SEVENTH FRAMEWORK PROGRAMME

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Report: Strategy for the implementation of the selected biotechnological solutions

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Content

1 Introduction

1.1 Background

The deliverable D 4.1 is the first part of Work Package (WP) 4: "Knowledge Transfer" of the project WATERBIOTECH. The project WATERBIOTECH foresees to contribute for managing water scarcity in Africa by providing relevant stakeholders access to the know-how in biotechnologies as well as good practices and management solutions for the sustainable management of polluted water resources. In this part, the task is to develop a strategy for the large scale implementation of best practice and selected biotechnologies in the targeted seven countries. Such a strategy encompasses not only the implementation of technologies, but also the transfer of its related know-how to relevant stakeholders for supporting their own technological and skilled workforce development.

The needed information for the development of a strategy is extracted from results of the previous work packages. The three work packages, namely WP 1: General frame assessment, WP 2: Assessment of biotechnological practices and WP 3. Coordination in technology development and improvement concerning the used technologies with its cost-benefit aspects, describe about the policy framework and legislation, used wastewater treatment methods, technical barriers and financial constraints as well as socio-economic situation of the investigated countries. The tenor of the investigations in short: Significant Lack of appropriate infrastructures (i.e. sewer networks, uninterrupted power supply, efficient treatment system and

waste management facilities), unsound policies, financial and human resource constraints, and ineffective environmental rules and regulations are the major challenges found that the countries are facing in implementing wastewater treatment plant. Involvement of stakeholders (investors, non-governmental organisations, and business people), institutional development and community participation are measured as immense important task for wastewater management sector development in those countries.

1.2 Objective of Deliverable

The objective of the deliverable is to present a strategy for the large scale implementation of best practices and selected biotechnologies in the targeted counties by considering their respective policies, institutional framework, socio-economic aspects and technological as well as non-technical implementation requirements. The strategy is targeted to enable authorities, decision makers, entrepreneurs, water service providers and other stakeholders for following effective procedures to implement the chosen biotechnologies according to regional conditions of the selected countries. How large scale implementation of selected biotechnologies can be initiated and expedited in the targeted countries is the main objective of this deliverable.

2 Methodology

The development of strategy is based on the results of previous work packages produced by different project partners. These results are thoroughly analysed. Besides the results from meetings and workshops conducted with projects partners are extracted. The results of informal discussions with all the

stakeholders participated in the first WAERBIOTECH international conference in Cairo are also included.

The analyses of the Deliverables (D) of previous work packages, namely D 1.1: Regional Segmentation and description of the Legal-Institutional and Socio-environmental characteristics; D 2.1: Evaluation report of the state of the art of the existing biotechnologies and water management strategies; D 2.4: Evaluation of the existing water biotechnologies and water management strategies in the targeted countries; D 2.5: Technical and non-technical requirements to overcome the present difficulties faced by the concerned regions; D 2.6: Cost-benefit analysis of biotechnological best practices in the targeted countries; D 3.7: Identification and evaluation of the potential innovative water treatment technologies of the targeted countries; D 3.8: Guideline for appropriate techniques applicable to each of the regions and D 3.9: Cost readjustment report, have been carried out and its results are considered to build a strategic frame. Particularly the information provided in D 2.4, D 2.5, D 2.6 and D 3.7 is considered to select the strategic determinants and steps which are crucial for the initiation of large scale implementation process. The results of the time-to-time meetings and workshops with project partners as well as of the informal discussion with the target groups and stakeholders are very useful for shaping the strategic frame in general.

3 Extract of the Analysis

In view of wastewater treatment and wastewater management the investigated seven African countries, namely Algeria, Burkina Faso, Egypt, Ghana, Morocco, Senegal and Tunisia, have two issues in common:

1. Lack of appropriate infrastructure (i.e. sewer networks, power supply, technologically updated wastewater treatment plant, and waste management facilities), unsound policies, ineffective management, and financial and human resource constraints are the major challenges (see Chart 2).

2. Central government is solely responsible for implementing, administrating and managing the wastewater treatment issues. No private sector is involved to deal with this issue (see Chart 1).

COUNTRY	**Exsiting Biotechnologies**	**Suggested Biotechnologies**	**Waste Water Reuse**	**Institutions involved in (Waste) Water Management**			
ALGERIA	Activated Sludges, Lagoons	Membrane Bioreactor System	Agriculture, Town road cleaning & Fire engines	Ministry of Water Resource:			
				Direction of sewage (DAPE);	National Office for Sewage (ONA);	Departmental directions – DHW Municipalities	No private sector involved
BRUKINA FASO	Lagoons	Constructed Wetland	Reuse increased (gardening, horticultute and irrigation); improvement of WW quality needed	**Urbaln Level:** National Water Company ONEA (office National de l'Eau et de l'Assainissement) **Rural Level:** Water Committees (Comite´s de l'Eau, CLE)		Water & Saniataion NGO network exists, but no private sector involved	
EGYPT	Activated Sludge, Oxidation Ponds ,Primary Sedimentation	Mmbrane Bioreactor System	No info avaiable	Ministry of Water Resources and Irrigation		No private sector involved	
GHANA	Stabilization Ponds, Activated Sludge, Anerobic Digesters	Activated Sludge, mechanized aerobic system	Marginal use	Ministry of Local Government, Rural Development and Enviornment		No private sector involved	
MOROCCO	Stabilization Pond, Activated Sludge, Aerated Lagoons	Constructed Wetland	Marginal use (landscaping)	Department of Energy, Mines, Water and Environment		No private sector involved	
SENEGAL	Activated Sludge, Lagoons	No Biotechnology suggested but rehabilitaion of existing regulations advised	No info available	Multiple Ministries		No private sector involved	

CHART 1: Suggested Biotechnologies and Wastewater Management Institutions

While sanitation coverage and wastewater treatment in urban areas of the investigated countries are (almost) fully existing, suburban and rural areas of the most countries (except Morocco and Tunisia) are not even partially covered with wastewater treatment systems and management facilities. Many of the implemented Wastewater Treatment Plants (WWTP) are set for decades, but many of them are not satisfying the current demands of the countries: less capacity, lack of management, technology failure among others. The reasons for failure of technologies or whole systems don't lie only on the used technology, but also on non-technical aspects related to management, economic and social factors which lastly influence the Management, Operation and Maintenance (MOM) of WWTP. Management, Operation and Maintenance are costly measures. Higher treatment efficiency is generally paid with higher operation and maintenance efforts and plant size while insufficient maintenance and operation jeopardizes system performance. Technical failures are often a result of poor operation and maintenance (D 3.7).

The common wastewater process treatment technologies used in the investigated countries are a) Activated Sludge and b) Aerated Lagoon. Other processes are Stabilisation Ponds and Trickling. The major problems encountered in managing the processing units are technical orders. Lack of spare parts, lack of skilled experts and non-availability of enough financial resources complicate the operation process further (see Chart 2).

Countries	Used Treatment Methods	Problems[1]
ALGERIA	Activated Sludge, Lagoons	Technical: power shortage, tertiary treatment off; lack of experts
BURKINA FASO	Lagooning system	Technical (not detail specified)
EGYPT	Activated Sludge, Oxidation Ponds	Technical: spare parts not available, expert staff lack Financial: low wages of workers
GHANA	Stabilization Ponds, Activated Sludge, Anaerobic Digesters	Technical (not detail specified)
MOROCCO	Stabilization Ponds, Activated Sludge, Aerated Lagoons	Political commitment and national strategies absent; Technical: power shortage – pump failure, feeding raw water quality, insufficient infrastructure (not designed for reuse); qualified personnel lack
SENEGAL	Activated Sludge, Lagoons	Technical: power cuts – pump failure, non-availability of spare parts; Financial: intake revenues insufficient,
TUNISIA	Activated Sludge, Lagoons, Trickling	Technical: Maintenance, tertiary treatment off

CHART 2: Used treatment methods and appeared problems

The reuse of treated wastewater is measured as a crucial factor by considering the cost coverage of WWTP and water saving. Thus in order to increase the treatment quality and quantity of treated wastewater for reuse purpose, some biotechnologies have been suggested. The majority proposed biotechnologies for targeted countries are Membrane Bioreactor (MBR) and Constructed

[1] Source: Evaluation report of the state of the art of the existing biotechnologies and water management strategies (D 2.1)

Wetland (see Chart 1). Apart from the both, there are also other applicable biotechnologies are selected for the targeted countries. These are: Lagoons and aerated Lagoons, Trickling filter, Aquaculture, Anaerobic digester, Sludge blanket reactor and Activated sludge.

Production of high quality effluent is the main advantages of Membrane bioreactor (MBR) that could be used for irrigation. Other advantage of MBRs is its easy retrofit mechanism to upgrade any conventional wastewater treatment plants (D 3.7). Both these advantages have a meaningful strategic importance: the reuse issue plays an important role for the cost coverage and the upgrade possibility through easy retrofit increases the effectiveness of treatment, thus produce better quality wastewater for reuse.

Given the socio-economic situation, power supply condition and skilled workforce position of the investigated country, the proposed constructed wetland as biotechnological system solution seems to be appropriate, particularly for semi-urban areas and rural communities. It is a natural process and almost free from power supply, but needs large land area (D 2.5, D 2.6).

Under contemplation of energy saving and MOM-cost reduction issues, lagoon systems are very appropriate for rural areas. They use less energy than most wastewater treatment methods and are very simple to operate and maintain while requiring only part-time staff. These systems are adequate for rural areas where land is available and inexpensive.

Aquaculture system falls under those conditions and criteria of lagoon system also. This controlled cultivation system of plants and animals runs by making use of wastewater streams as nutrient and water source for plants and fish. Barren land in rural areas can be well used in this system by maintaining ponds puts add value to lands and contributes to produce vegetable and fish (D 3.8).

As a cost-effective and MOM-friendly biotechnological treatment system, anaerobic reactor is proposed. This easy-adaptable technology can be setup at the household level as standalone or with small neighbourhood as community plant in rural areas. Anaerobic biogas reactor counts to this technological system that produces two very essential and useful products for agriculture and rural households: a) digested slurry and b) biogas. Where the former one could well be used as a soil amendment, the later one could be treated as fuel and let converted to electricity (D 3.7 and D 3.8).

If not activated sludge system belongs to those above mentioned cost-effective and simple-technology group, it is, however, an efficient centralized system with high effluent quality. Requirement of little land-space makes possible to set up such a system in urban areas (D 3.8).

Financing for the installation as well as the operation of WWTP seem to be very critical in all the cases. Budget constraints for running operation linked with the high energy cost leads to insufficient maintenance and limited personnel. Cost coverage through appropriate tariffs and reuse do not exist. Political and socio-economic factors such as, lack of awareness on both governance and users generate unfavourable conditions, e.g. low tariffs on fresh water and hence

treated wastewater for irrigation limit the possibility to sell treated water and to generate income for the plant operation, e.g. in Algeria and Tunisia. Many plants are not designed to meet certain (reuse) standards, thus upgrade would be necessary (D 2.5).

Power problem and lack of skilled personnel are two chronic problems facing all the investigated countries (see Chart 2). Power cuts leads to operation failure at collection, transport and treatment. The investigated countries also lack the institutional capacity, expertise and technical skills to assess problems or to propose alternative sustainable techniques for the improvement of WWTPs. In addition, general conditions for environmental awareness and social responsibility are lacking at various fields (private or public, community or individual) resulting no interest and less participation of relevant stakeholders.

Beneficial reuse of treated water has been identified for agriculture, watering green spaces in most of the investigated countries. Future treatment plants should be designed so that produces effluent meeting highest class standards. This standards of treatment maximises reuse opportunities by providing treated water that is suitable for a wide range of uses including irrigation. A regional effluent reuse and management strategy need to be developed as part of the planning process.

4 The Strategy

This analysis based strategy is conceived for large scale implementation of the chosen biotechnologies for wastewater treatment in the targeted countries to

enable authorities, decisions makers and other stakeholders for following effective procedures for implementation. In order to pursue this strategy, it is necessary to understand the current situation of the entire context of wastewater treatment and management sector, particularly for decision makers. As implementation, administration and management of the wastewater treatment issues are centrally organised and regulated by the respective governmental authorities of investigated countries, the entire responsibility for bringing this strategy into action lies also fully on them.

In order to describe the concrete strategic steps for the large scale implementation of biotechnologies for wastewater treatment, strategic factors and determinants are identified from the analyses. All these are interrelated and constitute a strategic frame for the strategy.

4.1 Strategic Factors

Factors that affect and ultimately comprise the strategy are

a) Areas (Urban, Semi-urban or Rural) and
b) Planning (Centralization or Decentralization)

The strategic planning will vary according to the selection of areas (Urban, semi-Urban or Rural) that needs to be taken into consideration to implement a wastewater treatment plant, as different requisites and conditions are existing there. Cities are expanding and growth of mega-cities is accelerating, particularly in emerging economics. That being the case, the issue of municipal wastewater treatment is critically important.

Wastewater generated in urban/municipal areas could be categorized into two different wastewater quality classes: Domestic wastewater and Industrial wastewater. Less contaminated domestic wastewater could be treated by biological methods with low-technology processes and less cost while energy intensive advance treatment with costly technology is needed to treat the extremely contaminated industrial effluent. On the other hand, wastewater generated in semi-urban and rural areas is domestic in nature as no (heavy) industries are located in such areas of the investigated countries. Separation of both the wastewater categories is needed to bring the treatment cost down. If industrial wastewater is separately treated by the industries themselves, the remaining domestic wastewater could be treated by low cost biological processes. As for an example, the tourism industry, particularly the hotel and holiday resort sectors, can easily treat their wastewater and produce fresh water themselves. The Membrane bioreactor treatment process is very well predestined to do so by producing effluent of high quality with high hygienic standards.

Other strategic factor is the level of planning of a wastewater treatment plant. It means that the decision of planning of a plant in centralized or decentralized manner will have a large impact of strategic planning. Centralized system is required for urban areas; its treatment is expensive, requires proper management and operation and maintenance are complex in handling and costly. Such a system is unlikely to be cost efficient for sub-urban or rural areas. Compared to that, decentralized system solutions is cheaper, and also have the advantage of highly flexible in operation and maintenance, and can be adapted to changing conditions. Semi-urban, rural and urban industries can be advised

to setup own decentralized treatment plant which could largely be managed by them.

For achieving a comprehensive “overall overview and planning” related to wastewater treatment and reuse in context of the large scale implementation of the selected biotechnologies, it is required to consider the aforementioned factors that influence planning, management and decision making structures. The decision on which areas with which level of planning can finally be combined for setting up a wastewater plant remains left to the governmental authority’s consideration. But it is generally advised to separate the policy for Domestic Wastewater and Industrial Wastewater, and to support for installing decentralized wastewater treatment plant in suburban areas and in urban industries.

4.2 Strategic Determinants and Steps

The following six determinants are crucial for the large scale implementation of biotechnologies for wastewater treatment and reuse in the targeted counties. The determinants are interrelated and represent all possible domain areas that affect the entire context of wastewater treatment and reuse.

The determinants are:

I Policy and Management

II Technological

III Financial

IV Training and Knowledge Transfer

V Demonstration and Dissemination

VI Cultural

I Policy and Management

Problems

Legal framework and legislation for wastewater management are existent in all the targeted countries, but no policy is formulated for the involvement of any third parties (investors, entrepreneurs, industries etc.) to manage wastewater treatment and reuse. Problem in organisation, planning and management for installed plants are very regular.

Strategic Steps

- Develop legal framework for inclusion of third parties to deal with the wastewater issue.

- Formulate separate rules and regulation for domestic and industrial wastewater management. Introduce wastewater disposing levy for generating funds and to reduce the quantity of wastewater, particularly for industries.

- Declare as a mandatory task to install own wastewater treatment plant for wastewater producing industries. Provide interest free loan or tax reduction for installation of a new plant.

- Adopt prevention and protection measures to promote sustainable water use to reduce wastewater. Provide tax-reduction mechanism to import/adopt up-to-date water-saving technologies to reduce consumption, and thus wastewater production.

- Comprise local government, business people, communities and Non-Governmental Organisations (NGO) into the decision making process from the beginning of any wastewater treatment plant planning.

- Introduce decentralized WWTP in semi-urban areas under the responsibility of local government and communities.

- Share responsibility and task with the local government to accomplish monitoring, controlling, regulating and maintenance of any WWTP.

- Support universities, academic and scientific institutions to develop sustainable plans and programmes to improve the organisation, management and maintenance structure, particularly for quality and use of the retreated wastewater.

II Technological

Problems

Treatment performance and quality of wastewater are not suitable for reuse. Load capacity needs to cope with the gradually increased quantity of wastewater. Complexities in operation and maintenance are very regular. Power shortage disrupts the smooth operation plants.

Strategic Steps

- Equip the installed treatment system with up-to-date and efficient system technology to get the better effluent quality for reuse.

Following options are possible to upgrade from the existing systems (D 3.9):

a) Lagoon upgrades to Aerated lagoon
b) Aerated lagoon upgrades to Activated Sludge
c) Activated sludge upgrades to Membrane Bioreactor

Upgrading of activated sludge to Membrane bioreactor – as for an example – will produce effluent of high quality with high hygienic standards and the retreated wastewater could be reclaimed for irrigation. Because of its small space requirements the Membrane bioreactor equipped with sophisticated technology could be used for suburban and for industrial wastewater treatment purpose as decentralised unit.

- Consider stepwise implementation of a plant by allowing modular layout with easy upgrade possibility.

A plant can have, for instance, two tanks built in the first stage, and other tank built in the second stage after the verification that the effluent load has increased. The gradual improvement of the treated wastewater quality could be the other option to avoid the huge cost at the beginning. Implementation of a less efficient process in the first stage and transferring then to a second stage towards a more efficient system in terms of pollutants is the next option.

- Build a special core MOM -Team particularly for Management, Operation and Maintenance that needs to be separated concerning their duties and

responsibilities to accomplish the works. Practice monthly incentive mechanism related to their performance of the team.

- Generate power by solar energy and biogas to make the treatment process and control system mechanism independent from power supply, particularly for decentralized plant.

III Financing

Problems

Financial constraints are big hindrance to install new wastewater treatment plant. The operation and maintenance section does mostly suffer under it.

Financing projects in the areas of wastewater management by international donors is essential, as national funds are insufficient. Funding initiatives in cooperation with international organizations should be taken to set an infrastructure in context of the entire wastewater treatment issues (management, treatment and reuse).

Strategic Steps

- Mobilize domestic and international financial resources at all level (bilateral or multilateral).

Some international agencies that provide funding for wastewater projects are given below:

- African Development Bank
- Islamic Development Bank
- World Bank

- United Nations Development Programme (UNDP)
- USAid and
- European Commission / EuropeAid
- Private Foundations

➢ Facilitate the establishment of a Public-Private-Partnership (PPP) with national and international partner, as for an example; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) supports PPP projects.

PPP should understand as a wide concept that open for private financing under business perspective. One possible PPP model could be: public authorities run the core activities (ownership, strategic planning and management) in publicly owned wastewater treatment plant, whereas the private sector provides noncore support services (planning and design, construction, equipment supplies, training, plant operation and maintenance).

➢ Initiate Build-Own-Operate-Transfer (BOOT) contract for installation of wastewater treatment plant.

Renowned European companies, like EURAWASSER or Veolia, are acting globally in water and wastewater sector. EURAWASSER has been seen as a pioneer throughout the whole Germany in the area of PPP in the German water sector. Municipal partners benefit from the extensive investments made by them[2]. Another competent actor is Veolia, one of the most experienced

[2] Source: http://www.remondis.com/en/news/archive/2012/remondis-aktuell-12012/latest-news/eurawasser-a-strong-partner-for-local-authorities/

operator in wastewater facilities, operating worldwide, particularly in North America[3].

- Arrange lease contract for plant operation and maintenance as well as for training.

Private companies could be well involved into that. Inclusion of private sector here provides minimum two advantages: e.g. a) they can train the personnel, as the lack of skilled personnel at all levels is immense, and b) they can provide the required best available technologies, best management practices and best professional judgement.

IV Training and Know-how Transfer

Problems

Lack of skilled personnel at all levels is immense. Formation of an expert team is important and necessary to manage, operate and maintain of a plant. No settled initiatives are taken to date. Supporting relevant institutions is necessary to develop own methodology to assure the process of technology and know-how transfer.

Strategic Steps

- Provide (short) training courses for decision makers on local, regional or national policy level, local private consultancy companies, local industrial water treatment private end-users (e.g. textile, agro-industrial, pharmaceutical industries).

[3] Source: http://www.veoliawaterna.com/municipal/wastewater-treatment/

Training configured in three sessions, namely technical, practical with group work and field visit, should focus on the issues like wastewater management, capacity building planning, technical design of decentralized wastewater treatment systems, wastewater recycle and reuse.

- Develop and prepare a training plan in consultation with the suppliers of technology.

- Develop regional, local and national “Trainer”, so that they can train to form “Technicians” later.

- Develop trouble-shooting skills to solve operational problems as they arise, especially during the early years of operation.

- Setup a decentralized wastewater treatment system plant as pilot teaching unit.

Decentralized wastewater treatment, storage and reuse technologies represent promising elements of a cycle-oriented management of water and nutrients as sustainable system solution today. Demonstrate pilot systems of such technologies to evaluate technical components of each process unit as for training purpose.

- Develop and introduce e-curricula and e-courses for colleges, polytechnics and universities.

- Select (at least) two partners (public or private) for the continuation of training.

- Allocate some fund to universities, institutions and relevant (private) companies for Research, Development and Application (RDA) activities in the wastewater management issue

V Demonstration and Dissemination

Problems

The need of communication in the wastewater management issue with all stakeholders, particularly with the public, is a challenge as effective communication is influenced by many factors like education, opportunities for public input and feedback, identification and involvement of stakeholders. It is very important to include opinions of stakeholders and public into the decisions-making process when implementing a wastewater treatment plant. Hence, proper demonstration and dissemination activities are needed to initiate for forming opinion process of the both.

Strategic Steps

- Demonstrate decentralized pilot plants using MBR for industrial use in urban areas and constructed wetland for semiurban areas.

- Demonstrate the practical use of retreated wastewater, especially for farmers in vegetable farming, irrigation etc.

The existing policies of the wastewater reuse need to be oriented towards a better strategy according to local site conditions. Local government of the

targated countries could play an important role regarding consciousness growing of users.

- Conduct seminars and worksops time to time to support the consiousness process of stakeholders and public.

- Arrange radio and TV-talk about wastewater treatment issues in context of sustainable enviornmental development.

- Develop and support wastewater management e-forum to share ideas, opinions and advices.

VI Cultural

Problems

Wastewater in general has a negative image and is associated with dirtiness and malodour. The bigger hurdle to public acceptance may be psychological. The so called “yuck factor” seems to be related to that. Religious sentiment plays also a big role. The purity issues are an important factor to each religion and to their followers. Information and demonstration of the effectiveness of technology, treatment process and use of retreated wastewater are therefore needed to bring a change in the fortified public opinion.

Strategic Steps

- Setup green gardens by using retreated wastewater and make it open to public so that they start to think about the positive side of wastewater.

- Convince farmers to use it for vegetable farming, irrigation etc. so that they achieve financial gain and propagate using for other purposes.

- Create multi-stakeholders platforms to facilitate dialogue and social learning to increase public awareness

5 Conclusions

Large scale implementation of biotechnologies for wastewater management is indispensible in order to address serious concerns over water scarcity and environmental pollution. Government, the hitherto lone actor in this arena, is overtaxed in every sense. Involvement of local government as well as private sector is necessary.

The identified two strategic factors, namely a) selection of areas (Urban Semi-urban or Rural) and b) level of planning (Centralization or Decentralization), will act to bring the mentioned multi actor's involvement resulting their active engagement, responsibility and risk sharing. Above all, these factors will have direct influence on the existing planning, management, investment and decision making structures. The targeted strategic steps derived from the proposed six determinants (Policy management, Technological, Financial, Training and Knowledge Transfer, Demonstration and Dissemination, Cultural) will thereby contribute to formulate policy, to develop own technology and know-how, to find adequate financing partners, and to raise public awareness and acceptance for expediting large scale biotechnological implementation. Promotion of (small) projects on organisation development, skilled workforce formation and awareness campaign should be prioritised than the much

desired big technology-domain ventures to develop and manifest one’s own development environment.