactured, installed and operated in order to effectively treat sludge and other BOW taking into consideration factors such as local characteristics, proven technology, environmental impacts, minimal risk to public health, compliance with EU environmental legislation and policy and sustainable market for the end product.

Different composting trials were performed developed based on the physicochemical characteristics of the raw material used. The composting processes optimisation was successfully carried out using different raw material including primary sewage sludge from the city of El Jadida, secondary sludge from food industry, sugar beet leaves, straw residues, sheep and cow manures in various ratios and in different operational conditions (air flow, hydration and agitation). Optimisation of composting processes using sludge individually was not performed since the obtained sludge acquired high moisture content and it was considered appropriate to mix it with other BOWs such as green waste which operate as excellent amendments and bulking agents. The high moisture content of sludge arises from the fact that there were not dewatering installations in the region where sludge was produced. Optimisation of composting processes was also performed using sludge and other BOW in combination with additives such as zeolite and perlite.

The evaluation of the produced compost was carried on three stages as initially planned. In the first stage the physicochemical properties of the compost product were evaluated. In the second stage phytotoxicity tests were carried out to identify whether composts incorporate potential phytotoxic compounds that can be potential hazardous to plant health and seed germination while in the third and last stage open field experiments were performed to test in real environment conditions the impact of composts to plant growth and soil properties when applied on land.

The market opportunities of compost in Morocco were assessed successfully along with the potential of compost end uses through land applications taking into consideration the current and future availability of the composted raw materials (sludge and other BOW)

and the quality of the produced compost and its compliance with the EU and national legislation policy

Finally the development and the determination of technical specifications for the optimum operation of the composting system were assessed while guidelines were prepared for the development of a set of robust and commercially beneficial compost standards and end use specifications in Morocco based on the existing worldwide experience.

e. Effectiveness of dissemination activities

As described analytically in section 8.2, significant training and dissemination activities took place that ran throughout the duration of the project. The outcome of these activities was of a great importance since:

- the training sessions/workshops contributed in informing the Moroccan farmers on the benefits of compost as soil improver in environmental as well as economical terms. They also contributed in promoting capacity building and the concept of sewage sludge composting by informing the relevant competent authorities. Finally the training sessions/workshops were targeted so as to inform industries and private companies in order to promote and enhance the development of compost market in Morocco.
- The regular tours to the composting facility along with the leaflets and printed material which were presenting the objectives and the results of the project were catalytic in enhancing public awareness and informing groups on sludge and other BOW management.
- The international conference that was held in July 2008 gave the opportunity for the meeting of international research institutions and universities, various industrial organisations and international associations and to further disseminate the sustainable sludge and BOW treatment.
- Representatives of several local authorities in Morocco expressed their interest in acquiring such a system for the treatment of sewage sludge and its reuse through land application.

f. The future: continuation of the project + remaining threats

Analysis of long-term benefits

a. Environmental benefits

1. Direct/quantitative environmental benefits (e.g. reductions of emissions, energy or resource savings)

- contribution in reducing the amount of untreated sludge that is disposed
- contribution in diverting biodegradable organic waste from landfilling and thus contributing to the reduction of green house gases.
- raising of the environmental awareness of the public
- lower burden of the landfill sites, in terms of quantity and polluting load, due to the reduction of the amount of BOW that are disposed, fact that results in the increasing of their operation life cycle.
- reduction in the air emissions from landfills in qualitative and quantitative terms
- less leachate production and less danger to underground and surface water contamination

- land application of compost resulting from sewage sludge and other BOW composting contributes in the reuse and conservation of valuable biosolids-borne constituents
- production of a material with added value that could be used for landscaping or for agricultural purposes such as soil fertilizer, soil improvement and soil conditioner
- compost improves the soil structure, porosity and density, increasing infiltration and permeability, reducing runoff and erosion, improving water holding capacity, reducing water loss and leaching in sandy soils, supplying macro and micronutrients, controlling of soil-borne pathogens, improving of cation exchange capacity of soils, increasing the ability to hold nutrients for plant use, supplying of beneficial micro-organisms to soil and growth media, improving/stabilizing soil pH and providing the potential to bind and degrade some pollutants of the soil.
- Replacement or reduction of the use of synthetic fertilizers for agricultural purposes and thus reduction of nitrate contamination

2. Relevance for environmentally significant issues or policy areas (e.g. industries/sectors with significant environmental impact, consistency with 6EAP or important environmental principles, relevance to the EU legislative framework (directives, policy development, etc.)

The outcome of the project has a great impact to all the actors involved in the field of the generation and management of sewage sludge and other BOW. In particular:

Farmers in Morocco can be provided with a rich in nutrient and chemical elements material that will enrich soil properties/characteristics and enhance crop yield without the addition of chemical fertilisers which can be expensive and hazardous to the public health and to the environment.

Local authorities: They are provided with a system for the effective treatment of sludge and other BOW and the production of compost that can be used. This, results in the reduction of the amount of biodegradable organic waste to be treated or sent to landfills. A product is obtained with added value that can contribute in creating job opportunities and earn money by marketing it.

Private companies: Private companies can benefit from the production of high quality compost that can be marketed and thus expansion of the industrial activity with a positive impact on the economy.

Public Authorities/decision and policy makers: The application of the system in large scale, will contribute in diverting BOW from landfills and in the uncontrolled disposal of sewage sludge.

Additionally, the MOROCOMP project is in consistence with the key environmental priorities of the 6EAP, and in particular with the thematic strategy on waste prevention and recycling, since the project focuses on the effective treatment of sewage sludge and other BOW resulting in the transformation of waste to a useful end-product with added value.

Moreover, the project is relevant to the EU environmental Directives related to the management of waste and in specific, the Directive 86/278/EC on the use of sewage sludge in agriculture, the Directive 99/31/EC on sanitary landfill of wastes and the

framework Directive 2006/12/EC on waste disposal consolidating and replacing 75/442/EEC.

In particular:

- The Council Directive 86/278/EEC sets minimum quality standards for the soil and sludge used in agriculture in order to regulate its use in such a way as to prevent harmful effects on soil vegetation, animals and humans, while encouraging its correct use (i.e. land application). The limit value defined in this Directive concern heavy metal concentration for sewage sludge as well as for soil when sewage sludge is applied on land and the maximum heavy metals loads, which may be added annually to agricultural land via the application of sewage sludge. The Directive also mentions the obligations for sludge treatment and the analysis foreseen before its use in agriculture, the surfaces on which its use is prohibited as well as further requirements of sludge usage.

- The Council Directive 1999/31/EC of 26th April 1999 on the landfill of waste impacts on sewage sludge management, as it bans the disposal of liquid waste (e.g. sludge) to landfills. This Directive aims at reducing the quantity of biodegradable waste going to landfills, and prohibits the landfilling of both liquid and untreated wastes. Consequently, it will eventually reduce significantly the disposal of sludge and other BOW to landfills. The use of the prototype in-vessel composting system contributes significantly towards to this direction, since it is based on the treatment of sewage sludge and other BOW via composting and preventing final disposal of biodegradable organic waste to landfills.

- According to the Directive 2006/12/EC member states must take actions for the management of solid waste in order to encourage:

  (a) firstly, the prevention or reduction of waste production and its harmfulness, in particular by:
    - the development of clean technologies more sparing in their use of natural resources,
    - the technical development and marketing of products designed so as to make no contribution or to make the smallest possible contribution, by the nature of their manufacture, use or final disposal, to increasing the amount or harmfulness of waste and pollution hazards,
    - the development of appropriate techniques for the final disposal of dangerous substances contained in waste destined for recovery;

  (b) secondly:
    - the recovery of waste by means of recycling, re-use or reclamation or any other process with a view to extracting secondary raw materials, or
    - the use of waste as a source of energy.

The application of the in-vessel composting system that is promoted through the MOROCOMP project is fully in accordance with the provisions and the priorities of this Directive (development of techniques for recovery and recycling of BOW).

Finally, the know-how and the technology that were developed via the project are based on other fundamental European environmental principles and priorities such as

the application of the three R management practices (Recovery, Reuse, Recycling), the development of waste management systems and schemes that promote the sustainable development etc.

The MOROCOMP project is also in accordance to the EU Environmental Technologies Action Plan (ETAP) which intents to make eco-innovation an every day reality throughout Europe and aiming to further environmental technologies within the EU and globally and to exploit their potential to improve both the environment and competitiveness, thus contributing to growth and possibly creating jobs

b. Long-term sustainability

1. Long-term/qualitative environmental benefits (e.g. long term sustainable technology, from product to functional focus, from end-of-pipe to prevention; high visibility for environmental problems and/or solutions; spin-off effect in other environmental areas etc.)

The technology that was developed and applied through the MOROCOMP project is based on the biodegradation and stabilization under controlled conditions of sewage sludge and other BOW using an appropriate prototype in-vessel composting system that was designed and manufactured specifically for this purpose. The prototype system is characterized by a high level of sustainability since:

- It is based on the application of a treatment method (composting) that is time-tested successfully.
- It is based on a technology that promotes the sustainable management of waste since it recovers organic material and transforms it into a useful end-product which, additionally, could substitute the use of synthetic products/ chemical fertilisers.
- It is a long lasting technology since it was manufactured under certain specification to guarantee increased lifetime (e.g. use of material and primer anticorrosive protection, that can withstand large shear and tensile stresses)
- Provides a source of plant nutrients and improves soil fertility; results in significant cost savings by reducing the need for water, pesticides, fungicides, herbicides, and nematodes. Used as an alternative to natural topsoil in new construction, landscape renovations, and container gardens. Using composts in these types of applications is not only less expensive than purchasing topsoil, but it can also often produce better results when establishing a healthy vegetative cover. Used as mulch for trees, orchards, landscapes, lawns, gardens, and makes an excellent potting mix. Placed over the roots of plants, compost mulch conserves water and stabilizes soil temperatures. In addition, it keeps plants healthy by controlling weeds, providing a slow release of nutrients, and preventing soil loss through erosion.
- The ecologically and commercially sustainable management of sludge and other organic waste constitutes a major goal for all European countries, regardless size or location. Sludge poses a number of threats and problems to the environment and public health, requiring special consideration. The key problem is the presence of anthropogenic pathogens, heavy metals and other hazardous chemicals in sludge. As a result, appropriate treatment prior to final disposal or application is required. The sludge characteristics depend on the original pollution load of wastewater, the characteristics of the wastewater treatment and the applied sludge treatment process. Alternative practices could be used for the sludge management. Thickening, dewatering and stabilization are conventional techniques, which lead to products of low quality characteristics and limited applications. Furthermore, by implementing such techniques, the priorities of EU policy and legislation are not met. In the meantime, thermal treatment requires energy recovery and special anti-polluting systems, since the air emission regulations are very strict. As a result, this process

has a high construction and operating costs. Therefore sludge composting along with other BOW is consider to be a promising method for the sustainable treatment of sludge while at the same time results in the formation of a useful end product with an added value.

- Extends current landfill longevity and delays the construction of a more expensive replacement landfill or incinerator.
- In vessel composting offers protection from severe weather and better odor control than other composting methods while the biodegradation of BOW under controlled conditions (agitation, aeration, hydration) contribute towards a more efficient biological process and thus to a better quality end product.
- The in-vessel composting technology has considerable operational flexibility regarding feedstock composition. It can use a variety of waste as feedstock for composting (primary or secondary sludge, animal excreta, green waste, food waste etc) under controlled conditions and allows the production of an end-product of a high quality and consequently its unobstructed use (on the contrary, the biodegradable fraction that is extracted from mixed waste in central mechanical sorting plants may have impurities, fact that can result in the production of an end-product of a low quality with limited potential for use).
- It is simple and easy to use since it is fully automated and can be operated by people that do not have the relevant scientific background
- Its capacity can be adjusted depending on the requirements of waste treated (single or parallel in-vessel systems)
- The operation and maintenance cost is significantly low since it has low labour requirements and, can be fully operated by just one individual.
- The composting unit can be used by the farmers to treat their BOW thus producing their own compost

Additionally, the application of such a system can lead to the limitation of significant environmental problems, giving tactile solutions, as described analytically in section fa1. Indicatively: lowering the quantity of untreated sludge that is disposed, diverting biodegradable organic waste from landfilling, reuse and conservation of valuable biosolids-borne constituents, production of a product with added value, avoidance of using synthetic fertilizers for agricultural purposes

Also, the use of the technology in large scale applications affects positively other environmental areas, since the end-product could be used for i. landscaping, ii. land restoration, iii. soil fertilizer and conditioner, substituting the use of synthetic fertilizers for agricultural purposes iv. deodorant mean at landfill sites.

2. Long-term / qualitative economic benefits (e.g. long-term cost savings and/or business opportunities with new technology etc., regional development, cost reductions or revenues in other sectors)

The application of the technology could result in cost savings in the sector of the municipal solid waste management since:

- The aggregated cost for the procurement, the operation and the maintenance of the prototype systems is quite lower than the respective cost which is required for the construction, operation and maintenance of a central composting plant.
- A product with high added value is produced, by transforming a waste into a useful end-product.
- The quality of the end product is good enough to be marketed.
- The quality of the compost produced by using the in-vessel composting systems is higher than the quality of other composting facilities e.g compost produced at

central plants, windrow composting or aerated static pile composting therefore allowng its easier use or/and forwarding to the corresponding market.

- In-vessel composting provides a faster method of composting than windrow composting or aerated static pile composting thus increasing the quantity of the end product and thus the profit.
- The cost for the collection and the transfer of the BOW to the landfill sites is reduced; as a result of the decrease of the number of the vehicle routes that are required for this purpose (lower quantity of waste must be collected and disposed). The cost to pickup and haul waste to landfill is reduced due to the reduction in the demands for personnel, fuel for the circulation of the vehicles and maintenance of the vehicles.
- The cost for the disposal of the mixed waste (disposal fees paid by the Municipalities to the operator of the landfill site) is reduced, since the level of this expense is proportional to the quantity of waste that are disposed.
- The lower burden of the landfill sites, in terms of quantity and polluting load, due to the reduction of the amount of organic waste that are disposed, results in the increase of the operational time life of the landfills and consequently the decrease in the demands for space in order to construct new landfill sites.
- The reduction of the organic load content of the leachates generated at the landfill sites due to the decrease of the organic waste that are disposed as well as the reduction in air emissions from landfills in qualitative and quantitative terms results in the decrease in the operation and maintenance costs of the landfill anti-polluting systems.
- The potential substitution of the synthetic fertilizers used for agricultural purposes by compost leads to saving of cost for raw materials and energy.
- Small or medium size isolated areas can use the decentralized system for the treatment of the organic fraction of municipal waste and other BOW and sludge in a much more cost-effective manner than transporting waste to long distance centralized facilities
- Individuals that produce BOW can use the system developed to produce a high quality product with economic interest (added value).
- Farmers in the long term and especially those that employ organic farming can benefit financially from the use of compost that originates from BOW.

3. Long-term/qualitative social benefits (e.g. positive effects on employment, health, ethnic integration, equality and other socio-economic impact etc.)

The project can lead to significant social and other relative benefits, such as:

The use of the prototype system in large scale applications, will lead in the creation of job opportunities and increased number of employees will be requested for a wide employment spectrum. Employees will be needed for the study, manufacture, testing and operation of the systems. The use of the prototype system in large scale, will lead to the production of large quantities of compost providing the opportunity for its trading and its final application therefore collectors of the composting product, drivers, engineers for the provision of technical support, agriculturists, etc. will also needed.

The diversion of biodegradable organic fractions from landfills and the treatment and reuse of sewage sludge will decrease the potential impacts that are occurred during the operation of the landfill sites and the uncontrolled or insufficient treatment of sludge to the environment and the public health. Also, the potential substitution of the synthetic fertilizers by compost will contribute to the conservation of the natural resources through the saving of raw materials (e.g. water) and energy.

The program handles the management of a wide variety of biodegradable solid waste (sewage sludge, green waste etc.) with the design, manufacture and operation of a pilot scale in-vessel composting unit. The diffusion of technology that resulted from the implementation of the program can contribute significantly in guaranteeing a solution for the integrated management of biodegradable solid waste produced in regions where central mechanical sorting and composting plants are not applicable. The installation of parallel composting units is able to contribute in the sustainable treatment of the biodegradable organic waste originated from small and remote communities which cannot be handled by central treatment plants. In addition the produced compost constitutes a useful soil improvement and/or fertiliser which increases soil fertility and yield productivity and thus underpinning the economy and the growth of these communities.

The implementation of the MOROCOMP project will result in substantial social and economic benefits among which:

- The sustainable management of waste (which will be treated in environmentally controlled facilities) which is a nuisance to the society and causes negative impact to the environment and to public health and undermines the local economy.
- The creation of new job opportunities as has been mentioned earlier due to the development of a new market which involves the study, manufacture, testing and operation of the systems as well as the production, promotion, transportation and application of compost.
- The alleviation of society pressure from unemployment
- The application of the produced compost increases fertility of the soil leading to higher yield production and thus income increase to farmers.
- Increasing public awareness with respect to the use of soil improvers – compost can boost organic or regular farming, substituting the use of conventional chemical fertilisers or to use them supplementary to compost.
- Increases the sensitivity of the competent authorities and the public in relation to the treatment of waste
- Social consensus in the environmental management of waste
- Sustainable development of the region and development of cooperation between the various sectors of the local economy.

Environment and public health

The management of biodegradable waste constitutes an essential and an important environmental problem worldwide. The EU through explicit and concrete policy obliges Member States and give guidance to other countries, as in the present case, to take initiatives in tackling this problem. The treatment of biodegradable waste in environmentally controlled facilities as in the case of MOROCOMP project results in the:

- Mitigation of environmental nuisance such as the
    - Pollution of surface and underground water
    - Atmospheric pollution
    - Stench –odour problems
    - Aesthetic devalorisation – degradation
    - Prevention of potential fires and consequential environmental disasters
- Promotion of recycling

- Improvement of the environmental picture of the community and its sustainable development
- Improvement of soil fertility through compost application
- Protection of public health
    - The uncontrolled disposal of biodegradable waste results in the creation of plague spots for insects and rodents which constitute carriers of many diseases
    - The uncontrolled disposal of biodegradable waste results in surface and groundwater pollution as well as air pollution.

c. Replicability, demonstration, transferability, cooperation

1. Transferability & Potential for Commercialisation, including cost-effectiveness compared to other solutions, benefits for users (e.g. improved health&labour conditions, less nuisance to others), drivers and obstacles for replicability/reproducability, market conditions, pressure from the public, potential degree of geographical dispersion, specific target group information, high project visibility (eye-catchers), possibility in same and other sectors on local and EU level, etc.

The project is characterized by a high level of transferability and potential for commercialisation, taking into consideration, the following:

A. The application of such a system in large scale applications presents a high level of viability, since:

i. The capital cost of the system is lower compared to other practices that are applied for the management of biodegradable waste such as central mechanical sorting and composting plants, thermal treatment and sanitary landfilling of waste. Moreover in the case of Morocco there are no alternative solutions for BOW management and the uncontrolled disposal of waste is a common practise whilst alternative solutions of waste treatment would acquire significantly higher investment cost.

ii. The operation and maintenance costs of the prototype in-vessel composting unit are low since the automated control system guarantees the continuous undisrupted operation and control of the unit.

iii. The system is based on a well-documented and reliable technology

iv. Significant and tactile environmental benefits are obtained through the use of the systems, as described at point b1

v. The prototype system is economically viable based on the economic benefits as described at point b2

vi. The use of the system in large scale applications can lead to significant social and other relative benefits, as described at point b3.

B. The application of the systems is based on the principles and the priorities of the European and national environmental legislation and policy, fact that facilitates its easier incorporation in the existing waste management schemes.

C. The end-product is characterized by a high quality level, fact that allows its possible trading utilization through the development of the relative market.

D. The technology that was developed through the project focuses on the effective treatment of sewage sludge and other BOW in an easy and simple way. In addition the capacity of the composting system can be adjusted according to the quantity of sludge

and BOW to be treated in a region and thus ensuring its possible application in large scale.

E. Sludge and other BOW management is a widespread environmental problem, common in all the countries, fact which indicates that the prototype system could be used extensively in European and other countries.

F. Throughout the implementation of the project scientific and technical knowledge was acquired which can be disseminated to parties that are interested in:

- the integrated and sustainable management of biodegradable solid waste
- the application of environmental friendly products such as compost for the improvement of soil fertility

G. The benefits for potential users are significant since the technology applied is simple while the operational and maintenance cost is low. In addition the energy consumption is relatively low since the agitation, aeration and hydration systems operate for specific time intervals per day in order to control the biological processes of composting. The users of compost will have additional benefits through its application on land economically as well as environmentally such as:

- reduction of inorganic fetilizers,
- better soil structure leading to greater workability of soil and increased traffic tolerance,
- improved water holding and thus lower consumption of water,
- increase yielding potential,
- reduced erosion risk
- beneficial soil microorganisms aid - soil aggregation - nutrient recycling - plant disease suppression
- nutrient leaching reduction

H. The composting system has the ability to operate at similar conditions at local level using different feedstock material. There are various other biodegradable organic fractions of municipal waste (e.g. agricultural, industrial) apart from those used during the program, that have to be treated accordingly since their uncontrolled disposal causes significant environmental and social problems at the local communities. Even in many EU countries the treatment of this waste stream constitutes a threat to the environment and they are seeking for sustainable solutions.

I. The system can be applied in other regions in Morocco or even in other developing countries for the effective treatment and management of biodegradable waste. The technological and technical dissemination of the project corresponds not only to developing countries but also to developed ones since the intergraded management of biodegradable waste, the recycling and reuse is one of the top EU waste management priorities.

d. Innovation

1. Level of innovation on (inter)national level (including technology, processes, methods & tools, organisational & co-operational aspects)

The content and the outcome of the MOROCOMP project are characterized by a high level of innovation at national and international level, since:

i. The use of the system is based on the treatment of sewage sludge and BOW via composting which represent a new trend in the treatment of this type of waste especially in Morocco (until now, in Morocco there was no system for the biological treatment of the biodegradable organic material since no central composting plants exists while sludge in most cases is disposed without appropriate treatment)

ii. The in-vessel composting applications in which sewage sludge is mainly treated along with other BOW are limited at European and international level, while it is the first attempt in Morocco to establish such a system for the effective treatment of the aforementioned type of waste. The designed system is a self-contained-compact unit which can be employed as a decentralized system to treat organic waste very effectively without environmental impacts and nuisance.

iii. The prototype system that was designed manufactured and operated through the MOROCOMP project has significant unique characteristics - advantages, compared to other similar systems that are available internationally, such as:

- The prototype system is an integrated system for the effective treatment of BOW that separates the collection of the product/compost and the produced leachates but it also handles the air emissions generated during composting through an appropriate air sanction system that transfers all gases to a biofilter for the diodorization of the bioreactor. The use of a bio-filter contributes in the drastic reduction and minimization of odours which is considered to be one of main drawbacks of other composting systems.

- The design of the agitation system and the arrangement of the blades were performed in such a way as to provide a uniform agitation, hydration and ventilation of the substrate and preventing the substrate to aggregate.

- The operation of the in-vessel composting system is fully automated since the control and monitoring of the composting process is performed by a Programming Logic Controller (PLC - automatic control system) which controls the agitation the aeration and the hydration system. The use of the PLC is accomplished through appropriate software designed specifically for this case.

- The system offers the possibility for automated in-situ analysis of several important composting parameters during the trials (e.g. temperature, oxygen, moisture level). Other parameters such as CO2, and NH3 can also be measured by providing the appropriate equipment. Therefore the system offers an easy way of controlling the composting process throughout its duration while it saves time from further laboratory analysis.

- The composting system operates on a batch mode but if parallel bioreactors (modules) are to be used than it works in continuous basis (continuous feeding of new organics in parallel with continuous collection and removal of composting product).

iv. The successful operation of the bioreactor is proven by its ability to produce high quality compost from a variety of biodegradable organic waste such as sewage sludge from UWWT plant, sludge from food industry, green waste and manure. Apart from the physicochemical and biological characteristics of compost that indicate that the end

product is of good quality, the experimental cultivations have shown that the compost stimulates plant growth and yield production and thus its application as a soil conditioner was a success. In addition during the operation of the in-vessel bioreactor no adverse environmental effects were recorded since the produced leachates (small quantities) and the air emissions (through the use of a biofilter) were controlled throughout the operation of the composting process. In addition the use of the PLC system, responsible for controlling the agitation, aeration and hydration systems, was successfully operated according to the specifications of the manufacturer.

v. It incorporates and develops new technologies which include the following activities:

- Developing an environmental friendly prototype state-of-the-art in-vessel composting technology system that provides environmental services to its user at local or national level. This was accomplished through the use of results from previous studies of the research team and the available relative international scientific and technical knowledge in small scale industrial applications
- Environmental activity towards the integrated management of biodegradable organic waste
- Activity for the development of an innovative prototype pilot system for composting under controlled conditions of various biodegradable solid waste.

vi. It provides a radical solution to a widespread environmental problem which involves the sustainable treatment of biodegradable organic waste, including sewage sludge, and organic fraction of municipal waste which is a common environmental problem in all EU countries, in Morocco as well as in all developed and developing countries.

10. AFTER-LIFE COMMUNICATION PLAN

As described analytically in Section 9, the project presents a high level of replicability and transferability. The after-LIFE plan to continue and expand the dissemination and the communication of the results and the outcome of the MOROCOMP project includes several actions divided in four groups as described below:

Further study:

- The operation of the in-vessel composting system is keeping on, and after the end of the project and it is foreseen to perform series of composting trials in which a range of raw materials will be used while sludge (primary or secondary) will remain the main ingredient/raw material. The produced compost will also be tested in field experiments using different seeds. The required resources will be provided by the Ministry of Environment in Morocco but also by private enterprises that have shown a particular interest to MOROCOMP project and wish to benefit from its results.
- NTUA will install a similar facility in the near future to treat BOW from the university including the restaurant organic waste and the green waste of the campus. Also it will serve as a demonstration system for interested parties e.g. local authorities, private companies ect.

Further research:

- Assessments and theses will be assigned to postgraduate students (UCD and NTUA) that will cover the following fields:
    - Further analysis on the increase of the capacity limits of the bioreactor in relation to the construction materials of each of the components of the

bioreactor (chamber, axle etc.) , the mechanical conditions of the materials the chemical reaction etc.
    - To redesign some parts of the bioreactor e.g. the positioning of the steel blades which are distributed along the length of the axis in order to optimise even further the uniform agitation of the substrate and to prevent it from aggregation.
    - The design of a small scale continuous mode bioreactor
    - Further optimization of the composting processes (through the parameters that influence composting e.g. the aeration, hydration conditions and the physicochemical characteristics of the substrate) using different biodegradable waste and different ratios aiming both at minimizing the retention time and increasing the quality of the end product.
    - The thermodynamic simulation of composting processes under different feedstock material and ratios
- Publications to scientific journals and presentations in scientific conferences so that the international scientific community will be informed about the obtained results.

Education:
The results obtained throughout the implementation of the project will be used as teaching material (case study) of biological processes for the treatment of organic waste for undergraduate and postgraduate students

Industrial application
Collaboration propositions with industries so that the obtained results of the project will be used for the development of small and moderate scale industrial production bioreactors.

Dissemination of know how to farmers and horticultures
The results obtained on the field experiments will be reported to the Ministry of Agriculture in Morocco and Greece as well as to corporations and other farmers' organisations so that the know how will be incorporated to the practices of farmers and agriculturalists. The beneficiary (UCD) in collaboration with the Ministry of environment in Morocco is planning to organise additional special events to target groups (competent authorities, farmers, private companies) all over Morocco in order to disseminate further the results of the project.Finally, the MOROCOMP outcome and the prototype system itself, are being and will be disseminated during the development of dissemination activities of another LIFE project WASTESUM that is implemented by the beneficiary.

11. ACTUAL PROJECT REALISATION AGAINST THE BASELINE IMPLEMENTATION PLAN

The following Gantt - chart presents the actual project realisation against the approved by EC, implementation plan. The initial duration of the project was 24 months and a 6 month extension was approved by EC.

LIFE05 TCY/MA/000141		Design and Application of an Innovative Composting Unit for the Effective Treatment of Sludge and other Biodegradable Organic Waste in Morocco, MOROCOMP															
Tasks/ Activities		2006				2007				2008				2009			
		1T	2T	3T	4T	1T	2T	3T	4T	1T	2T	3T	4T	1T	2T	3T	4T
Task1	Baseline	. .	. .														
	Actual	xx	xx														
Task2	Baseline		. . .	. . .													
	Actual		xxx	xxx	xxx	xxx											
Task3	Baseline				. . .	. . .											
	Actual					x	xxx	xx									
Task4	Baseline						. . .	. . .									
	Actual							x	xxx	xxx	xxx						
Task5	Baseline								. .								
	Actual									x	x						
Task6	Baseline								. .	.							
	Actual										xxx	x					
Task7	Baseline	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .							
	Actual	xx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	x					
Task8	Baseline	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .							
	Actual	xx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	x					

12. COMMENTS ON FINANCIAL REPORT

The following Table presents a consolidated picture of the costs incurred during the implementation of the project.

Categories of expenditure	Real Cost (€)	Eligible Cost (€)
Personnel	471,268.48	471,268.48
Travel	54,819.62	54,819.62
Equipment	23,058.09	11,529.05
Consumables	52,474.65	52,474.65
Other costs	9,411.23	9,411.23
Overheads	41,068.00	41,068.00
TOTAL	**652,100.07**	**640,571.03**

13. APPENDICES

Deliverable 14b	Report on the effects of compost on the tested cultivations
Deliverable 17A	Report on the alternative uses of compost and on the market opportunities for the compost products (in English)
Deliverable 17B	Report on the alternative uses of compost and on the market opportunities for the compost products (in French)
Deliverable 18A	Report on the optimum operating conditions for the composting unit
Deliverable 18B	Development of specifications and guidelines concerning the quality of compost products and compost uses
Deliverable 18C	Manual for physicochemical compost analysis
Deliverable 19	2nd training session/workshop
Deliverable 20A	3rd training session/workshop
Deliverable 20B	3rd training session/workshop - Leaflet
Deliverable 20C	3rd training session/workshop - Programme
Deliverable 21A	MOROCOMP International Conference Proceedings
Deliverable 21B	MOROCOMP International Conference - Newspapers articles
Deliverable 21C	Presentations of MOROCOMP project in other conferences
Deliverable 21D	Photographic material
Deliverable 22	Minutes of the management meeting in El Jadida on 12.07.2008