European Cooperation in the field of Scientific and Technical Research - COST -

Brussels, 15 May 2014

COST 031/14

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action ES1403: New and emerging challenges and opportunities in wastewater reuse (NEREUS)

Delegations will find attached the Memorandum of Understanding for COST Action ES1403 as approved by the COST Committee of Senior Officials (CSO) at its 190th meeting on 14 May 2014.

MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action ES1403
NEW AND EMERGING CHALLENGES AND OPPORTUNITIES IN WASTEWATER REUSE (NEREUS)

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4114/13 "COST Action Management" and document COST 4112/13 "Rules for Participation in and Implementation of COST Activities" , or in any new document amending or replacing them, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to develop a multi-disciplinary network to determine which of the current challenges related to wastewater reuse are the most concerning ones in relation to public health and environmental protection, and how these can be overcome.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 108 million in 2014 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of section *2. Changes to a COST Action* in the document COST 4114/13.

A. ABSTRACT AND KEYWORDS

Wastewater reuse is currently considered globally as the most critical element of sustainable water management. Water scarcity, foreseen to aggravate, pushes for maximum utilization of non-conventional water. Although reuse is accompanied by a number of benefits, several potential drawbacks still puzzle scientists. The applied treatments fail to completely remove microcontaminants, antibiotic-resistant bacteria and/or their genes (ARB&Gs). Knowledge on the actual effects of reuse with regard to these aspects is currently not consolidated. This Action will answer critical questions through a European multidisciplinary network, structured in interactive Working Groups (WGs), to achieve: a) identification of the microbiome and mobile antibiotic resistome in treated wastewater, b) assessment of the potential for uptake/transmission of microcontaminants and ARB&Gs in crops, c) determination of effect-based bioassays required for wastewater reuse, d) identification of efficient/economically viable technologies able to meet the current challenges and, e) development of a relevant risk assessment and policy framework. The Action, will establish criteria on technologies/assessment methods for wastewater treatment, and suggest new effluent quality criteria to overcome current barriers and safeguard the reuse practice. The Action will have a major impact on the enhancement of sustainable wastewater reuse in light of current challenges at technological, economical and societal level.

Keywords: wastewater treatment and reuse, microcontaminants, antibiotic-resistant bacteria and genes, crops' uptake, quality standards and risk assessment

B. BACKGROUND

B.1 General background

In response to the escalating problem of water shortage, treated wastewater is nowadays widely reused, and is generally considered as a reliable alternative water source for irrigation and replenishment among other applications. Water demands already exceed supplies in regions with more than 40% of the world's population, and in just 12 years as much as 60% of the world's population may confront water scarcity (Qadir et al., 2007). The ever-increasing shortage of water, the increasing needs for food security of the expanding world population, the increasing demand for irrigation water both in respect to good quality and quantity, renders the reuse a 'sine qua non' condition. Currently, sustainable and safe urban water cycles have a high priority on the policy agenda of many EU Member States and elsewhere.

Although the reuse practice is accompanied by a number of benefits relating to the enhancement of water balance and soil nutrition, a number of unanswered questions are still related to this practice. Besides the lack of knowledge in respect to possible elemental interactions that may influence the accumulation of metals/elements in the soil and the subsequent uptake by plants and crops, organic microcontaminants, and ARB&Gs with possible implications on food-chain contamination (biomagnification) require much attention, since treated wastewater is not exempt of such contaminants. The effluents' remaining organic matter after conventional treatment consists of a number of recalcitrant organic compounds including potential endocrine disrupting compounds, many types of pharmaceutical compounds including antibiotics, disinfection by-products, personal care products, metabolites and transformation products and others, as the currently applied treatment processes fail to remove completely such contaminants including ARB&Gs. This leads to their subsequent release in the terrestrial and aquatic environment through disposal and reuse applications, which is of major environmental and health concern.

Wastewater reclamation and reuse has been the subject of a number of studies whose main purpose has been the determination of quality criteria for reuse focusing though mainly on conventional pollution parameters like Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, total suspended solids (TSS), heavy metals and microbiological load (i.e. viruses, bacteria and protozoa). During the last fifteen years however, microcontaminants constitute a major concern. As stated in the 2002 Hyderabad Declaration, on Wastewater Use in Agriculture, ‘without proper management, wastewater use poses serious risks to human health and the environment (Muñoz et al., 2009). It is important to note that the very few existing national guidelines on wastewater reuse tend to focus mainly on risks from pathogens and there is little mention of other trace pollutants. Summarizing, current open challenges include the contaminants of emerging concern, their transformation products originating both during treatment and while being in the environment through biotic and abiotic processes, their potential uptake by crops, the effects that these contaminants may induce in the environment, the evolution and release of antibiotic resistance, the identification of technologies that are able to remove such contaminants from wastewater, and the identification of means and solutions to overcome these problems, and promote safe reuse practices further. To avoid negative environmental and human impacts, regulatory frameworks are required, based on validated scientific information. As for wastewater irrigation, there is general lack of knowledge in relation to the associated environmental risks, since all studies have been devoted to human-health implications, mainly from pathogens or heavy metals. In addition, there is a methodological gap in environmental risk assessment of wastewater irrigation, since guidelines (EC, 2003) consider only two possible routes for pollutants to enter the soil compartment (i.e. aerial deposition and application of wastewater sludge). Given the increasing interest in reusing wastewater in water-scarce regions, there is a clear need to include irrigation as an additional exposure route for microcontaminants including ARB&Gs in terrestrial ecosystems, in order to assess the potential risks derived.

All these issues have never been considered up to now all together, and most importantly, in relation to wastewater reuse practice. The overall benefit of this COST Action is that it will consolidate the existing scattered data related to reuse, and address the open challenges associated with it. It will provide the platform for a systematic consolidation of data and standardization of methods for assessing emerging hazards associated with reuse. This field is currently vertically fragmented, and this fact results in testing in non-uniform manner, in the evaluation of methods/technologies based on varying criteria, in using a variety of bioassays, different methods of sampling/interpretation of results, etc. Hence, the information is fragmented and the decision-makers cannot base any informed decision on this basis. This will be overcome by this Action and this is exactly the major benefit that it can potentially bring to science and society. This is also the reason why this should be funded by COST and not by any other funding framework as it will not be a research-based activity but rather a consolidation of knowledge towards the particular problems faced by the wastewater reuse practice. The Action is envisaged to have enormous social benefits, since the information that will result in, will directly influence and support decision-making in the EU Member States, and also economical benefits stemming from the fact that wastewater reuse is a vital practice for establishing sustainable water balances, very crucial for the countries' economies.

B.2 Current state of knowledge

Pollution from contaminants of emerging concern (i.e. contaminants currently not included in routine environmental monitoring programmes, and which may be candidate for future legislation due to their adverse effects and/or persistency) in the environment, is now recognized as an environmental concern, and this, has led to the creation of an extensive area of research, including amongst others i) their chemical identification and quantification, ii) elucidation of transformation pathways when present in wastewater treatment plants or in environmental matrices, iii) assessment of their potential biological effects, and, iv) development and application of advanced treatment processes/systems for their removal and/or minimization. Over the last decade the scientific community has embraced research in this specific field, and the outcome has been immense. This was facilitated by advances in chromatographic techniques and relevant biological assays. Despite this, a number of unanswered questions exist and still, there is much room for development and work towards a more solid understanding of the actual consequences of the release of these contaminants in the environment, through wastewater reuse. There are already many proven cases where aquatic organisms are permanently exposed to this pollution. Even at very low concentrations, microcontaminants can be harmful to sensitive aquatic organisms: for example, they affect the growth and reproduction of fish and amphibians, damage the nervous systems of aquatic organisms or inhibit algal photosynthesis. Whether a substance causes problems in the water depends on its physicochemical and ecotoxicological properties and its concentration in the water. As Bolong et al. (2009) mention, the industrial and technological advances in respect to the production of chemicals, have outpaced the regulatory practices. A major concern is the absence of limiting regulations, especially for new compounds as related to water and wastewater treatment works. One example of the few actions that have been taken by the European Commission (EC), related to the development of strategies to deal with endocrine disrupting compounds, is the amendment of the European Community on Risk Assessment and Directive on the classification of dangerous substances (Europa, 2006). In the United States (U.S.), the Food and Drug Administration does require ecological testing and evaluation of pharmaceuticals when environmental concentration exceeds 1 μg/L (Snyder et al., 2003). This example of regulatory practices indicates that there is no coordinated ordinance that is accepted by the global community. Furthermore, limits on pharmaceuticals and personal care products, and other recently detected compounds have not yet been determined for water and wastewater treatment criteria. In addition, the release of pharmaceutical compounds through wastewater discharges is at some extent dealt by the European Medicines Agency (EMEA) guidelines, since these are concerned with the release of medicinal products for human use to the environment (EMEA, 2006). According to the latter, the terrestrial environmental fate and effects analysis for medicinal products is required within Tier B - Phase II. However, in general, environmental risks to the soil compartment have been much less studied, with the exception of heavy metals. These elements being characterized by residual effect may eventually affect unfavorably plant growth, human and animal health and environmental quality. In fact, the soil-plant transfer of toxic heavy metals constitutes one of the major pathways of human exposure to these heavy metals (Cui et al., 2004).

It is known that the biological wastewater treatment processes (i.e., activated sludge) create an environment potentially conducive to antibiotic resistance development. During wastewater treatment, environmental- and human-derived bacterial communities are in close contact, and they are continuously subjected to sub-inhibitory concentrations of antibiotics. These conditions may promote horizontal transfer of antibiotic resistance genes and selection of resistant bacteria. Other factors may be important as well, since studies on the effects of the operating conditions and different types of conventional treatment technologies revealed that either high sludge retention time or high organic loads offer ideal conditions for the proliferation of antibiotic resistance. Only little synthesized knowledge is available currently with regard to the capacity of various treatment processes to remove resistance. A crucial issue is that emerging treatment technologies such as advanced chemical oxidation, despite being promising with regard to bacteria and microcontaminants removal, may sel ect bacteria with higher capacity to resist stress conditions, and therefore may lead to the emergence and spread of ARB&Gs. The operational conditions of these processes cause stressful conditions on the bacterial cells, damaging vital components such as cell walls and membranes, enzymes and DNA (Süss et al., 2009), thus selecting for resilient subpopulations with enhanced defense mechanisms, horizontal gene transfer or mutation rates. Hence, in addition to the adverse effects as chemical pollutants, antibiotics are also associated with the spread of antibiotic-resistant bacteria and the corresponding antibiotic resistance genes. The spread in and contamination of the environment, the food chain, drinking water and human microbiota with ARB&Gs is presently considered a serious public health problem. For this reason, the World Health Organization (WHO) identified the development of antibiotic resistance as one of the major global threats to the society, and recommends intensive monitoring for the identification and surveillance of critical hot spots, aimed at reducing resistance dissemination (WHO, 2013). Sewage collectors and treatment systems are the most critical points for this kind of pollution in urban areas, continuously receiving high loads of antibiotics and ARB&Gs (Baquero et al., 2008; Michael et al., 2012; Rizzo et al., 2013). This is an important environmental problem, and the consequences can be seriously worsened by the wastewater reuse practice.

Various studies emphasize the potential uptake of active pharmaceutical compounds by crops in organic-matter-poor soils irrigated with reclaimed wastewater and highlights the potential risks associated with this agricultural practice (Shenker et al., 2011). As an example, a study performed by Boxall et al., (2006) investigated the potential for a range of pharmaceuticals to be taken up from soil, by plants used for human consumption and to assess the potential significance of this exposure route in terms of human health. Soil analyses indicated that, for selected substances, measurable residues of these were likely to occur in soils for at least 5 months following application. These studies have shown the uptake into carrot roots (tubers) and lettuce leaves. Plant uptake of microcontaminants may also influence plant development. The negative effects on plants may originate either from the direct damage of the plant by the pharmaceuticals themselves for example, or by the antimicrobial action of pharmaceuticals on soil microorganisms which is responsible for the damage by affecting the plant-microorganism symbiosis (Chander et al., 2005). The latter is attributed to the fact that antimicrobial activity of pharmaceutical compounds in the soil may influence the plant development indirectly by disrupting soil communities: the decay in the number of soil bacteria leads to a lack of feed for soil fauna (i.e. protozoa, nematodes, micro arthropods), and finally influences soil functions: plant residues are decomposed slower, denitrification is slower, and therefore nutrients are recycled more slowly (Migliore et al., 1998). Risk assessment for the uptake of pharmaceuticals in edible portions of crops suggests that with the allergenic potential and long-term effects of antibiotics, the risk cannot be neglected (Kumar et al., 2005). Not only toxicity and selection of resistant strains may be induced by the presence of antibiotics, but also damage to the genetic structure of non-target populations are among the possible effects of the release of such compounds in the environment. Thus, the toxicity and uptake potential of microcontaminants including ARB&Gs, need to be urgently addressed in the framework of wastewater reuse.

The challenging issue herein is the crucial need to look beyond the conventional target pollutants when assessing the potential hazards of wastewater disposal and reuse practice with regard to human health and ecosystems. This is now generally recognized as a priority issue in all environmental policy areas at both the European level and national level in the various countries. It has also become clear that it is not possible for individual countries alone to develop the knowledge and methodologies needed for measuring and evaluating the effects and associated risks of a vast number of such pollutants. Europe has been in the forefront of research with regard to contaminants of emerging concern. Two previous major and very important COST Actions (i.e. 636 and TD0803), that worked on the xenobiotics in the urban water cycle and the identification of wastewater plants as major hotspots of ARB&Gs in the environment, respectively, have established a solid and pioneering background in the field. This new Action is a continuation of these two previous Actions and builds on their significant findings. Noteworthy is that various MC members of these two past Actions are now participating herein. In addition, this Action will draw expertise and knowledge from all the relevant past and on-going EC-funded projects in the field, as well as from numerous national relevant projects, that are undertaken towards specific research directions with which this Actions relates. This Action already includes all the major players of the relevant scientific community and is expected to be able to involve during its implementation many others, so that it will be able to consolidate scientific knowledge immediately and implement this knowledge into proposals for guidelines at a much greater pace than without this Action. This is without any doubt, the most important major attempt ever taken place, on an international level, to look into these interrelated and multidisciplinary issues that are important for wastewater reuse practice. Even in the United States or Asia and Australia, no integrated efforts have been made so far in this field to tackle all the issues referred herein. The originality thus, is an inherent characteristic of this COST Action, which will seek innovations to drive knowledge and understanding of the reuse practice, with the aim to reduce risks and identify opportunities for establishing safe reuse systems.

B.3 Reasons for the Action

This COST Action aims at answering critical questions related to wastewater reuse under the threat of the various current challenges with regard to contaminants of emerging concern including ARB&Gs, and in particular to provide consolidated insight on the potential effects of the reuse practice with regard to microcontaminants and ARB&Gs, data on crops' uptake, establish criteria/specs on technologies/assessment methods, and suggest new effluent quality criteria to overcome current barriers and enhance further the reuse. Currently there is no consolidated data referring to these issues and it is high time to look into them. Technological advances allow now for the identification of such contaminants down to trace levels, bioassays have evolved to allow for the development of insightful relevant information, molecular techniques are able to provide valuable information on the resistance, treatment technologies are being optimized, new ones or combined systems can be designed and applied for the minimization of these contaminants, etc. This new Action builds on the great momentum developed by the two previous COST Actions 636 and TD0803. A large number of participants of these 2 very successful Actions are already interested in this one, as the latter aims to progress the current state-of-the-art considering the new insight compiled by the previous two. In essence, this COST Action is a spin-off idea based on them, and this has an immense benefit for the capitalization of knowledge. Moreover, the scientists to be involved in this Action are very active in national and European/international research projects and hence, all the available existing knowledge will be considered and utilized in the present COST Action. A number of relevant European research projects have now been completed (as mentioned in section E3), and this, will also provide an important basis for the Action. The timing thus is very good and this is the time to synthesize knowledge to progress the state-of-the-art. Further to this, very important it is to highlight the fact the NORMAN Network of reference laboratories, research centers and related organizations for monitoring of emerging environmental substances, has recently recognized the importance of the wastewater reuse issue and the contaminants of emerging concern, and for this reason it created a new working group on the exact topic (its activities though are not funded, and are based on the in-kind contribution of its participants). This effort will be undertaken in parallel with this COST Action for maximum exploitation of synergies and productive outcomes. Another important aspect to be considered is the fact that the EC has recently embarked on the task of determining quality standards for wastewater reuse, in the framework of a new Directive on Wastewater Reuse that will be developed. Therefore this Action will have lots to offer towards this direction as well.

COST is the most suitable framework for such an activity since it will bring together scientists and expertise from various disciplines like for example environmental engineering, biology, molecular biology, microbiology, analytical chemistry, eco-toxicology, risk assessment, agriculture, etc and also from various parts of Europe, so that distinct scenarios and problems dealt by specific geographical areas will also be considered.

Besides the concrete deliverables that would be obtained/produced from the 5 WGs of the Action, the benefits of the Action will be of scientific and technological, economical and of course societal character, as the wastewater reuse issue needs to be based on scientific evidence that will enable overcoming existing obstacles and barriers (i.e. contaminants of emerging concern, bioassays to evaluate toxicity and other potential biological hazards of the treated flows, microbiological advanced techniques to assess the potential of the treated flows to contribute to the propagation of antibiotic resistance, technologies, processes and methods to remediate the various hazards, risk assessment methodologies to foresee these hazards, and development of quality standards to safeguard the environment and humans, and at the same time enhancing and valorizing the wastewater reuse. Overcoming the various doubts, and establishing norms and guidelines will definitely enhance the trust of implementing reuse, and this has a significant added value in the economy of the countries in trying to establish solid water balances, avoiding at the same time investments on more expensive and energy exhaustive means like for example water desalination, import of water, etc. Undoubtedly, the society has many to gain from this Action including sustainable water resources, clean environment and health protection. All these benefits are reflected in the way the Action is structured already (this will be enhanced even more during the implementation) by including not only representatives from research and science organizations but also from companies, water/wastewater related authorities and other stakeholders like European advisory and policy-making bodies. The wastewater reuse is a multiple-character issue, and thus the vital importance of this Action.

B.4 Complementarity with other research programmes

There are several projects, past and on-going (see Section E3), that considered/consider various of the aspects of this Action. It is clear that wastewater reuse is related to chemical analytical issues, chromatographic analysis of contaminants of emerging concern, biological and (eco)toxicological tests, microbial ecology, plant physiology associated with crop uptake, modeling, engineering of technologies and assessment of efficacy, risk assessment, etc. Substantial knowledge has been developed during the last 15 years on these various aspects. However this has happened in topic-specific areas, without any effort to combine the knowledge in relation to the wastewater reuse practice. No consolidation and capitalization has been done, and this constitutes the added value of this Action. Interaction between the scientists, policy makers, agronomists and industrial entrepreneurs from various disciplines will be made feasible through the Action. This COST Action, represents a unique framework for European researchers to jointly develop their own ideas and also new initiatives across different scientific disciplines relevant to wastewater reuse, through trans-European networking of research activities, funded by different entities. This structure will enhance the exploitation and maximization of knowledge and outcomes (avoiding potential duplication of efforts). Moreover, this Action constitutes a perfect starting-point of more business-oriented networks as for example Eureka and for the creation of new and successful projects in the Horizon 2020. Important it is to note that this Action is a spin-off idea, formulated based on comprehensive deliberations from DARE TD0803 (COST Action), and a continuation of COST Action 636, which identified missing gaps while evaluating existing knowledge, projects and other research efforts. Also, due to the involvement of participants of this Action in almost all major on-going programs and projects, the Action will be constantly updated and any potential overlap of efforts will be avoided. All the relevant on-going efforts will be identified early on, and as described in section E3, communication channels will be established with them, during the implementation of the Action. As explained elsewhere herein, the activities of the NORMAN network, will also be synergistically exploited and a very close collaboration will be established.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The main objective of the Action is to develop a multi-disciplinary network to provide insight into which of the current challenges related to the wastewater reuse practice, are the most concerning from both public health and environmental perspectives (e.g. chemical and biological hazards, crops' uptake), and how these can be overcome. The Action will a) deliver best-practice advice to practitioners, and solid scientific knowledge to decision makers/public, b) develop uniform means for assessing the quality of the wastewater in respect to contaminants of emerging concern and also

ARB&Gs, c) establish specs for technologies able to produce wastewater with minimal levels of such contaminants, and d) compile valid and reliable information to be used in regulatory frameworks. This way the COST Action aims to enhance and valorize wastewater reuse, contributing to European scientific and technological excellence, to the society and economy.

C.2 Objectives

The Action will focus on the following secondary objectives:

1. Develop uniform approaches and techniques for the evaluation of the chemical and biological hazard potential of treated wastewater
2. Understand the biological impact of various contaminants of emerging concern including ARB&Gs, once released into the environment through wastewater reuse
3. Assess the potential of contaminants uptake by crops
4. Develop specs and standards for technologies able to produce wastewater safe for reuse and guidelines for specific parameters to be assessed
5. Reveal the role of reuse in the evolution and spread of antibiotic resistance and assess the impact of different treatment processes on the dissemination of antibiotic resistance, aiming at the effective control and monitoring of the reuse practice
6. Facilitate and expedite interaction and exchange of ideas between different disciplines; for example chemistry, microbiology, engineering, epidemiology, toxicology, ecology, etc.
7. Develop new trans-disciplinary partnerships that will be vital to thoroughly understand the various complexities concerning the different disciplines involved
8. Identify and counteract weaknesses and knowledge gaps in environmental chemistry and microbiology/toxicology required for the abovementioned activities
9. Determine what information is valid and reliable to be used in regulatory frameworks (e.g. Water Framework and Urban Wastewater Treatment Directive and for any other relevant Environmental Quality Standards policy framework)
10. Deliver best-practice advice to practitioners and disseminate unbiased perspectives of scientific knowledge to decision makers/public

11. Provide solid and state-of-the-art information to relevant companies in order to be able to design, develop and apply technologies able to tackle the current challenges

12. Facilitate the transfer of knowledge to the stakeholders, end-users and the wider public

13. Establish a network at the forefront of the relevant scientific and technological research

14. Serve as a forum for early-stage and young researchers to network, present results and obtain state-of-the-art knowledge

15. Generate original ideas for new research projects and collaborations

16. Keep European scientific community at the cutting edge of this interdisciplinary field of scientific and technological research

C.3 How networking within the Action will yield the objectives?

Achieving the aim and objectives described above, requires a strong inter- and multidisciplinary network. A high quality consortium is already in place, which is foreseen to become even wider and stronger during the implementation of the Action. This includes scientists and researchers with recognized expertise in chemistry (analytical, organic, inorganic), biochemistry, microbiology, molecular biology, aquatic ecology, toxicology, epidemiology, agriculture, water and sanitary engineering, chemical engineering, environmental scientists and engineers, and also representatives from relevant companies, end-users, governmental authorities and institutes, and other stakeholders on national, European and International level. The Action will act as a unique platform to consolidate various ongoing research efforts, and add value in terms of knowledge exchange and transfer towards the various interesting ends. This can be achieved as the required funding for the networking, advanced equipment and instrumentation, pilot wastewater treatment reactors, manpower, high level experience and expertise, possession of state-of-the-art knowledge, experience in project management, are all already available within each of the WGs. Moreover one should highlight the enthusiasm of the network to proceed with this spin-off Action.
The networking activities presented below will play a key role in accomplishing the Action’s objectives:

- Public and ecosystem protection through the transfer of knowledge and best-practice to end-users

- Development of a transnational approach in the preparation of guidelines, standards and regulations for harmonized risk assessment and management
- Better use of the data for decision making
- Improvement of the relevant awareness of authorities and of the wider public
- Integrating expertise and interdisciplinary teams in and among the various WGs of the Action
- Organization of open dedicated workshops, but also cross-discipline ones for planning, harmonizing, disseminating and elaborating on data and results
- Assuring the openness and flexibility of the Action and of its structure in order to allow the inclusion, at the implementation stage, of perspectives and activities not foreseen during the preparation of the proposal
- Interacting with EC-funded projects and Joint Programming Initiatives (JPI) on the same topic, existing networks and associations and international bodies (e.g. WHO, IUPAC (International Union of Pure and Applied Chemistry), NORMAN network, WssTP (European Water supply and sanitation Technology Platform), JPI on Water Challenges in a changing world, SETAC (Society of Environmental Toxicology and Chemistry), IWA (International Water Association) Reuse Group), national and international scientific societies and national science and research centers, and EUREAU (European Federation of National Associations of Water Services)
- Knowledge transfer between different scientific communities and between different levels through the organization of training schools dedicated to specific issues, early-stage researchers (ESRs), short scientific missions
- Collaborating with stakeholders in the organization of activities, definition of needs, and data supply
- Implementing a continuous dissemination of information, methodologies and results (by a web page, conference participations, publications, social media)
- Collaborating with developing countries to facilitate development of safe and economically-feasible water reuse technologies that can be implemented to address growing water shortages

- Extensive exchange of know-how that will foster increased scientific innovation at European level

C.4 Potential impact of the Action

The Action will enable new research groups in COST countries, without research expertise and practical experience in the various scientific and technological challenges related to the wastewater reuse, to mutually benefit from other more advanced-stage researchers. It is foreseen that the awareness raising, training and technology transfer via networking will disseminate more than 15 years worth of relevant research expertise, of potentially limited geographical coverage, to the whole Europe.

Specific benefits of the Action include:

- Characterization of the microbiome and mobile antibiotic resistome in treated wastewater to pinpoint factors that may be detrimental in water reuse
- Assessment of the potential for uptake/transmission of microcontaminants and ARB&Gs in crops (consolidate data and extract conclusions)
- Determination of selected effect-based bioassays required for monitoring the wastewater quality that will be reused
- Identification of efficient/economically viable technologies able to produce wastewater safe to be reused
- Development of a relevant risk assessment and policy framework
- Enhance sustainable wastewater reuse in light of current challenges at technological, economical and societal level by counteracting the vertical research strives undertaken by individual research groups
- Ecosystem and public health protection through the transfer of knowledge and best practice to end-users (e.g. governmental/public authorities, wastewater plant operators, water utilities, health authorities, other sectors)
- Development of a transnational approach in the preparation of guidelines, standards and regulations for harmonized testing of the quality of wastewater to be reused

- Development of a transnational approach in the preparation of guidelines, and specifications for technologies for wastewater treatment for the production of wastewater free from contaminants of emerging concern and ARB&Gs
- Development and dissemination of uniform monitoring tools for the wastewater quality assessment
- Optimization of available research resources (man-hours, equipment, pilot reactors, etc) and funds and finally avoidance of duplication of work
- Better use of data for risk assessment and decision making
- Improvement of public and authorities' awareness and risk management capabilities on the relevant issues
- Increase the best practice in environmental chemistry and microbiology/toxicology for monitoring wastewater quality and reuse potential
- Dissemination of new and consolidated information to all stakeholders and the general public
- Extensive exchange of information and know-how that will foster increased scientific innovation and increased competitiveness for European companies

These developments will result in important benefits for the environment (lower impact and increased protection), economy (lower operational costs and investments), and society (improved and sustainable use of resources). From a long-term perspective, the horizontal networking between experts in wastewater treatment and reuse, bioassays, contaminants of emerging concern, crops' uptake, who are individually involved in different national and EC-funded projects will therefore gain great momentum. Duplication of efforts will be reduced, developments accelerated, and scientific and technological gaps will be identified much faster. Hence, this Action will counteract the vertical fragmentation of European scientists', decision-makers' and other societal groups' efforts and will deliver a surplus by producing a better understanding on the concerned issue throughout Europe and elsewhere. The Action will communicate scientific knowledge to key public groups in an accessible manner. One powerful tool available for the expert groups is the publication of freely accessible position papers. A further main task is the collaboration with public servants and politicians during decision-making processes related to this topic. Very important to note is that ESRs will directly benefit from the COST instrument support as explained in Sections E1, E4, etc. Additionally, intensified exchange between the Action partners will enable an increase in scientific innovation.

C.5 Target groups/end users

The following target groups and end users are examples of those expected to be benefitted from the Action and exploit its results and findings.

- Scientists working:
    - in the field of analytical and technological research on contaminants of emerging concern in the urban water cycle
    - in the fields of microbial epidemiology and microbial ecology specifically interested in the public health and environmental risks associated with antibiotic resistance elements in the environment
    - on the determination of the fate of contaminants during technological treatment of wastewater and when in the environment through biotic and abiotic processes
    - on the crops' uptake of contaminants of emerging concern and those at the sub-lethal level
    - on the risk assessment of wastewater reuse practices
- Engineers working on the design, application and operation of wastewater treatment plants
- Policy makers working in governmental authorities; for example water authorities, departments of agriculture, state laboratories, managers, planners, etc.
- Ministries of Environment, Natural Resources, Agriculture
- Legislative executive bodies
- Risk assessment regulators
- Public health authorities and professionals
- Wastewater treatment plant operators
- Water industry; companies in the field of water/wastewater works and ecological services

- Technological clusters and societies in the field of water treatment
- Eureka clusters for financing innovations (e.g. ACQUEAU)
- Representatives from local authorities and associations of farmers and agriculturists
- Representatives from industries that produce chemical products that end up in wastewater like for example pharmaceuticals
- Representatives from industries that are consuming high quantities of water in their processes and thus interested in the reuse
- European and International bodies interested in the outcomes of the Action, that could also act as potential disseminators of the results to be obtained, at global scale (WHO, FAO (Food and Agriculture Organization), EC, JRC (Joint Research Center)-Water Resources Unit, IUPAC-Chemistry Division, WssTP, JPI on Water Challenges, NORMAN network, European Environment Agency, European Water Partnership, IWA, SETAC, World Water Council, etc)
- Journalists (since the media are always very interested in promoting public awareness in issues relating to environmental and human health; through TV, internet, radio, press, social media, etc)
- The non-scientific community (wider public and non-governmental organizations)

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

Many microcontaminant classes have been documented to occur in treated wastewater including pharmaceuticals and personal care products, pesticides, phenolic estrogens, surfactants, dispersants, biocides, disinfection by-products, and also ARB&Gs. Though the potential health and environmental hazards derived from continued exposure to these contaminants is not well understood, the ecotoxicological effects that they could induce remain of great concern. Still estrogenic responses on aquatic organisms exerted by endocrine disruptors, inhibition of multixenobiotic resistance in mussels caused by polycyclic musks, the carcinogenicity and/or mutagenicity elicited by polyaromatic hydrocarbons in humans, and the potential development of antibiotic resistance as a result of low concentration exposure to such contaminants as for example pharmaceutical compounds are well documented. These evidences illustrate that the occurrence of some microcontaminants, even at low concentrations, can lead to chronic health effects, particularly when a possible synergistic effect of contaminants mixtures could take place. In addition, the uptake of such contaminants from soil into plants has also been documented but remains still largely unknown for a variety of microcontaminants. The possible accumulation of such contaminants in the soil, and in the various plant parts, and especially in their edible part, due to the long-term reuse of treated wastewater, must be carefully studied, and relevant guidelines for reuse must be established. Furthermore, factors affecting this accumulation must be thoroughly examined. Since the so-called traditional wastewater treatment methods are not capable of fully removing recalcitrant contaminants of emerging concern, advanced technologies or new integrated processes must be applied, which will be effective in simultaneously removing, pathogens, ARB&Gs and xenobiotics (and their transformation products). Current water quality guidelines for reclaimed wastewater predominantly address risks associated with the presence of microbial organisms and parameters like COD, suspended solids and at some cases heavy metals. Comparatively, other chemical parameters including organic compounds (e.g. xenobiotic recalcitrant compounds and endocrine disrupting compounds) have been largely overlooked.

Currently there is a number of knowledge gaps related to the potential effects that the wastewater reuse practices might induce. These are related both with the identification of the compounds present in the treated effluent organic matter, which is also related to the gaps of knowledge with regard to degradation mechanisms and transformation products. Moreover, the puzzle concerning the risks that relate to non-target organisms in the environment, to crops' uptake and finally the fate and behavior of various compounds in mixtures is only now starting to shape. Furthermore, knowledge is greatly lacking on the possibilities of chemical residues reaching humans through biomagnification in the food chain. Risk assessment protocols for antibiotics and resistant bacteria in water systems, based on better systems for antibiotics detection and antibiotic resistance microbial source tracking are also on the research agenda. In conclusion, wastewater reuse is a practice related not only to a number of benefits with regard to water balances and management but also to a number of question marks. This Action aims to undertake the following major research tasks in order to tackle these questions:

- Research on the role of wastewater reuse in the evolution and spread of antibiotic resistance
- Development of specifications and harmonized methods for the measurement of antibiotic resistance in wastewater and receiving environment
- Studies and consolidation of knowledge on the biological impact of various microcontaminants once released in the environment through wastewater reuse practices
- Selection of the most appropriate methods and means to perform the evaluation of the biological

impact for the treated wastewater

- Investigation of the uptake potential of contaminants by crops
- Evaluation of technologies and combined processes for the purification of wastewater (for the abatement of contaminants of emerging concern and ARB&Gs)
- Development of technical specifications and standards for technologies (also economically feasible ones) able to produce wastewater safe for reuse and guidelines for the parameters to be assessed
- Development of an appropriate risk assessment and policy framework

Clearly, the Action cannot provide exhaustive answers to all research questions but rather aims to bring together an interdisciplinary consortium to address these important issues in a holistic way, for the very first time, and develop guidelines for future work, considering also the Precautionary Principle which can form the basis to justify discretionary decisions in situations where there is the possibility of harm from taking a particular course or making a certain decision when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public and the environment from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result.

The participating organizations will use their resources to carry out research, while the Action will provide the necessary networking and communication mechanisms for coordination. The majority of the participants were members of past COST Actions (i.e. 636, TD0803), already highly networked, and this new Action will immediately start capitalizing on the previous findings and knowledge. Short Term Scientific Missions (STSMs), training schools, and interdisciplinary collaborative work using already existing advanced instrumentation, will lead to maximum results. Moreover, strong dissemination activities will be developed to facilitate the transfer of knowledge to stakeholders and the public at large.

This Action provides a structured plan, but flexible enough to permit future adjustments and inclusion of perspectives, activities and innovations not foreseen or realized during the preparation of the proposal. The framework of the Action will remain open to engage other researchers, end-users and stakeholders, also from countries beyond those, which have been anticipated to participate in the Action initially.

D.2 Scientific work plan methods and means

WG1: Microbiome and mobile antibiotic resistome in treated wastewater and in downstream

environments

Wastewater treatment plants are considered important sources of ARB&Gs. Three major arguments are often used to sustain this idea. The first is that antibiotic residues and other substances with potential selective pressure, and ARB&Gs are discharged into the municipal sewage system. The second is that conditions offered to microorganisms during the wastewater treatment process may favor either the selection or the horizontal gene transfer of antibiotic resistance determinants. The third, is the observation that, worldwide, wastewater treatment, regardless of its efficiency or operational conditions, leads to the production of final effluents containing antibiotic-resistant bacteria, sometimes at higher percentages that in the raw inflow.

In spite of being widely recognized that treated wastewater is not exempt of bacteria and genes with possible adverse effects on the environmental and human health (pathogens and ARB&Gs), at the moment it is not possible to have a clear image of the type and intensity of risks involved, in particular concerning antibiotic resistance. Hence, it is important to advance the current knowledge on the impact of the discharge of treated wastewater on the quality of water and soil. In particular, it is urgent to have additional insight into the most prevalent and/or hazardous resistance genes that are being discharged in treated wastewater, as well as their ability to persist and spread (due to physical transport or biological gene transfer). The compilation of already existing data (scientific papers and public databases) and the generation of new data over the next years will feed the main achievements of this WG. Because the analysis of already existing data is often biased by the use of varying sampling and detection methods, the establishment of recommended procedures for antibiotic resistance analysis in water and soil samples is also an aim of this WG.

Objectives:

- Propose the standardization of the procedures used for ARB&Gs detection and quantification in water and soil samples
- Identify most prevalent and/or hazardous ARB&Gs with ability to persist, spread and proliferate after wastewater disposal, including under wastewater reuse scenarios
- Assess the fate, whenever possible quantitatively, of ARB&Gs discharged in treated wastewater and released in surface water or soils
- Identify the conditions favoring ARB&Gs persistence or proliferation

Activities:

- Formulate standardized protocols to measure antibiotic resistance in wastewater (to be recommended to stakeholders, constituting the basis to build a European database on ARB&Gs)
- Assess, over a hypothetic gradient in the receiving environment and based on both culture-dependent and culture-independent methods, the occurrence, persistence and capacity to proliferate of ARB&Gs discharged in treated wastewater
- Identify critical factors concerning the characteristics of the treated wastewater and of the receiving environment (temperature, microcontaminants, organic matter content, mineral composition, or soil characteristics such as texture) that coincide with the highest antibiotic resistance prevalence, persistence and horizontal transfer
- Compilation of a report on the occurrence and prevalence of ARB&Gs in wastewater in EU Member States (with analysis on the treatment processes applied for the purification of the specific wastewater samples)
- Determination of relevant scientific gaps and missing knowledge with regard to the identification of the microbiome and mobile antibiotic resistome in treated wastewater
- Based on the knowledge compiled and produced, establish a list of recommendations and guidelines for a sustainable wastewater reuse
- Dissemination and training on methods for testing ARB&Gs for students, wastewater engineers, others
- Based on the data to be compiled and generated, contribute to the development of an improved risk assessment framework for wastewater reuse
- Train ESRs and other interested scientists on the detection and quantification of ARB&Gs in wastewater and soil samples

Achievements – Deliverables

- List of the top 10 most prevalent and persistent, and of the top 5 most hazardous ARB&Gs in treated wastewater and surrounding environment, specifically focusing on antibiotic resistance genes associated with mobile genetic elements
- Guidelines for the analysis of treated wastewater planned to be reused
- List of ARB&Gs to be taken into account for risk evaluation for wastewater reuse

- White paper on the implications of wastewater reuse on the spread of ARB&Gs and adequate measures to minimize adverse impacts
- A training school on methods for detecting and quantifying ARB&Gs in wastewater and soil samples

WG2: Uptake and translocation of organic microcontaminants and ARB&Gs in crops

During irrigation with reclaimed water, the fate and behavior of organic microcontaminants (e.g. pesticides, phenolic estrogens, surfactants, biocides, pharmaceuticals, personal care products, disinfection by-products) and of bio-pollutants (e.g. ARB&Gs) depends on various chemical, physical and biological processes. Based on their physicochemical properties (e.g. K_{ow}, Henry's constant, and pK_a), and the characteristics of the receiving soils, the contaminants may be retained in the topsoil layer or leached to the groundwater or run off into surface water. Besides this fate, ARB&Gs can even proliferate and spread in the rhizosphere and phylosphere of crops, and thus be transferred to humans via the food chain.

Reclaimed water, which is subject to state and local microbiological and heavy metal regulations, still contains organic microcontaminants and numerous microorganisms, which are only partially removed or not removed at all by conventional wastewater treatment plants, which can enter the hydrological cycle. Hence, both chemical- and biocontaminants present in treated wastewater have the potential to affect the soil microbial community, with implications on agriculture yields and with high probability of being taken up by plants, increasing the risks of the food chain contamination.

Contaminants of emerging concern can access plants via at least, three main pathways: (i) root and foliar uptake from aqueous solutions, (ii) vapor uptake from the atmosphere via stomata, and (iii) the deposition of contaminated soil and dust on plant cuticles and subsequent diffusion of the contaminants through plant surfaces. In green plants, gas and vapor exchange mainly occurs in the leaf surface. The stomata in the leaf provide a very effective way of regulating this exchange according to internal and external conditions. Environmental stressors (primarily drought) and sunlight affect the stomata's opening and closing mechanism, and the plants' survival depends on several factors, one of the most important of which is its cuticle properties. The cuticle is the last barrier to prevent water loss and enable the controlled exchange of abiotic and biotic material where hydrophobic contaminants can adsorbed and be transported by diffusion.

In the last years many studies have been published regarding this issue, but the information is fragmented and dispersed. The activities of WG2 are formulated towards the collection of the required information to systematically organize and to identify the gaps of knowledge in this field.

Objectives:

- Consolidate knowledge on the uptake and translocation of microcontaminants and ARB&Gs in crops
- Identify the main physicochemical characteristics affecting the behavior of the various microcontaminants and ARB&Gs with regard to uptake and translocation
- Develop a set of recommendations regarding the minimization of biomagnification processes and environmental and human health impacts associated with wastewater reuse

Activities

- Compile already existing information of uptake occurrence, crossing data relative to type of crop, contaminants, water quality, and management options (type of crops, contaminants, wastewater quality, type of irrigation and regime, in vitro, hydroponic, greenhouse, full scale)
- Assess the factors affecting the bioavailability and/or bioaccessibility of organic microcontaminants by crops such as crop characteristics, type of soil and its organic matter content, irrigation regime and physicochemical characteristics of reclaimed water (e.g. pH, COD, electrical conductivity, TSS)
- Based on the selection of the most frequently contaminants taken up, get an overview of the physicochemical or biological characteristics that may increase the chances of uptake and translocation in plants
- Assess the potential of plants metabolism, including of endophytic bacteria, as a mode of detoxification
- Propose predictive models to assess the uptake, translocation and accumulation of organic microcontaminants of health concern
- Identify missing knowledge and gaps in the context of new emerging contaminants (including their transformation products) uptake, translocation and accumulation by crops
- Develop guidelines regarding the reclaimed water quality and management to minimize the uptake of organic microcontaminants and ARB&Gs of health concern
- Train ESRs and other interested scientists in the uptake of microcontaminants and ARB&Gs testing in wastewater and soil samples

Achievements – Deliverables

- Identification of microcontaminants (chemical and biological) prone for crop uptake
- A list of crops with highest and lowest potential for contaminants uptake
- Key factors affecting the uptake of organic microcontaminants and ARB&Gs by irrigated crops
- Determination of the predictive models to assess the uptake of organic microcontaminants and ARB&Gs by crops
- Determination of the daily intake of organic microcontaminants and ARB&Gs from irrigated crops with reclaimed waters of different quality
- White paper on the uptake and translocation of organic microcontaminants and ARB&Gs in crops
- A training school on the uptake of microcontaminants and ARB&Gs testing in wastewater and soil samples

WG3: Effect-based bioassays required for wastewater reuse schemes

The physicochemical assessment of wastewater based on 'traditional' chemical parameters (e.g. USEPA/600/R-12/618 September 2012 Guidelines for Water Reuse), has indicated in many cases that the quality of the wastewater complies with the limits set by the relevant national and international guidelines for discharge or reuse. However, ecotoxicological assessments demonstrated the presence of toxicity, and therefore, negative effects on organisms exposed to the reused water cannot be excluded. The resulting poor correlation between the physicochemical and biological assessments demonstrates that both assessments are necessary and should be performed in parallel in order to be able to obtain concrete and reliable results on the overall quality of the treated effluent.

The benefits of complementing the physicochemical evaluation of wastewater with a biological one are demonstrated in a recent study by Vasquez and Kassinos, (2013). Four organisms from different trophic levels were used for the biological assessment of the wastewater, namely, *Pseudokirchneriella subcapitata*, *Daphnia magna*, *Artemia salina* and *Vibrio fischeri*. The physicochemical assessment of wastewater based on 'traditional' chemical parameters indicated that the quality of the wastewater complies with the limits set by the relevant national guidelines for discharge. The ecotoxicological assessment, however, indicated the presence of toxicity throughout the sampling periods. For example, recently, a wastewater treatment plant integrated with ozonation and powdered activated carbon filtration, was assessed for its efficacy to remove trace organic contaminants from secondary treated effluents. A chemical analysis of 16 organic compounds was accompanied by a comprehensive suite of in vitro and in vivo bioassays with the focus on genotoxicity to account for the potential formation of reactive oxidation products. The chemical evaluation revealed an efficient oxidation of about half of the selected compounds by more than 90%. Nevertheless, various toxicological tests applied showed a broad variety of results from a further decrease of effects (e.g. genotoxicity by umuC test) to even an increase of effects (e.g. genotoxicity detected with the comet assay using fish erythrocytes) for both, ozonation and activate carbon application (Magdeburg et al., 2014).

The toxicity profiling should be considered as an effective tool for screening the hazard of complex environmental mixtures with known and unknown toxicologically active constituents. Biological-based assays can analyse mixture effects providing data from molecular up to organism level. Treatment technologies need to be evaluated in respect to their capacity not only to remove microcontaminants and antibiotic resistance, but also potential biological effects. Toxicity (i.e. acute and chronic, estrogenicity, mutagenicity, cytotoxicity, and phytotoxicity) are mere examples of potential effects. The variety of applicable bioassays, the variety of protocols and the way of implementation, the variety in the endpoints that may be considered significantly increase the complexity of the issue. Additionally, the relevance of the endpoint of a specific test on the stability of the systems exposed to the reused water and the fitness of organisms is a central aspect to be considered.

Objectives:

- Assessment of the existing information available in the literature with regard to biological effects and wastewater based on different tests applied
- Identification of potential relationships between the physicochemical characteristics of the wastewater and biological effects derived
- Determination of the most appropriate and relevant to the reuse practice bioassays and/or bioassay battery to be applied for wastewater quality evaluation
- Propose the harmonization of the procedures used for this purpose (see previous point)

Activities

- Compile already existing information concerning wastewater and biological effects
- Assess the factors affecting the behavior of wastewater in relation to its qualitative characteristics

- Propose bioassays that may be easy to apply, cost efficient and able to provide insightful information
- Identify missing knowledge and gaps in this context
- Develop guidelines regarding the reclaimed water quality
- Define a risk characterization procedure to optimize the efficiency of treatment plant and needs to improve its technical quality (this will be developed in conjunction with the activities of WG5)

Achievements – Deliverables

- White paper on the existing knowledge with regard to wastewater and biological hazards
- Bioassays able to serve as routine tools for analysis and evaluation of the efficiency of the various treatment technologies to remove toxicological hazards and evaluate the quality of the wastewater to be reused (relevant to the reuse practice)
- Harmonized protocols for the mentioned bioassays

WG4: Technologies efficient/economically viable to meet the current wastewater reuse challenges

Elimination and transformation of microcontaminants during the biological treatment is the result of different processes that can be biotic (biodegradation, mainly by bacteria and fungi) and non-biotic or abiotic (e.g. sorption, photolysis, stripping). The amount of removal mainly depends on the sorption capacity to the sewage sludge and degradation or transformation during biological treatment. It is generally accepted that even low loaded Conventional Activated Sludge (CAS) treatment, does not lead to complete removal of xenobiotic compounds such as antibiotics or other pharmaceuticals. In addition, currently, there is a big gap in knowledge in regard to the capacity of CAS in removing ARB&Gs; and through which mechanisms ARB&Gs are removed, survive, multiply, evolve etc. WG4 aims at shedding light on the efficacy of treatment technologies and treatment trains suitable to meet requirements for safe wastewater reuse as defined by the previous WGs.

Membrane Biological Reactor (MBR) and Moving Bed Biofilm Reactor (MBBR) systems, as well as CAS can be coupled with an advanced treatment such as Activated Carbon (AC) adsorption or Advanced Oxidation Processes (AOPs) to further evaluate the maximum possible purification potential. AC can further enhance the removal through various mechanisms of adsorption i.e. solute transport, pores and film diffusion, depending again on the characteristics of the adsorbent and the contaminants. AOPs have been found effective in the degradation of a wide range of organic and inorganic contaminants, as well as in the removal of toxicological effects but, if not correctly operated, they can form oxidation transformation products more toxic than the parent compounds. Moreover, only few studies have investigated the effect of wastewater treatment on antibiotic resistance and no conclusive results are available to evaluate if e.g. AOPs increase/decrease the risk for human health in agricultural wastewater reuse practice.

To develop efficient and economically viable technical solutions, currently applied technologies (mostly CAS) as well as advanced biological technologies like MBR or MBBR, have to be evaluated in regard to requirements defined by the previous WGs as a first step. Additionally, basic needs for different reuse patterns (e.g. agricultural irrigation, irrigation in urban areas) have to be considered as wastewater occurs on a rather continuous basis on a specific place, whereas reuse demand can be also time- or season- (e.g. seasonal crop water requirements) and space- (e.g. urban and agricultural areas) dependent. These demands may require storage and transport and thus these scenarios should be addressed in order to find out the suitable solutions.

Objectives:

- Consolidate knowledge on the fate of microcontaminants during treatment (conventional and advanced treatment)
- Assess the fate of ARB&Gs during biological processes (CAS, MBR, MBBR) and characterize removal mechanisms (in collaboration with WG1)
- Assess the effect of AOPs on ARB&Gs and the subsequent risk for effluent reuse related to oxidation transformation products and residual ARB&Gs release (in collaboration with WG2)
- Assess the economical feasibility of AOPs compared to more conventional advanced treatment processes/technologies in wastewater reuse scenarios
- Identify the combinations (and economical feasibility) between biological, advanced treatment and required reuse infrastructure in terms of global efficiency/compliance with standard parameters (e.g., BOD, COD, N, P etc.) and contaminants of emerging concern including ARB&Gs

Activities:

- Identify the technologies with the higher efficiency with respect to microcontaminants removal

- Identify missing knowledge and gaps with regard to the fate of ARB&Gs in urban wastewater treatment plants
- Characterize ARB&Gs removal mechanisms during biological processes (CAS, MBR, MBBR)
- Review the results on the application of biotests on different wastewater treatment technologies and evaluate them from the technical point of view
- Investigate design parameters and operating conditions of treatment technologies to minimize the release of ARB&Gs and final toxicity
- Organize a summer school on advanced treatment technologies and contaminants of emerging concern including ARB&Gs

Achievements – Deliverables

- Understanding the contribution of biological processes to antibiotic resistance spread into the environment
- Compilation of a report or white paper on the best available technologies able to minimize the release of microcontaminants including ARB&Gs, and biological risk, and fulfill requirements for a safe reuse as defined in the WGs1,2,3
- A summer school on advanced treatment technologies and contaminants of emerging concern including ARB&Gs

WG5: Risk assessment and policy development

(This WG will be formulated in year 2 and will draw expertise/insight from all the WGs of the Action).

Based on a scenario of average economic growth, according to the EC DG Research and Environmental Technologies report (EUR 24552 EN), the worldwide water supply-to-demand gap is likely to reach approximately 40% by 2030 unless significant efficiency gains can be made. The Intergovernmental Panel on Climate Change (IPCC) predicts that by the year 2050, around 60% of the world's population could experience severe water shortages, with 33% thought to be already under stress. In Europe, competing demands for limited and sometimes over-exploited water resources concern more than a few EU Member States; water scarcity and droughts already affect one third of the EU territory across different latitudes.

Tackling the water gap challenge, while achieving good status of all water bodies in Europe - as targeted by the EU Water Framework Directive (Directive 2000/60/EC) for 2015 - will require a transformation of the sector based on the combination of new technological, organizational and management-based approaches for supply, conservation, reuse and recycling in agricultural, industrial, urban and domestic contexts. Even though the importance of wastewater reuse is now recognized internationally as a vital component of sustainability, environment, economy and society, uniform guidelines still do not exist. Countries already applying standards for reuse are some regions of Spain like Andalucia, Balearic Islands, and Catalonia (developed own guidelines based on WHO guidelines of 1989), Israel (a modified version of California Title 22), Italy (Decree enabling the regional authorities of implement also stricter norms), France (based on WHO standards of 1989), Cyprus (criteria stricter than WHO but less strict that the California Title 22 ones), Belgium (based on Australian EPA guidelines). Furthermore and very importantly, even those existing guidelines refer to global and ‘conventional’ pollution/contamination parameters, and do not include contaminants of emerging, or endocrine disrupting compounds, or ARB&Gs, etc. Till now, priority substances or other contaminants of emerging concern are not directly regulated in wastewater treatment plant effluents either.

It is now demonstrated, that even low concentrations of substances in wastewater can cause undesired environmental effects. Among other pathways, microcontaminants via the effluents from wastewater treatment plants, leaking sewer systems and storm-water overflow structures, find their way into lakes and rivers, where due to modern analytical methods they can be detected even at very low concentrations. Under conditions of wastewater reuse, exposure and effects can be even more significant, since there may be accumulation of persistent contaminants, for example due to adsorption.

Contaminants of emerging concern are a challenge to protection of water resources because they may have adverse effects on aquatic organisms even at very low concentrations. Another problem is the fact that environmental impact can be caused not only by a single substance, but also by its metabolites, transformation products, and therefore by mixtures of substances. A large number of studies exist in respect of the protection of water bodies, but the data gathered so far have not been related to wastewater reuse practice.

Therefore it is apparent, that a risk assessment framework is urgently needed, that could ensure treated wastewater planned for reuse, with reduced risks with regard to contaminants of emerging concern, ARB&Gs, etc. A reliable risk assessment protocol, implementation and verification must rely on a uniform policy framework. This is only possible if standardized quality criteria for the wastewater to be reused, harmonized testing methods and systems for ARB&Gs, contaminants of emerging concern or assays for the evaluation of biological potential risks are available. The need for a European Directive on Wastewater Reuse has been now recognized by the EC. This is fully in line with the activities of this Action.

Objectives:

- Develop quality criteria for selected contaminants of emerging concern and ARB&Gs for wastewater reuse
- Propose a battery of assays for wastewater evaluation for reuse purposes
- Develop a risk assessment framework for wastewater reuse purposes
- Propose guidelines/suggestions on possible technologies and systems able to produce wastewater of quality in compliance to the quality criteria to be set (with respect to ARB&Gs, biological risks, etc).
- Overcome existing barriers in the field of wastewater reuse and valorize wastewater as a non-conventional water resource

Activities

- Assessment of the existing guidelines on wastewater reuse
- Elaborate the information developed by WG1 and extract the information useful for risk assessment and policy development
- Elaborate the information developed by WG2 and extract the information useful for risk assessment and policy development
- Elaborate the information developed by WG3 and extract the information useful for risk assessment and policy development
- Elaborate the information developed by WG4 and extract the information useful for risk assessment and policy development
- Propose qualitative criteria for wastewater reuse with regard to ARB&Gs and other biological risks related to contaminants of emerging concern
- Propose a risk assessment framework adequate for sustainable wastewater reuse

Achievements – Deliverables

- A list of quality criteria concerning ARB&Gs and biological risks related to contaminants of emerging concern
- A list of parameters to be taken into account for a qualitative risk assessment framework

- A list of “highly hazardous” conditions commonly met in wastewater and which represent a high risk for wastewater reuse

E. ORGANISATION

E.1 Coordination and organisation

The Action will bring together experts from specific disciplines with their own funding to work within a transdisciplinary environment within the five WGs. Using organization features common to COST Actions, the skills and knowledge of these experts will be successfully unified and national barriers will be overcome to provide a coordinated international perspective. Since many of the participants have already participated in the two previous relevant COST Actions, a very smooth and successful implementation of the Action is foreseen.

The Management Committee (MC), led by the Chair and the Vice Chair, will manage the Action. The MC will be responsible for the overall strategy of the Action and for the coordination of the international network and platform activities. The MC is scheduled to meet annually, although more frequent MC meetings will be held if necessary.

The Steering Group (SG) is scheduled to meet twice a year (during the MC meetings, time will be allowed for the SG members to meet as well). The SG meetings will be coordinated with those of the MC and WGs meetings. It is envisaged that the SG will include the Chair and Vice Chair of the Action, the WGs leaders, the Grant Holder, the coordinator responsible for the dissemination activities, the STSMs coordinator, the ESRs and gender equality issue coordinator and the person responsible for the Training Schools. Under the instruction of the MC, the SG will review the work programme of the WGs. If needed, additional scientists/participants will be invited to join the SG (i.e. in case other expertise is needed for a particular reason). The SG will be responsible for carrying out monitoring and evaluation of the objectives. During each MC meeting, the SG will present the progress of the implementation of the various activities and report on potential deviations and corrective measures taken or measures that need to be taken. The WG leaders will submit brief but comprehensive reports to the SG twice a year so that the smooth implementation of the work is ensured. A brief written note on the progress will be prepared by the SG twice a year, and communicated to the MC.

WG meetings will be coordinated by the Chair and the Vice Chair of the Action who will be responsible for the organisation of the transdiciplinary WG meetings in collaboration with the WGs leaders. Each WG will be led by two (2) leaders and an early-stage researcher who will act the

secretary of the WG. WG meetings are scheduled to take place twice per year, for the entire duration of the Action. Communication between the WGs and the SG will be electronic and supported by video conferencing if required. The WGs leaders will together coordinate the Actions' workshops and conferences, together with the Action's Chair and Vice Chair.
'Liaison' scientists will be designated to present the findings of the WG in which they participate to the rest of the WGs. This way, a structured and planned communication channel among the WGs will be established, in order to identify synergies in time and maximise outcome products. If considered appropriate, joint meetings between WGs will take place, while once a year, an effort will be made so that the meetings of all WGs will take place together.
A final open conference (with international participation)**,** a training program consisting of 2 advanced training events and one summer school, each covering a specific research area, and 2 thematic workshops that will be organized together with WGs meetings, are scheduled. Workshops are one of the key COST tools for this Action, bringing together scientists working in very different fields. It is envisaged that the scope of the workshops will become more transdiciplinary and exploratory as the Action progresses. Training Schools will allow for best-practice, knowledge transfer, and accelerate uptake of the approach. The MC will appoint a Training School Coordinator to manage these activities. An effort will be made to organise the Action's events back to back (if and when possible) with other relevant major events in order to maximise synergies and budget utilization added value. Important also is to note that in the various events invited experts and speakers (with high expertise on an international level) will take place. The Action already includes a number of such scientists that work in various non-COST countries like in Asia, Australia, and the USA. The various topics that will be selected to be tackled in the events will be decided after thorough discussions will the scientific community of the Action, the stakeholders and the policy makers.
STSMs and the mobility of ESRs will also be very important, as they will facilitate knowledge exchange and transdisciplinary research. The MC will appoint a STSM Coordinator to manage these activities. In addition, an ESRs recruitment and gender equality issues Coordinator will be assigned, to enhance the impact of the activity. A scientific network of ESRs will be established under the name Blue Circle.
It is noted that the applications for STSMs will be made through a standardised form that will be developed by the Action, and in addition, the reporting after the completion of the mission will also be made through a standardised report format of high scientific quality. These reports will be assessed by the SG.
The Action will coordinate the production of both scientific and popular scientific information for

dissemination through both conventional and social media. A task to be performed by the MC appointed Dissemination Manager**.** All of the Action's activities will be reviewed by the SG, which will also secure the involvement of ESRs in the Action.

An Action-specific website will be developed under the supervision of the SG. The website will serve as an open info-point for all stakeholders with a members-only section for communication among participants (the website will host amongst others planning activities and events, presentations, forum, discussions and videoconference capabilities). The website will be updated on a monthly basis, and it will be a major dissemination gate through which the results of the Action will be made available to everybody interested. A number of other social media will be utilised like for example Facebook and Twitter. A Wikipedia webpage will also be created describing the network and the general topic of wastewater reuse.

The results achieved during this Action will be presented in annual Progress Reports and in a Final Report according to the rules set by document COST 4159/10. The major milestones of the Action are:

M1-First Action meeting - Assignment of roles (WGs leaders, coordinators for various activities and other responsibilities) (Either in month 1 or 2, depending on the administrative paperwork that needs to precede the kick-off meeting)

M2-Design/Creation of a website (Month 6)

M3-Preparation of general guidelines for the analysis of treated wastewater planned to be reused in relation to ARB&Gs (Month 12) (WG1)

M4-Identification of the top 10 most prevalent and persistent, and of the top 5 ARB&Gs presenting higher risk of contamination via wastewater reuse (Month 24) (WG1)

M5-Determination of bioassays able to serve as routine tools for analysis and evaluation of the efficiency of the various treatment technologies to remove toxicological hazards and evaluate the quality of the wastewater to be reused (relevant to the reuse practice) (Month 30) (WG3)

M6-Identification of the ARB&Gs to be taken into account for risk evaluation for wastewater reuse (Month 30) (WG1)

M7-Determination of the best available technologies able to minimize the release of ARB&Gs and biological risk and fulfill requirements for a safe reuse defined in the WGs1,2,3 (Month 36) (WG4)

M8-Identification of microcontaminants (chemical and biological) prone for crop uptake (Month 40) (WG2)

M9-Identification of the crops with the highest and lowest potential for contaminants uptake (Month 44) (WG2)

M10-Development of a risk assessment framework for wastewater reuse (Month 46) (WG5)

M11-First training school (Mid second year)

M12-Second training school (Mid third year)

M13-Summer School (summer of fourth year)

M14-Final conference (Month 47)

All the technical/scientific activities that will reach the aforementioned milestones, consist of a compilation and first assessment of data and information, and as a second stage the consolidation of data and development of final outcomes. Therefore, most of them will reach important milestones after the second year of the Action implementation.

E.2 Working Groups

The 5 WGs will be established as outlined in section D. Each WG will be led by 2 WG leaders and one secretary. The WG leaders will:

- Coordinate the activities within their WG to meet the objectives defined in the scientific program
- Stimulate and foster the set-up of joint research funded by members' own institutions and grant awards (e.g. through use of Short-Term Scientific Missions)
- Plan the appropriate scientific meetings and workshops
- Promote the co-authoring of scientific publications
- Ensure the reporting of WG progress to the Action MC and Chair and Vice Chair
- Participate in MC meetings
- Stimulate the development of new research proposals
- Identify future research needs and perspectives
- Prepare relevant material to be uploaded on the website of the COST Action

E.3 Liaison and interaction with other research programmes

During the FP6 framework program, two large projects (AQUAREC, RECLAIMWATER) were run to fit water reuse into the overall concept of integrated water resources management. These projects focused on the need for risk governance frameworks in all water reuse applications; need for better understanding of water buffering and storage components in agricultural irrigation schemes; challenge of interactions between different actors in the agricultural sector; identify attractive business models for those wishing to invest in reuse initiatives; charging/pricing arrangements such that full cost pricing is consistent regardless of source; need for uniform (risk-based) water reuse guideline framework in Europe. Further, during the FP7 framework program some related projects have been continued in global scale such as: SuWaNu (Sustainable Water treatment and Nutrient reuse options), NaWaTech (Natural water systems and treatment technologies to cope with water shortages in urbanized areas in India), TREAT&USE (Safe and efficient treatment and reuse of wastewater in agricultural production schemes), WATERBIOTECH (Wastewater treatment by means of biotechnology for sustainable water supply in Africa), etc. Their results and outcomes, and those of other projects like for example AMADEUS (Accelerate membrane development for urban sewage purification), EUROMBRA (Membrane bioreactor technology (MBR), NAMETECH (Development of intensified water treatment concepts by integrating nano- and membrane Technologies), ACE-ART Assessment and critical evaluation of antibiotic resistance transferability in food chain, REP-LECOTOX Reinforcement of research potential of laboratory for ecotoxicology, CONTAMED (Contaminant mixtures and human reproductive health - novel strategies for health impact and risk assessment of endocrine disrupters) will be utilized in the Action. Moreover, the findings of other completed projects like COMPREHEND 2002, REMPHARMAWATER 2003, ERAVMIS 2004, POSEIDON 2004, NoMiracle 2005, ERAPharm 2007, START 2007, MODELKEY 2010, PILLS 2012, will be considered. Liaisons with relevant on-going research projects funded by the FP7 framework like SOLUTIONS (started in 2013), EFFORT (started in 2013 on complex epidemiology and ecology of antimicrobial resistance and the interactions between bacterial communities, commensals and pathogens in animals, the food chain and the environment), Marie Curie ITN projects like EDA-EMERGE (started in 2011), ERC grants like ATHENE (ERC grant started in 2011), and others will be created. Communication channels and links with on-going COST Actions, like ENTER, EURO_Agriwat, SCORE, Water_2020, etc., will be established. Important is to note that links between this COST Action and all these projects already exist (among the participants), and therefore this process is expected to be smooth and easy to implement. Furthermore, links with national on-going projects but also other relevant efforts carried out in European and International level will be established. All the existing knowledge will be included in the activities of the Action and key-scientists from these projects will be invited in the various events organized by the Action. In addition, efforts will be made to maximize synergies (within the framework of all the Action's activities including STSMs), and potentially organize joint events. Members of the Blue Circle (i.e. the network of ESRs) will be assigned the task of identifying the on-going relevant research projects and any other similar activities so that contacts will be made early on.

E.4 Gender balance and involvement of early-stage researchers

A MC member will be appointed as an equal opportunities coordinator to ensure that all of the Action's activities are proactive towards gender balance and the positive role of ESRs. Actions will be taken to achieve a gender balance through promoting the participation in the MC and the WGs. At every management meeting a gender distribution plot showing the balance between male/female and ESR taking part in the activities of the Action will be presented. In organizing workshops and conferences, gender balance will be taken into account when selecting (keynote) speakers, as this Action is an excellent means to reach out to both female and male participants. ESRs will be encouraged to actively take part in the conferences and training schools by organizing and setting up the program, taking a leading role in dissemination, with particular focus on social media. ESRs will also be encouraged to take part in STSM. To ensure the largest impact on both male and female participants, a balance in gender amongst the participants will be sought. An effort will be made to assign important roles (e.g. Vice Chair, WGs leaders, etc.) to females as well. As the specific field has many known female scientists this is expected to be a quite easy task for the Action.
In addition, innovative procedures as the ones referring to the assignment of coordinating roles to scientists for the recruitment of ESRs and ensuring the participation of both males and females at a balance considered important and beneficial towards these aspects.
A scientific network of ESRs will be established under the name Blue Circle, which will be able to meet separately during the WGs meetings and come up with suggestions and ideas that will be relayed to the WGs leaders and participants, the SG and the MC. Blue Circle will serve as the Think Tank of the ESRs. Efforts will be made to establish links between the Blue Circle and IWA Young Professionals Network to increase visibility.
Training schools will be planned for disseminating knowledge, methodologies and results in order to supply ESRs with tools and means for their specialization and professional growth in a collaborative connect and to enhance their networking capacity. Capacity building for ESRs is foreseen by means of STSMs, training schools, participation in workshops (by oral presentations and other special roles like presenting overview of activities for example), and assignment of specific roles as for examples the secretary role of the 5 WGs and participation in the Blue Circle network. This Action aims to assign to selected ESRs under the supervision of advanced researchers, the collection of information on the on-going relevant research projects at national, European and international level. Moreover, during the final conference, a special session will be

organized during which the ESRs of the Action will have the opportunity to present their work during STSMs and their outcomes and also present how their participation in the Action helped and/or enhanced their professional maturity.

These innovative features and plans are expected to impact positively the activities of the Action towards the wider goals of the COST.

F. TIMETABLE

The four-year COST Action will be initiated with a kick-off meeting that will take place as soon as possible during the first two months. This meeting will serve also as a coordination meeting, in order to assign roles and responsibilities to the participants. A MC meeting will be held on a yearly basis, and WGs will meet twice a year. An effort will be made to organize these meetings in a way to allow information flow among WGs. The Action's website will be established and maintained updated during the entire duration of the Action's life and even beyond that, by the Grant Holder. Two training workshops will be organised, and a major final conference.

The milestones and their completion dates are provided in Section E1.

<table>
<tr><th>Year</th><th colspan="4">Year 1</th><th colspan="4">Year 2</th><th colspan="4">Year 3</th><th colspan="4">Year 4</th></tr>
<tr><th>Quarter</th><th>1</th><th>2</th><th>3</th><th>4</th><th>1</th><th>2</th><th>3</th><th>4</th><th>1</th><th>2</th><th>3</th><th>4</th><th>1</th><th>2</th><th>3</th><th>4</th></tr>
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<tr><td>WG2 meeting</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td></tr>
<tr><td>WG3 meeting</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td></tr>
<tr><td>WG4 meeting</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td></tr>
<tr><td>WG5 meeting</td><td colspan="2"></td><td colspan="2"></td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td><td colspan="2">x</td></tr>
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<tr><td>Training School 2</td><td colspan="4"></td><td colspan="4"></td><td colspan="4">x</td><td colspan="4"></td></tr>
<tr><td>Summer School</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">x</td><td></td></tr>
<tr><td>Final Conference</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">x</td></tr>
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G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: AT, BE, CH, CY, CZ, DE, DK, EE, EL, ES, FI, FR, HR, IE, IL, IT, LU, NL, NO, PL, PT, RS, SE, SI, SK, TR, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 108 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

This Action aims to maintain and extend a pan-European inter- and trans-disciplinary network to tackle all the current challenges related to the wastewater reuse practice and help overcome existing barriers, and to provide new insights into wastewater reuse in order to become a sustainable practice with technological, economical and societal benefits. This unique platform will involve early stage and experienced researchers from diverse scientific disciplines such as environmental and chemical engineering, chemistry, epidemiology, toxicology, agronomists, microbiologists, etc, as well as decision makers, stakeholders and others. The trans-disciplinary character of the Action foresees several scientific benefits as described in Section C. With this Action that combines innovative approaches with state-of-the-art techniques, a wide scientific and non-scientific audience will be reached for the dissemination of the results. Next to the scientific goals, special emphasis will be given on applied scientific issues and social benefits. Communication of the results to public authorities, national and local governments, and to the general public will play a key role. Therefore, the involvement of policy makers and end-users, such as WHO, FAO, EU, JRC, JPI on Water Challenges, and others like IUPAC, SETAC, WssTP, IWA Reuse group, EUREAU etc., as well as local stakeholders is highly important. The integration of scientific and social spheres will also help identify and address critical research issues. Several end-users (e.g. researchers, decision makers) and stakeholders (e.g. wastewater treatment companies, state laboratories, agricultural institutes) are already participating in the network and form a strong basis for the Action. Others have been contacted and have expressed interest to be involved as soon the Action is approved. In summary, the COST Action will have an impact on:

- the Scientific community, since innovative methods, assays, systems, technologies, will be developed by a strong and scientifically excellent Network (e.g. Universities, Research Institutes and Organizations, ESRs in the field of environmental engineering, environmental chemistry and microbiology, toxicology, molecular biologists, risk assessment, just to name some examples fields)

- Wastewater/water industry: e.g. engineering, operation and construction of wastewater treatment plants, as an outstanding business opportunity will be provided for optimum treatment processes development
- Farmers, agricultural industries, water reclamation operators
- Policy makers, planners/managers, since the achievement of the water quality required for reuse purposes will be determined through the Action activities
- Risk assessment regulators
- Public health authorities and professionals
- Environmental laboratories both public and private
- Equipment and material designers and manufacturers with regard to analytical chemistry, microbiology and wastewater treatment technologies
- Technological clusters and societies (in the field of water treatment)
- ACQUEAU, Eureka cluster for financing water innovations
- Ministries of Environment, Natural Resources, Agriculture
- European/International Organizations: (WHO, FAO, EC, JRC-Water Resources Unit, IUPAC-Chemistry Division, WssTP- Water supply and sanitation Technology Platform, Joint Programming Initiative on Water Challenges, NORMAN network, European Environment Agency, European Water Partnership, IWA, SETAC, World Water Council, EUREAU, etc.)
- Economy, which will be a special feature to be considered during the development of specification of technologies but also since sustainable wastewater will serve the enhancement of water balances
- Communication media, journalists, scientific magazines etc.
- Society, which will become aware on water/wastewater issues and safety

H.2 What?

The following dissemination methods will be used in order to communicate the research outcomes of the Action to each target audience:

Scientific audience

- Publications in scientific peer-reviewed journals of highest international standing
- At least one special issue in a scientific journal on a topic selected by the Action
- Presentations at thematic workshops, seminars and international conferences
- Training programmes (advanced courses and technical workshops)
- A final open conference with international participation
- Position papers (e.g. on the methods and means to assess the wastewater quality, the specification of the treatment technologies, on scientific gaps and future perspectives, etc.)
- A flyer describing the Action and its activities, methodology and objectives

Policy makers, stakeholders, governmental authorities

- Invitations to workshops and workgroup meetings
- ‘Non-scientific’ reports (in layman form)
- Direct dialogs
- Policy recommendations
- A flyer describing the Action and its activities, methodology and objectives (same as above)
- Printed synoptic material informing on specific topics related to the Action's methodology and findings

General public

- Popular communication media (internet, television, radio, newspapers)
- Open access website
- Social network platforms/media (Facebook, Twitter)
- e-newsletter
- Organization of 'café scientifique’ events in three different countries
- A flyer describing the Action and its activities, methodology and objectives (same as above)
- Wikipedia webpage dedicated to the wastewater reuse and the COST Action

H.3 How?

Dissemination and outreach activities are considered to be of great importance to the Action for the wide and diverse dissemination of research outcomes. Communication will be appropriate for each kind of target audience. The dissemination plan will be updated during the course of the Action taking into account the progress of the Action as well as the results of its evaluation.

A professionally-developed flyer describing the Action's objectives, methodology and activities will be developed and distributed in the various participating countries (to the scientific community, stakeholders, end-users).

A Wikipedia webpage will be developed that will be dedicated to wastewater reuse and the related open current challenges, and how this COST Action is tackling them.

The scientific audience will mainly be addressed via scientific publications in peer-reviewed journals of high ranked journals and thematic workshops, seminars and international conferences. Special efforts will be made to invite external keynote speakers and publicize the various Action events outside the Action's network (at European and International level). An effort will be made to prepare at least one special issue in a scientific journal of high impact factor, on a topic selected by the Action. COST will be acknowledged for its support in all the scientific publication that will be produced and co-authored by Action participants. Special rules will be prepared for acknowledging the COST Action in the scientific papers produced by the participants.

Students and ESRs will be especially encouraged to present their results at scientific conferences. The training programme will consist of courses and workshops, and a summer school, covering a specific area of expertise, providing at the same time special emphasis on the ESRs. The various events will be also open to practitioners, end-users and stakeholders. The Action will organize technical and information workshops. These events will meet the twofold goal of: (i) presenting (scientific) results, and (ii) training technical staff of public bodies, industries and other concerned stakeholders on the aspects covered by the Action. Members of the Blue Circle (i.e. the network of ESRs) will be assigned with the task of identifying the on-going relevant research projects and any other similar activities so that contacts will be made early on. Furthermore, a second task will be assigned to them, to prepare lists with stakeholders at national and international level, so that the Action would be able to create communication channels towards them, and take advantage of potential synergies. Senior researchers, members of the Action will, of course supervise these activities.

Position papers and printed informational material will also be prepared and sent to appropriate stakeholder (European and international) in order to promote the implementation of the Action’s findings.

The Action’s website will play a prominent role in the dissemination of information and results. It will give access to all the relevant documents generated (reports, guidelines, printed informational material, etc), and include a discussion forum where specific questions can be posted. The website and a web-based e-newsletter will keep the members of the network informed, but will also serve to disseminate the outcomes to the general public. Furthermore, considering the importance of social network and popular media, these will also be used for the dissemination of the Action in order to reach the public in an understandable ´non-scientific´ (i.e. layman) language. Towards this objective, the idea of 'café scientifique' will be utilized by the Action, so that useful information will be provided to the wider public (to be organized in at least 3 countries of Action). These events aim to demystify scientific research for the general public and empower non-scientists to more comfortably and accurately assess science and technology issues, particularly those that might impact social policy making.

The scientists and other stakeholders of the Action will make an effort to disseminate information on national level, towards the society, through TV and radio interviews, articles to newspapers, etc. Documentation of all the activities will be compiled and records will be included in the annual reports of the Action. An important feature is the fact that the Action intends to use an acronym and a logo to be used on all written material (reports, presentations, website, dissemination material, etc), so that the Action becomes known and recognizable.