INTEGRATING BIOTREATED WASTEWATER REUSE AND VALORIZATION WITH ENHANCED WATER USE EFFICIENCY TO SUPPORT THE GREEN ECONOMY IN EU AND INDIA

Work Programme 2012 "COOPERATION"

Theme 2: FOOD, AGRICULTURE AND FISHERIES, AND BIOTECHNOLOGY

Activity 2.3: Life sciences, biotechnology and biochemistry for sustainable non-food products and processes
Area 2.3.5: Environmental biotechnology
KBBE.2012.3.5-03
Biotechnological waste water treatments and reuse in agronomical system
Call: FP7-KBBE-2012-6

Integrating biotreated wastewater reuse and valorization with enhanced water use efficiency to support the Green Economy in EU and India

Grant agreement nº: 311933
Funding scheme: Collaborative Project
Coordinator: Antonio Lopez, IRSA-CNR (Italy)

Water4Crops - EU

Work Package 5
Identifying business opportunities and integration of solutions

Deliverable D5.3
Short report summarizing knowledge gaps and training needs

Due date: Month 12
Actual submission date: Month 12
Start of project: 1st/08/2012
Deliverable Lead contractor: ALTERRA
Participants: STEP, EIRC,TERI
Author/s: Annemarie Groot (ALTERRA), Christian Siderius (ALTERRA) Sueleyman Yuece (STEP) Christoph Rams (STEP), Deepthi Prasad (EIRC), Malini Balakrishnan (TERI)
Contact for queries: annemarie.groot@wur.nl
Dissemination Level: PU

INDEX

FIGURES

ANNEXES

1. Introduction

Context and objectives

This report describes gaps in knowledge, attitude and skills as well as training needs of the potential users of wastewater reuse and valorisation technologies. The document also highlights potential topics which can be addressed in the INNOVA platform meetings to be organized in the context of the Water4Crops project.

Water4Crops (W4CSs) stands for "integrating bio-treated wastewater reuse and valorisation with enhanced water use efficiency to support the Green Economy in Europe and India**".** This deliverable (5.4) is part of Work Package 5 which focusses on green growth through technological innovations in the field of 1) wastewater valorisation and reuse in agriculture, and 2) water use efficiency. The gaps in knowledge, attitude and skills described in this document support the organization of the INNOVA platform meetings. The creation and facilitation of the INNOVA platform is one of the main activities of Work Package 5.

The INNOVA platform is an important tool to facilitate the development of business opportunities for innovative technologies with a link to 1) wastewater reuse and valorisation in agriculture and/or 2) to improving water use efficiency. The INNOVA platform is based on two premises (Hekkert et al., 2007):

- Development of innovative technologies requires a knowledge co-creation process in which different stakeholders from the main areas (i.e. technology production, technology use and marketing /retailing) share, integrate and generate new knowledge.
- Development of innovative technologies requires more than technical devices only. Changes in the social dimension such as user practices, user mind sets, regulation or industrial networks are also required.

In W4CSs two INNOVA platform meetings will be organised in which participants will 1) share lessons learnt in the co-creation of the new technologies with a link to wastewater valorisation and reuse in agriculture, 2) discuss common problems and, 3) search for opportunities to increase the probability of a successful innovation in view of the aim of supporting green growth. To be able to effectively organise relevant INNOVA platform meetings a questionnaire (see annex1) was developed to identify, amongst others, the status of development of the technologies, problems

encountered and gaps in knowledge, attitude and skills amongst the potential users of the technologies and amongst other stakeholders.

The gaps in knowledge, attitude and skills described in this document also serve as input for activity 6.5 of Work Package 6 which aims to support capacity building in wastewater valorisation and wastewater reuse.

Scope

The identified gaps in knowledge, attitude and skills are based on the difference between actual and required human performance for application of the technologies under development. These gaps are translated into training needs of the potential users of a) wastewater treatment and reuse technologies, b) water use efficiency technology. This document describes a first inventory of gaps and training needs. Since some of the technologies are still in a very early development stage, the required competences for their application cannot yet be estimated. In addition, for some technologies potential users have not yet been identified. Therefore, for the design of the training sessions the gaps in knowledge, attitude and skills need to be further explored in a later stage through discussion with developers of the technology and its users (see chapter 3).

In addition to the identification of knowledge gaps, the principal investigators were asked to highlight problems and barriers they experienced in the development of the technologies. These problems and constraints were translated into potential discussion topics which can be addressed in one of the two INNOVA platform meetings.

Research methods

To elaborate this deliverable the following research methods were used:

- An analysis of results of an online questionnaire (see annex 1). This online questionnaire has been developed to identify the status of development of technologies on wastewater valorisation and reuse. It also assists in discovering structures and processes that support or hamper the co-creation of the technologies. The results of the questionnaire are helpful to organise the INNOVA platform meeting as to the type of experts to invite and the issues that should be addressed. One question specifically addresses gaps in knowledge, attitude and skills amongst

the potential users of the technologies and other stakeholders. The questionnaire was filled in for 24 different technologies;

- An analysis of deliverable 1.1 ‘Evaluation on the exploitation of the target wastewaters’ (Pant et al., 2013); Additional information and further clarifications from principal investigators of W4CS.

2. Results

The first section (2.1) presents the results of the inventory on gaps in knowledge, attitude and skills amongst potential users of the technologies. It also describes some problems faced and barriers to the development of the technologies. In the second section (2.2), these gaps and barriers are translated into training needs for the technologies under development in the context of W4CS and into topics which could be addressed in one of the two INNOVA platform meetings.

The wastewater treatment, reuse and valorisation technologies as well as those related to water use efficiency are categorized in the following 5 clusters:

1. Valorisation, treatment and reuse of agro food industry wastewaters technologies
2. Innovative municipal wastewater bio-treatment for agricultural reuse technologies
3. Technologies for efficient water use in irrigated agriculture
4. Technologies improving water use efficiency and drought tolerance via genomics approaches and modelling
5. Other technologies

For each technology we provide a brief description on the technology itself, the identified users, a summary of gaps in knowledge, attitude and skills and barriers to the development of the technologies. To facilitate further contact we also include the name of the principal investigator who is involved in the development of the technology.

2.1 Gaps in knowledge, attitude and skills – barriers

I. Valorisation, treatment and reuse of agro food industry wastewaters technologies

Technology	**Improved valorisation of volatile fatty acids and alcohols out of bio refinery waste waters**
Description	Adiabatic extraction using gases instead of solvents in order to extract specific component ranges. Its thermodynamic characteristics allow efficient, clean and fast processes
Potential users of the technology	Water-using Industries, Sewage processing plants, bio refineries, remediation
Gaps in knowledge, attitude and skills amongst potential users	Potential users are not yet aware of this adiabatic technology. They lack experience with this process

Barriers	Financing schemes for technology development – mobilising financial resources
Contact person	Pierre Salvat (Bionactis International Group SA)

Technology	**New multi-step design in olive mill wastewater treatment to obtain natural antioxidants: Olive Mill Wastewater polyphenols through an SPE (Solid Phase Extraction) procedure**
Description	Recovery of bio based bioactive antioxidant compounds from agro-industrial wastewater (i.e., olive mill wastewater)
Potential users of the technology	Olive oil producers (Olive mill industries) for sectors where polyphenols could be exploited for their antioxidant features (food industry, cosmetic, pharmaceutical sector)
Gaps in knowledge, attitude and skills	Main gaps in knowledge and skills amongst potential users are related to the lack of knowledge on potential benefits of exploitation of polyphenols
Barriers	• Technology costs • Reproducibility of results by changing the wastewater employed as the feedstock
Contact person	Lorenzo Bertin (University of Bologna (DICAM))

Technology	**New multi-step design in olive mill waste water treatment to obtain natural antioxidants: anaerobic digestion**
Description	Anaerobic digestion of organic residues from bio refinery of olive mill wastewater
Potential users of the technology	Agro-industries and in particular the olive mill industries
Gaps in knowledge, attitude and skills amongst potential users	The anaerobic digestion process under development focusses on the possibility of processing organic leftovers from the exploitation of olive mill wastewater for polyphenol recovery and biopolymers production, but effectiveness of the process still has to be studied. A gap in knowledge is the exact information about anaerobic digestion plants.
Barriers	• Investment costs • Knowledge about the anaerobic digestion process • Olive oil producers not yet involved
Contact person	Lorenzo Bertin (University of Bologna (DICAM))

Technology	**New multistep design in olive mill waste water treatment to obtain natural antioxidants: Production of biodegradable polymers from wastewater treatment**
Description	The technology is part of a modular integrated technology for the tailored decontamination and valorisation of olive mill wastewaters (OMWs), aimed at obtaining bio based energy and chemicals, mostly polyphenols and polyhydroxyalkanoates (PHAs), as well as treated waters to be employed for different irrigation purposes. Key issue of the technology are: a) Development of an integrated suspended-cell anaerobic-aerobic process for the production of PHAs from OMWs, either with or with no previous recovery of polyphenols from raw OMW and,

	b) Development of an effective, low-cost procedure for the extraction of PHAs from cells, without employing chlorinated solvents.
Potential users of the technology	No potential users have been identified yet
Gaps in knowledge, attitude and skills amongst potential users	No gaps amongst potential users have been identified. Only scientific knowledge gaps are mentioned
Barriers	• Concerns of potential producers about relatively low productivity • Concerns of potential end users about relatively low reliability of the process and related variability of polymer characteristics • Concerns of both producers and end-users about the extraction step, if chlorinated solvents are used
Contact person	Mauro Majone (Sapienza University of Rome, Department of Chemistry)

Technology	**New irrigation strategies to improve the sustainability of irrigation systems for TWW reuse: Improved pressure compensation emitter adapted to waste water distribution**
Description	Improved pressure compensating emitter adapted to waste water distribution: development of a new product.
Potential users of the technology	Potentially all actors involved in effluent treatment
Gaps in knowledge, attitude and skills amongst potential users	Not yet known. The technology is not yet under demonstration.
Barriers	• Financial means • Industrial and research constraints and interest negotiation • Lack of partnership with potential users of various horizons
Contact person	Molle Bruno (Irstea)

Technology	**Improved valorisation of volatile fatty acids and alcohols out of bio refinery waste waters**
Description	Electrodialysis is a technology that is already commercially applied for desalination of (waste) water and for removal and recovery of e.g. heavy metals from industrial wastewater in combination with water reuse. The technique relies on transport of ions under an electrical field from a feed stream to a concentrate stream. It does not imply water transport as in pressure driven membrane technology. Depending on the sequence and type of membranes applied in the electrodialysis stack, either anions, or cations are removed from the feed stream. Some degree of selectivity can be introduced in the type of ions removed, and even water splitting into protons and hydroxyl ions is possible leading to pH changes. Recently, the technique is considered for the recovery of organic acid salts from fermentation broth.

Potential users of the technology	Any sector where technology shows perspective: desalination, heavy metal recovery, ion recovery.
Gaps in knowledge, attitude and skills amongst potential users	• Technology suppliers have limited experience with the application of electrodialysis in the field of wastewater valorisation • Technology users often perceive the technology as expensive
Barriers	• Lack of demonstration scale examples to show robustness and cost efficiency of the technology in an overall treatment and valorisation scheme • Costs • Energy consumption • Relevance and cost efficiency in overall treatment scheme
Contact person	Heleen de Wever (VITO)

Technology	**Carbons and membranes from sugar cane ash for the recovery of phenolics /pigments**
Description	Waste ash based adsorbents and filters for wastewater treatment targeted at water reuse
Potential users of the technology	Suppliers/developers of water/wastewater treatment equipment (not involved presently)
Gaps in knowledge, attitude and skills amongst potential users	The potential technology users (industries selling developed products) have no obvious lack of skills or knowledge that is limiting the uptake of technology.
Barriers	• Industry involvement in an early stage of development would be very helpful. However, in our experience, industry focus is more on "market-ready" products. • Lack of funds for translational research.
Contact person	Dr Malini Balakrishnan (TERI)

II. Innovative municipal wastewater bio-treatment for agricultural reuse technologies

Technology	**Tailoring effluent properties from decentralized membrane bioreactors for agricultural re-use: new membranes (I)**
Description	Bio treatment of municipal wastewater coupled to surface filtration for agricultural effluent reuse. Technologies based on the integration of biological wastewater treatment with surface filtration (membrane or other) will be tested for effectiveness in providing effluents suitable for reuse in irrigated agriculture.
Potential users of the technology	Integrated water service providers and farmers consortia.

Gaps in knowledge, attitude and skills amongst potential users	Water utilities: operators and managers lack in knowledge in the management of the proposed technologies
Barriers	Standards and regulations
Contact person	Alfieri Pollice (IRSA (IT)

Technology	**Tailoring effluent properties from decentralized membrane bioreactors for agricultural re-use: new membranes (II)**
Description	MBBR-MBR combines of the Moving Bed Biofilm Reactor (MBBR) technology with a Membrane Bioreactor (MBR). The aim is to exploit the advantages of biofilms growing on carriers freely swimming in the oxidation tank and the effective separation of suspended biomass attainable with membranes. This should allow limiting biomass growth (i.e. sludge production) and obtaining high quality effluents suitable for unrestricted irrigation.
Potential users of the technology	Water utilities (e.g. AQP in Italy), technology providers
Gaps in knowledge, attitude and skills amongst potential users	Plant operators are normally not very well trained to work with innovative systems. Operation of relatively complex systems such as MBBR-MBR requires some knowledge of the processes involved. This knowledge is often lacking.
Barriers	Insufficient integration, cooperation and poor communication among the different stakeholders
Contact person	Alfieri Pollice (IRSA (IT)

Technology	**An innovative system for wastewater treatment and reuse in agriculture: SBBGR system**
Description	Sequencing Batch Biofilter Granular Reactor (SBBGR) is the innovative system developed by IRSA for wastewater treatment and reuse. It consists of a single basin into which the wastewater is fed, treated and then discharged. SBBGR is a unique system in virtue of the particular type of biomass growing in it (i.e., a mixture of biofilm and granules packed in a filling material) which allows a greater retention of the biomass in the reactor to be obtained (up to one magnitude order higher than that recorded in conventional biological systems). As a result, a notable reduction of sludge production (up to 80% lower) is achieved. Moreover, this system is featured by high operational flexibility and treatment effectiveness, and low footprint which make it suitable for small or large communities. SBBGR treatment can be also chemically or physically enhanced when a high effluent quality is needed for agriculture reuse. Furthermore, due to certain operational features of the system, the chemical/physical enhancement can be activated or deactivated on the basis of water demand.
Potential users of the technology	Urban wastewater treatment plants and companies involved in wastewater treatment field
Gaps in knowledge, attitude and skills amongst potential users	Reluctance and scepticism towards the emerging technological innovation often due a lack of knowledge of the new technologies/processes
Barriers	• Limited expertise in the operation of the system;

	• Initial difficulties in the conversion of the existing treatment plants.
Contact person	Claudio Di Iaconi -IRSA (IT)

Technology	**Nanobiocatalysts as tertiary treatment for the removal or organic micro pollutants**
Description	The technology consists on the immobilization of oxidative enzymes, i.e. laccases onto nanomaterials (fumed silica) for the degradation of phenolic micro pollutants, e.g. bisphenol A as a polishing step in the wastewater treatment. The so-called Nano biocatalysts are applied to membrane bioreactor, which is operated in continuous mode.
Potential users of the technology	Industrial wastewater treatment companies
Gaps in knowledge, attitude and skills amongst potential users	No clear gap could be identified at the moment. The advantages of the technologies must be assessed in depth at the moment.
Barriers	• Status existing wastewater treatment plants • Wording nanotechnology • Removal of cocktails of pollutants has low efficiency • Financial aspects (public private partnerships)
Contact person	Mr. Corvini (FHNW)

Technology	**Optimized constructed wetlands**
Description	Clogging and evapotranspiration assessment
Potential users of the technology	Private and public agencies responsible for the implementation and management of urban wastewater treatments, agro-food industries, farmers, municipalities
Gaps in knowledge, attitude and skills amongst potential users	Lack of knowledge on the treatment performance, the environmental sustainability and the overall advantage of constructed wetland systems (for users and policy makers)
Barriers	• Poor knowledge on the efficiency and reliability of constructed wetland plants • Complex wastewater legislation and poor availability of funds for constructed wetland construction and management • Uncertainty in the real lifespan of these systems (due to the clogging of the substrate)
Contact person	Attilio Toscano (University of Catania (UNICT))

Technology	**Nanobiocatalysts as tertiary treatment for removal of organic micro pollutants**
Description	Using protected and Nano immobilized enzymes for enhanced and sustained activity of micro pollutant removal from wastewater.
Potential users of the technology	Wastewater treatment plant

Gaps in knowledge, attitude and skills amongst potential users	• It is particularly hard to modify existing practices in the field of wastewater treatment. • Operators are used to a given set of protocols and changing for an emerging technology is often seen as problematic.
Barriers	• Conservatism of potential users • Difficulty to find funding for industrial demonstration • Time required to reach industrial requirements
Contact person	Yves Dudal (INOFEA)

Technology	**Optimization of engineered constructed wetland systems for WW treatment and reuse**
Description	Improved hygienization (slow sand filtration)
Potential users of the technology	Municipalities, stakeholders in agricultural sector
Gaps in knowledge, attitude and skills amongst potential users	• Insufficient knowledge about the environmental and human health impacts applying untreated waste water for e.g. agricultural reuse • Insufficient knowledge about the emerging new technologies and their advantages (e.g. improved quality of the agricultural product)
Barriers	Due to economic reasons the treatment of wastewater is limited
Contact person	Anja Hebner (Vita 34 AG)

Technology	**Optimization of engineered constructed wetlands: bamboo systems**
Description	The technology deals with bamboo systems to treat municipal wastewater without producing sludge but producing bamboo biomass that must be harvested and give a high value to the treatment. The technology is already on the market for tertiary treatment without discharge into the river, but in this project the innovative part is to test bamboo filter as a secondary treatment, with a discharge that can be reused for agriculture.
Potential users of the technology	Residential parks, hotels, industrial parks, universities.
Gaps in knowledge, attitude and skills amongst potential users	• Unfavourable way of thinking: sanitation is very often thought as a centralized issue for municipalities, communities ... so big sewerages are built and as well as big and sophisticated waste water treatment plant, close to a river or to the sea. In order to help with further development of our innovation, they should think about decentralisation... and so consider that the wastewater treatment plant is a part of urbanisation.
Barriers	• Institutions – regulation: regulation is made for old technologies and even if a new technology has proven its efficiency... institutions need time to check it on long term and they are afraid of innovation, especially when innovation is a real new concept and not only a detail in a technology • Too many actors and stakeholders to convince
Contact person	Véronique Arfi (PHYTOREM)

Technology	**Optimization of engineered constructed wetland systems for WW treatment and reuse: substrate optimisation for delay in clogging**
Description	Optimized performance of constructed wetland systems
Potential users of the technology	Sewage Treatment groups
Gaps in knowledge, attitude and skills amongst potential users	• Lack of awareness about the new technology • Insufficient knowledge about the implementation
Barriers	• Proper advertisement is lacking • Lack of appropriate mathematical models
Contact person	Rakesh Kadaverugu (CSIR-NEERI)

Technology	Optimization of engineered constructed wetlands: enhanced efficiency of ECWs using selected microbes
Description	Screening of microorganism which helps in reduction of pollutants. Optimization of filter media in constructed wetland.
Potential users of the technology	Brewery and Distillery industry
Gaps in knowledge, attitude and skills amongst potential users	Gap in knowledge/skill as to the maintenance of constructed wetlands.
Barriers	No participation from industries in R&D
Contact person	Karthik Raghunathan (CSIR-NEERI)

III. Efficient water use in Irrigated Agriculture

Technology	**New monitoring combinations for precision irrigation: non-point based measurements**
Description	These technologies aim at measurements at larger scale. In contrast to the current technologies which are based on point measurements and suffer from the spatial variability, the new technologies are non-point based (area and transect based) to account for the spatial variability in soil moisture and evaporation. The new technology will better estimate the soil moisture deficit and actual evapotranspiration. Both would lead to better estimate the crop water requirements and better plan for irrigation scheduling and subsequently more efficient water use and water saving. Three different technologies are under development. *Cosmic ray soil moisture observation system* (COSMOS, area based, 300-700m radius) combined with Electrical Resistivity Tomography (ERT, transect based). *Evapotranspiration measurement* using Scintillometer and Eddy covariance over larger areas (Area based measurements). *Simulation and modelling-Model system*: SALTMED model development to suit the use of treated waste water and the new monitoring systems. The model helps to investigate the short and long impact of using different water qualities on crops and soils, the best irrigation system and strategy, the optimum water use for high water productivity, the best cropping system and rotation and the possible impact of climate change on crop productivity.
Potential users of the technology	Large size farm holders, Farming companies, Extension services, Academics and PhD students
Gaps in knowledge, attitude and skills amongst potential users	• Lack of knowledge about the models, theories and instruments behind the technologies • Lack of knowledge and skills in the operation and maintenance of each instrument • The new Field scale model is software. The user needs to learn what the model does , what processes involved, what input data required and what output results to expect
Barriers	Cost -the new technologies require large area to justify the cost
Contact person	Ragab Ragab (Centre for Ecology and Hydrology, CEH-Wallingford, UK)

Technology	**Optimized constructed wetlands**
Description	Improved hygienisation for tertiary wastewater treatment by new technical modifications of slow sand filtration.

Potential users of the technology	Rural communities in India
Gaps in knowledge, attitude and skills amongst potential users	Limited awareness of available technologies and insufficient expertise in the implementation of technologies.
Barriers	• Costs • Limited awareness of available technologies and limited expertise in implementation of technologies
Contact person	Matthias Kästner (Helmholtz Centre for Environmental Research - UFZ)

Technology	**Agro-aqua farming system**
Description	Designing and implementing integrated agro-aqua farming system using bio-treated industrial waste water
Potential users of the technology	KCP Sugar, EID Parry, Pioneer Jellice, Farmers, Research Community
Gaps in knowledge, attitude and skills amongst potential users	• Farmers are unaware of biological treatment of industrial waste water and reusing in an integrated manner to cultivate both crops and fishes • Industries: unaware of waste water treatment using microbes and constructed wetlands to reduce physical characteristics especially colour, and odour
Barriers	• Isolating potential microbes to reduce colour and odour of the waste water • Maintaining quality of the waste water
Contact person	Dr.J.D.Sophia (M S Swaminathan Research Foundation)

Technology	**Improved drip irrigation management**
Description	New dripper for spreading waste water
Potential users of the technology	Jain Irrigation Systems Ltd.
Gaps in knowledge, attitude and skills amongst potential users	Collectives and farmers are insufficiently aware of the existence of such a technology. But further tests are needed in order to demonstrate the performance of this technology.
Barriers	• Lack of real tests • Lack of manufacturing • Lack of spreading information – lack of knowledge about ways to spread/communicate information to users.
Contact person	Mr. Tomas (Irstea)
Technology	**Improved drip irrigation management**
Description	The innovation is about design of a new emitter which can resist plugging by physical contaminations. Various geometries of the emitters as well as some new concepts are under

	development to make it pressure compensating.
Potential users of the technology	Industries generating treated waste water e.g. Sugar Factories and Farmers
Gaps in knowledge, attitude and skills amongst potential users	• Illiteracy of the user (farmer) • Limitation of skilled manpower to handle the technology • Users' mind-set unfavourable to the use treated waste water
Barriers	• User of this technology is mostly from an unorganized sector (farmer). • Government norms to use treated waste water for agriculture. • Variations in quality of treated waste water.
Contact person	Abhijit Joshi (Jain Irrigation Systems Ltd.)

Technology	**SA a pressure compensating emitter**
Description	Apart from the development of simulation tools to better understand what are the drivers of drip irrigation systems ageing when distributing low quality water, we have developed with Phytorem SA a pressure compensating emitter adapted to effluent with high contaminants content. The prototype is under test with real effluent and in laboratory conditions.
Potential users of the technology	Farmers, Food processing Industry (effluent cleaning)
Gaps in knowledge, attitude and skills amongst potential users	Very difficult to answer such question provided the technology is not yet fully developed and industrial prototype not available.
Barriers	• Health administration puts restriction and apply precautionary principles often without scientific basis • Regulation that ignores the type of innovation proposed
Contact person	Bruno Molle (IRSTEA)

IV Improving Water Use Efficiency and drought tolerance via genomics approaches and modelling

Technology	**New genetic mechanisms (QTLs) regulating drought adaptive traits in the three crops (maize, millet, tomato)**
Description	The technology aims at identifying the loci (chromosome regions with loci (genes and/or Quantitative Trait Loci) that control the water balance of the plant and thus the water-use efficiency (WUE) of the crop itself. Once the loci are identified and well-characterized as to their overall effects on yield and related traits of agronomic interest, the molecular markers in the vicinity of such loci (i.e. highly associated in genetic terms) can be used to perform marker-assisted selection at the target loci.
Potential users of the technology	Seed companies

Gaps in knowledge, attitude and skills amongst potential users	Stakeholders (i.e. seed companies) that are not actively involved and have poor understanding, hence appreciation for the applied technology (i.e. QTL mapping and their marker-assisted selection)
Barriers	• Scientific knowledge gaps i.e. difficulty in phenotyping appropriately; complexity of the genetic and functional basis of water-use efficiency and drought tolerance of crops and, lack of understanding in genotype x environment x water management interaction • Insufficient public–private partnership
Contact person	Roberto Tuberosa (University of Bologna, Italy)

V. Others

Technology	**Remediation of saline land caused due to irrigation with bio methanated spent wash**
Description	The technology will address amelioration of land salinity through microbiological intervention
Potential users of the technology	Sugar cane industries and distillery industries
Gaps in knowledge, attitude and skills amongst potential users	Insufficient knowledge about the application of microbes to ameliorate soil.
Barriers	Reproducibility of the technology
Contact person	Dr. Alok Adholeya (TERI)

2.2 Synthesis: training needs and topics for discussion in INNOVA platform meetings

Training needs for potential users of the technologies

Common training needs

For 13 of the technologies under development, the principal investigators indicate that the users still lack awareness about the technology or lack of knowledge about the existence of the technology. Most of them also mention the lack of experience with the application of the technologies. Six of the principal investigators explicitly mention that the users still lack the knowledge about the costs and/or (social, environmental and financial) benefits.

Specific training needs

Only one principal investigator, who works on the optimization of engineered constructed wetland systems for wastewater treatment and reuse, mentions the gap in the users' knowledge about the environmental and human health impacts of applying untreated waste water for agricultural reuse. Awareness about these environmental consequences is important for convincing potential users about the usefulness of the new technology.

There is one principal investigator who underlines that innovation development requires fundamental shift in thinking rather than addressing knowledge and skill gaps. She is working in the field of innovative municipal wastewater bio-treatment for agricultural reuse through constructed wetlands with bamboo systems and stresses the need for a change in thinking about sanitation and its place in planning how it fits amongst municipalities and communities.

Slightly different, but certainly related is the experience of another principal investigator that it is particularly hard to modify existing practices in the field of wastewater treatment. Conservatism of wastewater treatment plants is identified as one of the barriers to the development process of nano-biocatalysts as tertiary treatment for the removal of organic micro-pollutants.

No needs (yet)

Some principal investigators clearly mention that at this moment there are no gaps in the users' knowledge or skills. This is the case for example for the technology 'carbons and membranes from sugar cane ash for the recovery of phenolics/pigments since activated carbon adsorbents and ceramic membrane filters are already being used in waste water treatment). Others, for example the investigator working on 'Greater biomass retention in SBBGR' indicates that in this stage it is difficult to identify gaps in knowledge amongst the intended users of the technologies they work on. The technology development process is still in its early stages. The principal investigators are more preoccupied with gaps in their own knowledge as to effectiveness, feasibility and efficiency of the technology, than with potential users. They, however acknowledge that it is important to start building contact with these intended users.

Synthesis: need for tools to design tailor made training

So far, the results indicate clear gaps between the actual and required human performance for application of the W4CS technologies. The main reason for these gaps is the fact that most of these technologies are new and the majority of them is still under development. These knowledge gaps, however can be covered by well-designed training. The main task of these trainings is to transfer knowledge from the developers of the W4CS technologies to their users. The efficiency and thus the success of such training is highly dependent on proper definition of the training task, training design and its execution as well as on close monitoring of the training. In other words; a Strategic Approach for Training (SAT) that focusses on the topics of W4CS and addresses the needs mentioned in the table above is required (Gebel and Yüce, 2008). SAT is a methodology which applies quality assurance to training and assures the required competencies for the personnel to be trained. SAT consists of five interrelated phases (see figure 1):

Phase 1: Analysis of existing situation/screening (personnel screening for managers, operators, etc.)

Phase 2: Design of training plan (determination of the knowledge level of developers and owners of a particular W4CS technology; definition of the knowledge gap that is to be covered by training in relation to the job description of the user)

Phase 3: Development (Curricula, trainers, trainees, etc.)

Phase 4: Implementation

Phase 5: Monitoring and evaluation of the training

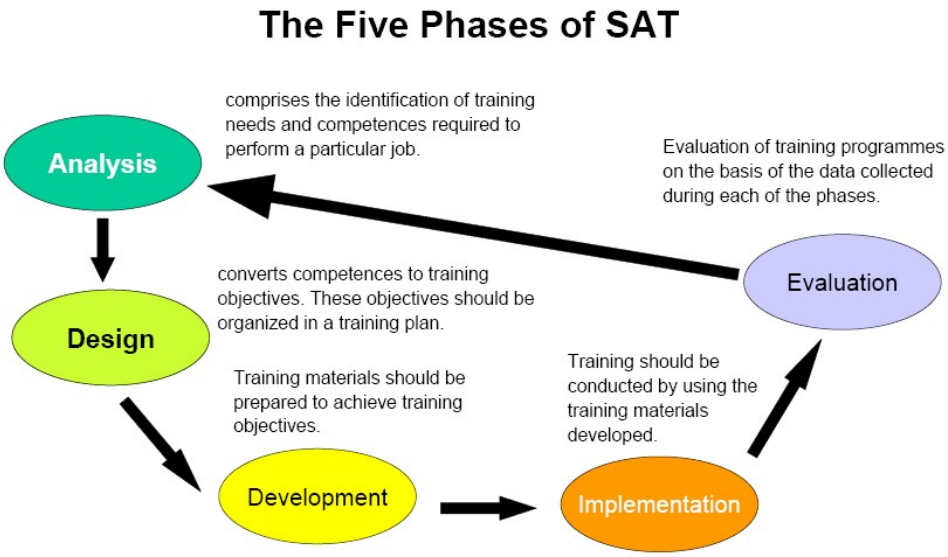

Figure 1: The five phases of SAT (Gebel and Yüce, 2008)

Chapter 3 will further describe how SAT will be applied in one of the next steps of the W4CS project.

Issues that could be addressed in the INNOVA platform meetings

Mobilization financial resources

Three principal investigators explicitly mention the lack of funding as one of the barriers to the development of the technologies they are working on. The INNOVA platform meetings can facilitate an exchange of experience with e.g. methods for fund raising and potential funding agencies. The meeting can also invite some of these potential funding agencies to start the networking.

Constraining regulations

The present standards and regulations are set for existing technologies but do not always favour the development and uptake of innovative technologies even if a new technology has proven its efficiency. Institutions need time to change. Four principal investigators indicate that current regulations are a barrier to the technology they are working on. Two of them work on technologies for a more efficient water use in irrigated agriculture and two are involved in the development of innovative municipal wastewater bio-treatment for agricultural reuse technologies.

Networking –building (public–private) partnerships

Some principal investigators identify barriers in relation to a poor involvement of the potential users in the development of the technologies. Others stress the importance of building public –private partnership to address the lack of funds and/or to better involve private industries. These experiences show a clear need for the facilitation of networking amongst e.g. researchers, potential users, funding agencies, private industries and policy makers.

Marketing

One principal investigator mentions the need for better promotion of the technology. In the INNOVA platform meeting, the issue of methods for promotion and advertisement could be dealt with. The meeting could also address other marketing issues such as ‘user need assessment’.

Training tools

The SAT training tools will be explained to the participants by demonstrating its application for selected W4CS technologies during the first INNOVA platform meeting. If considered necessary, STEP will organize workshops on the SAT tools.

3. Next steps and conclusions

This chapter briefly describes steps that will be taken to address the identified gaps in knowledge and skills.

Design and dissemination of training tools

To help the principal investigators to address the training needs as described in chapter 2, the necessary SAT tools will be (further) developed under consideration of two groups of W4CS technology users:

1. Wastewater treatment and valorisation
2. Wastewater reuse

Figure 2 shows a systematic approach that will be pursued to develop training tools dedicated to address W4CS training needs.

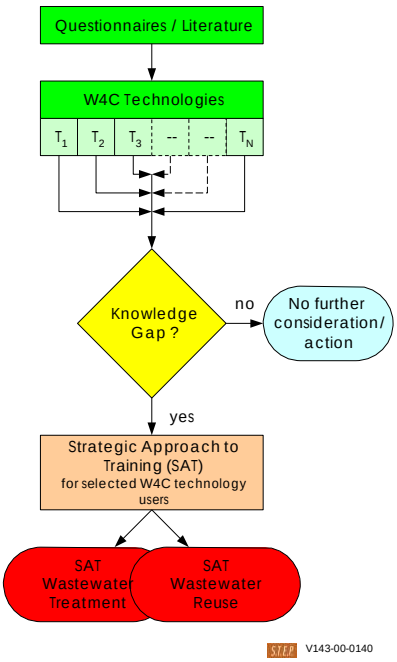

Figure 2: Flowchart for developing training tools in the context of W4CS

STEP will develop the training tools as template and apply them to W4CS wastewater treatment, valorisation and reuse technologies. The SAT training tools will be explained and demonstrated during INNOVA platform meetings and/or other relevant W4CS meetings. The tools will be also available via internet. Beyond these demonstration workshops there will be no multi-day training courses offered by W4CS. So, for the design, demonstration and dissemination of appropriate training tools the following activities will be carried out during the coming months:

- Refining the results from the questionnaires by literature survey and by additional data from technology owners and developers
- Selection of technologies and their potential users from the W4CS mirror cases
- Creation and development of SAT tools as templates, also for online use
- Application of the SAT tools to the selected users
- Dissemination of the SAT tools at workshops during W4CS meetings

INNOVA platform meeting

In the first INNOVA platform meeting relevant stakeholders, involved in technology production, technology use, marketing/retailing, funding, regulation and policies, will share experiences and develop new knowledge on W4CS technologies. The meeting will address (some of) the identified barriers to the development of W4CS technologies and will help to jointly create solutions. The first INNOVA platform meeting which will be organized in the beginning of December 2013. Its preparation include the following activities:

- Contact will be made with the principal investigators who experience the mobilization of financial resources, regulation, marketing and/or the building public and private partnership as being a barrier to the further development of the W4CS technologies. The discussion will further clarify what specific aspects need to be addressed during the meeting and who should be involved.
- Relevant fact sheets will be developed (WP 5, task 5.2) on e.g. policies, legislation and standards for wastewater treatment and reuse in agriculture and, costs & benefits which will support the discussions in the INNOVA platform meeting
- Key resource people will be contacted and invited
- Identifying relevant stakeholders, making contact and start developing a INNOVA platform
- Designing and implementing a well organised INNOVA platform meeting

The combination of SAT training tools and, new insights and new relationships emerging from the INNOVA platform meetings will accelerate the further development of W4CS technologies and their uptake.

3. References

Hekkert, M.P., R.A.A. Suurs, S.O. Negro, S. Kuhlmann and R.E.H.M. Smits. Functions of Innovation systems: A new approach for analyzing technological change. *Technological Forecasting & Social Change 74 (2007) 413-432.*

Gebel, J. and S. Yüce. A new approach to meet the growing demand of professional training for the operating and management staff of desalination plants. *Desalination 220(2008) 150-164.*

Pant, D., H. De Wever, L. Diels and L. Bertin (2012). *Insight in exploitation potential of biorefinery wastewaters and olive mill wastewaters*. Milestone 1.1. Water 4Crops project: Integrating biotreated wastewater reuse and valorization with enhanced water use efficiency to support the Green Economy in EU and India.

Annex 1: Water 4Crops INNOVA co-creation platform questionnaire

Water 4Crops INNOVA co-creation platform questionnaire

In Water4crops (W4C), the INNOVA platform will be an important tool to facilitate the co-creation process on business opportunities to increase the reuse of waste water in agriculture. The INNOVA platform will consist of key stakeholders in i) technology production, ii) technology use, and iii) marketing /retailing. The members of the INNOVA platform may represent work on different waste water treatment and water (re)use technologies but share some of the common problems and challenges.

WP5 has planned to organise two INNOVA platform meetings in which participants will: 1) share their experiences and the lessons learnt in the co- creation of the new technologies with a link to waste water treatment and reuse in agriculture, 2) discuss common problems and challenging boundary conditions and, 3) search for opportunities to increase the probability of a successful innovation in view of the aim of supporting green growth. The first meeting is expected to be held by the end of 2013, possibly the beginning of 2014.

In order to prepare this first meeting we kindly ask you to fill in the questionnaire. For each 'waste water reuse technology' under development in W4C, only one representative will fill in this questionnaire. Each technology or sub component has its own ID CODE. You can find this code in the list of W4C technologies which was sent to you by email.

Your answers to the questionnaire will help the W4C project to map the status of development of the emerging technologies on waste water reuse and to find out about the actors and factors that support or hamper it. Your answers will also assist us to decide on the type of experts to invite to the INNOVA platform meeting and the issues that should be addressed. We will also combine all questionnaires and present these at the next W4C project meeting. In addition we will prepare a feedback document relating the status of your innovation to the status of the innovations in the rest of the W4C consortia.

The questions are based on the latest thinking about 'innovation development'. The central idea behind it is that in order to make technological change sustainable, technical change alone is not sufficient. Changes in the social dimension–such as user practices, regulation, and industrial networks–are also required.

The questions are organized in three
parts: I. Introduction
II. Analysis: Finding out about actors and factors supporting or constraining the development and implementation of the waste water reuse technology
III.Synthesis.

The questions are a mix of closed and open questions. Some questions do appear with a red star which means that it is mandatory for you to respond to these questions. It will take you about 30-45 minutes to fill in the questionnaire.

We request you to kindly spare time to respond to the questionnaire which will help us determine further actions in facilitating co-creation of innovations and business opportunities.

In case of any queries, please contact annemarie.groot@wur.nl or christian.siderius@wur.nl

Thank you.

I. Introduction

1. Name: *

2. At which firm/institute are you working? *

3. Considering the four W4C topics, which topic does the technology under development most relate to? *

- ☐ Valorization, treatment and reuse of agrofood industry wastewaters
- ☐ Innovative municipal wastewater bio-treatment for agricultural reuse
- ☐ Efficient water use in Irrigated Agriculture
- ☐ Improving WUE and drought tolerance via genomics approaches and modelling

4. Does the technology under development directly target (multiple answers possible) *

- [ ] Waste water treatment
- [ ] Water reuse
- [ ] Waste water reuse in irrigate agriculture
- [ ] Other:

5. What's your experience with marketing and implementation of new technologies in European countries? (select only one answer) *

- [ ] No experience
- [ ] Little experience
- [ ] Moderate
- [ ] Much experience

6. What's your experience with marketing and implementation of new technologies in India? (Select only one answer) *

- [ ] No experience
- [ ] Little experience
- [ ] Moderate
- [ ] Much experience

II. Analysis of motors and barriers: technology, actors, institutions and functional activities

The objective of this section is to find out about technological factors, actors, institutions and functions supporting or/and hindering the development of the waste water reuse technology.

TECHNOLOGY

Technology is the making, modification, usage, and knowledge of tools, machines, techniques, crafts, systems, methods of organization, in order to solve a problem, achieve a goal or perform a specific function. Examples of technologies under development in W4C include 'valorization of volatile fatty acid purification through electrodialysis', 'Tailoring effluent properties from decentralized membrane bioreactors for agricultural re-use', 'Optimized constructed wetlands by Clogging delay (prefiltration)' and 'Agro-aqua farming - ponds suitable for saline tolerant agriculture/tree crops and fish species'.

The questions in this sections help to identify characteristics of the technology itself that support or hinder its development.

7. What is the innovative technology under development about? *

7b. Please fill in the ID number of your technical innovation from the W4C innovation list (supplied as an attachment). If you would like to describe a technical innovation not in the list, please fill in '00'. *

8. How would you classify the development stage of the technology? (tentative idea, PhD status/lab phase, field testing phase, application testing phase, commercial marketing phase, other) *

- [ ] Early (formative) stage (tentative idea, lab phase..)
- [ ] Middle stage (testing, prototype development)

- [ ] Later stage (industrialisation, upscaling, market expansion)

9. Consider the following aspects of the technology under development and indicate if these can be considered a motor supporting the development or a barrier. (Please select one answer per row) *

	Motors	Barriers	Not relevant
Investment costs	☐	☐	☐
Reliability	☐	☐	☐
Environmental sustainability (think of e.g. use of fossil energy, GHG emission, pollution..)	☐	☐	☐
Social sustainability (think of e.g. safety, equity, employability..)	☐	☐	☐

10. Where do you see opportunities to implement the technology under development in the context of Water4Crops? In (multiple answers possible) *

- [ ] My own country only
- [ ] India
- [ ] European countries and India
- [ ] European countries
- [ ] I don't know yet

ACTORS

Actors involve organizations or networks contributing to a technology, as a developer or user, or indirectly as a regulator, financer, etc. Experience shows that the development of technologies and their uptake will largely depend on the involvement of actors and their relationships.

The questions in this section help to identify the actor(s) supporting the development and/or uptake of the technology, but also to discover actors who are still missing in the innovation system and as such hinder the development of the technology.

11. Who are the main actors involved in the development of the technology? Please mention the name of the actors involved per category (research, private sector party, policy makers, user groups, civil society/NGOs)

Research / academic institutes: *

Private sector parties: *

Potential user groups: *

Policy makers: *

Civil society-NGOs: *

12. Considering all participating parties, who are the actors in the driving seat? *

13. Which parties are still missing? Why? What's the impact? *

INSTITUTIONS

It is common to consider institutions as 'the rules of the game in a society'. Examples of institutions are laws, regulation, policy decisions, contracts, agreements, traditions/culture.

The questions in this section help to identify the institutions supporting or hindering the development and implementation of the technology.

14. What institutions are supporting the development and implementation of the technology? *

15. What institutions are constraining technology development? *

16. Consider both the supporting and constraining institutions, what's your overall assessment? *

	1 (very much hindering)	2 (hindering)	3 (moderate)	4 (supporting)
Overall assessment of institutions				

Functional activities

Besides the actors, technology and institutions, the premise is that, in order to properly develop innovative technologies, one should carry out specific functional activities including: Entrepreneurial Activities, Knowledge Development, Knowledge Exchange, Guidance of the Search, Market Formation, Resource Mobilisation and Counteract Resistance. In this section, the questions will help to identify strenghts and weaknesses in these activities.

KNOWLEDGE DEVELOPMENT

Knowledge development involves activities to learn, mostly on the technology under development, but also on markets and potential users. Learning activities can be fulfilled by e.g. universities and research institutes. Examples of knowledge development are modelling studies, prototype development and laboratory trials.
Usually knowledge development does not have a direct commercial orientation.

17. Assess the following knowledge development activities. Please make use of the table below. *

	1 (very limited)	2(limited)	3(good)	4(very good)
Conducting (modeling) studies				
Development of prototypes				
Conducting laboratory trials				
Conducting controlled field trials				
Testing real-world application				
Overall score of the knowledge development activities				

KNOWLEDGE EXCHANGE

For the development of the technology and its uptake an exchange of information between all relevant actors is important. Knowledge activities include partnerships/alliances between actors, but also meetings like workshops and conferences.

18. Assess the following knowledge exchange activities for the technology under development. Please make use of the table below. *

	1 (very limited)	2 (limited)	3 (good)	4 (very good)
visiting exhibitions				
building new partnerships & alliances				
Website for the technical innovation				
Visiting meetings & conferences				
Scientific publications written				
Overall knowledge exchange activities				

MARKET ANALYSIS

A market analysis brings focus to the research based on the needs, requirements and expectations of potential users of the emerging technology.
Examples of events include: exploring expectations and needs of potential users, mapping policy targets, mapping marketing trends, exploring profitability.

19. Assess the following 'Market analysis' activities for the technology under development. Please make use of the table below. *

	1 (very limited)	2 (limited)	3 (good)	4 (very good)
Mapping potential users of the emerging technology (or new areas of application of an existing technology)				
Exploring expectations and/or needs of potential users				
Mapping policies				

and/or regulations				
Exploring profitability				
Explore market trends				
Overall score market analysis				

ENTREPRENEURIAL ACTIVITIES

Entrepreneurs are essential for innovation development. The classic role of the entrepreneur is to translate knowledge into business opportunities, and eventually innovations. Entrepreneurial Activities involve projects aimed to prove the usefulness of the emerging technology in a practical and/or commercial environment. Such projects typically take the form of experiments and demonstrations.

20. Assess the following entrepreneurial activities for the technology under development. Please make use of the table below. *

	1 (non existing)	2 (very limited)	3 (limited)	4 (good)
Demonstration with the new technology				
The presence of active entrepreneurs as advisors or potential users/owners (not financially committed)				
Joint development with entrepreneurs/companies (entrepeneurs are financially committed)				
Overall score of these entrepreneurial activities				

RESOURCE MOBILISATION

Resource Mobilisation here refers to the allocation of financial and human capital. Its importance is obvious as an emerging technology cannot be supported in any way if there are no financial means, or if there are no actors present with the right skills and competences. This question seperates between the allocation of funds and the development of specific knowledge and skills.

21. Assess the following financial resource building activities *

	1 (Very limited)	2 (limited)	3 (good))	4 (very good)
Search for financial investors				
Search for subsidies for further research				
Search for subsidies for testing and implementation				
Overall score financial resource building activities				

22. What are important gaps in knowledge and skills amongst the potential users of the emerging technology and other stakeholders? Please mention relevant users and other stakeholders and describe the knowledge and/or skills they are lacking *

III. Syntheses

23. What do you consider the 3 key factors supporting the development and/or implementation of the emerging technology? *

24. What do you consider the 3 key factors constraining the development and/or implementation of the emerging technology? *

25. Which organisations should we try to invite for the meeting? Please also suggest a name, if possible. (We will not contact a person without prior consult with you) *

26. What are the issues you would like to address in the upcoming meeting? *

Your answers will be uploaded automatically.

Thank you very much.

Annemarie Groot
Christian Siderius
Alterra, Wageningen UR