

COST Action ES1403: New and Emerging challenges and opportunities in wastewater REUse (NEREUS)

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Background

Treated urban wastewater is currently widely reused to compensate for dwindling water supplies, as it is considered to be a reliable alternative water source. In addition, the increasing demand for food due to the expanding world population, both in respect to food security and food safety, and therefore for irrigation water, renders wastewater reuse a practice of utmost importance. As a consequence, sustainable and safe urban water cycles are presently of high priority on the policy agendas of many countries around the world.

Although reuse has a number of benefits and major advances have been made with respect to producing treated effluents for reuse (e.g., successful removal of metals, reduction of chemical oxygen demand and of other pollution parameters), several important questions are still unanswered and barriers exist regarding the safety/sustainability of reuse practice.

Knowledge gaps associated with wastewater reuse include the following: (a) possible elemental interactions that may influence the accumulation of metals/elements in the soil and their subsequent uptake by plants and crops, (b) the fate

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of organic microcontaminants in receiving environments, and (c) the epidemiological potential of antibiotic resistant bacteria and/or resistance genes (ARB&ARG) released in the environment via treated effluent. Possible implications on food-chain contamination (biomagnification) require much attention, since treated wastewater is not exempt of such contaminants. The effluents' residual organic matter after conventional treatment consists of a number of recalcitrant organic compounds including potential endocrine disrupting compounds, many types of pharmaceuticals including antibiotics, disinfection by-products, personal care products, metabolites and transformation products, other organic substances (i.e. pesticides, surfactants, biocides, etc.), and not to be forgotten ARB&ARG. In fact, preliminary results suggest that the relative abundance of certain ARG or ARB may even be enriched during the wastewater treatment (Rizzo et al. 2013). This leads to their subsequent release in the terrestrial and aquatic environments through disposal and reuse applications, and the level of risk to environmental and human health is yet to be evaluated.

Contamination of the environment, food chain, drinking water, etc with ARB&ARG is presently considered to be a *serious public health problem*. For this reason, the World Health Organization (WHO) (WHO 2013) characterized the development of AR as one of the *major global threats to society* and recommends intensive monitoring for the identification/surveillance of critical hot spots (e.g., wastewater treatment plants), aiming at reducing its propagation. In September 2014, a national strategy (The White House 2014) was announced in the USA by the White House that lays out a series of steps to address the decreasing effectiveness of antibiotics, many being similar to those identified by WHO. According to the European Centre for Disease Prevention and Control, it is estimated that infections caused by a subset of ARB are responsible for about 25,000 deaths in Europe annually. In addition, the extra healthcare costs and productivity losses due to ARB are estimated to reach EUR 1.5 billion (European Centre for Disease Prevention and Control 2013). In the USA, equally dramatic numbers are reported by the Centers for Disease Control and Prevention, with AR infections killing at least 23,000 people and sickening 2 million each year (The White House 2014).

All these issues have not received significant attention in the framework of the wastewater reuse practice. The EU-COST Action ES1403 (NEREUS) aims at consolidating the existing scattered data related to wastewater reuse and will 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 wastewater reuse. The Action is chaired by D. Fatta-Kassinos from Nireas-International Water Research Center and Department of Civil and Environmental Engineering of the University of Cyprus and vice-chaired by C. Manaia

from Escola Superior de Biotecnologia, Universidade Católica Portuguesa.

Actions' objectives

The main objective of the COST Action is to develop a multi-disciplinary network to provide insight into the current challenges related to wastewater reuse practice, in particular the most concerning ones from both the public health and environmental perspectives and how these can be overcome. The Action intends to (i) deliver best-practice recommendations for wastewater reuse in irrigation and solid scientific knowledge to decision makers/public, (ii) develop uniform means for assessing wastewater quality with respect to contaminants of emerging concern including ARB&ARG, (iii) establish specifications for technologies able to produce wastewater with minimal levels of such contaminants, and (iv) compile valid and reliable information to be used in regulatory frameworks. NEREUS aims at enhancing and valorizing wastewater reuse, thus making major contributions to the European scientific and technological excellence, wider society, and economy.

Work plan and organization

To reach its aim, the work plan of the Action is organized into five working groups (WGs) with the following corresponding objectives.

- WG 1 Microbiome and mobile antibiotic resistome in treated wastewater and in downstream environments (Leader: E. Cytryn, Vice-leader: Th. Berendonk)
- (i) To propose standardization of procedures used for ARB&ARG detection and quantification in water and soil samples, (ii) to identify the most prevalent and/or potentially hazardous ARB&ARG in effluents and downstream environments, (iii) to assess the fate of ARB&ARG discharged in treated wastewater and released in surface water and soils, and (iv) to identify the conditions favoring ARB&ARG persistence or proliferation.
- WG 2 Uptake and translocation of organic microcontaminants and ARB&ARG in crops (Leader: J. Bayona, Vice-leader: B. Chefetz)
- (i) To consolidate existing relevant knowledge, (ii) to identify the main physicochemical characteristics affecting the behavior of microcontaminants including ARB&ARG with regard to uptake and translocation, and (iii) to develop a set of recommendations regarding the minimization of biomagnification processes and

environmental and human health impacts associated with wastewater reuse.

WG 3 Effect-based bioassays required for wastewater reuse scheme (Leader: J. Slobodnik, Vice-leader: N. Kreuzinger)

(i) To consolidate existing relevant knowledge, (ii) to identify the potential relationships between the physicochemical characteristics of the wastewater and biological effects, (iii) to determine the most appropriate and relevant bioassays to assess the effects of the reuse practices, and (iv) to propose the harmonization of the procedures used for this purpose.

WG 4 Technologies efficient/economically viable to meet the current wastewater reuse challenges (Leader: L. Rizzo, Vice-leader: S. Malato)

(i) To consolidate knowledge on the fate of microcontaminants during wastewater treatment, (ii) to assess the fate of ARB&ARG during biological processes and characterize their removal mechanisms, (iii) to assess the effect of advanced oxidation processes (AOPs) on ARB&ARG, (iv) to assess the economic feasibility of AOPs compared to conventional processes, and (v) to identify optimum integrated technologies in terms of global efficiency/compliance with standard parameters.

WG 5 Risk assessment and policy development (Leader: L. Lundy, Vice-leader: A. Ledin)

(i) To develop quality criteria for selected contaminants of emerging concern and ARB&ARG for wastewater reuse, (ii) to propose a battery of assays for wastewater evaluation for reuse purposes, (iii) to develop a risk assessment framework for wastewater reuse purposes, (iv) to propose guidelines/suggestions on possible technologies able to produce wastewater of quality in compliance to the quality criteria to be set, and (v) to overcome existing barriers in the field of wastewater reuse.

organizations (i.e., University of South Australia, GIST-Gwangju Institute of Science and Technology, Nanyang Technological University, US EPA National Risk Management Research Laboratory, Cincinnati, University of Arizona, and University of Cincinnati) from four International Partner Countries (i.e., Australia, Korea, Singapore, and the USA), and two representatives from the European Commission's Joint Research Center (JRC) are already included in this COST Action as Management Committee (MC) Observers. Moreover, the Jordan University of Science and Technology and the National Research Institute of Rural Engineering, Water and Forests (INRGREF) from two "Near Neighbor Countries" (i.e. Jordan and Tunisia, respectively) are also MC Observers.

This Action already includes 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. NEREUS is without any doubt, the most important attempt ever taken place, on an international level, to investigate these interrelated and multidisciplinary issues that are important for wastewater reuse practice.

The Blue Circle society for early-stage researchers

A scientific network of early-stage researchers (ESRs) has been established under the name "Blue Circle society," able to meet separately during the WGs meetings, having its own platform for discussions, development of new ideas and suggestions, dedicated tasks, training events, workshops, short-term scientific missions, etc. This is a great opportunity for the ESRs, since through this Action, they will have their own voice in a more structured way, in order to ensure their active participation in this COST Action. The Blue Circle society will serve as a "Think Tank" for the ESRs.

Actions' duration and participants

The Action started on the 7th of November 2014 and it will run for four years. Twenty-nine COST countries have already signed the MoU as follows: Austria (AT), Belgium (BE), Bosnia and Herzegovina (BD), Croatia (HN), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Ireland (IE), Israel (IS), Italy (IT), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Serbia (RS), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE), Switzerland (CH), and the United Kingdom (UK). In addition, six universities/institutes/

Potential impact of the action

NEREUS will enable new research groups in COST countries, without research expertise and practical experience in addressing scientific and technological challenges related to wastewater reuse, to mutually benefit from other more advanced-stage researchers. It is foreseen that the enhanced awareness, 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 of Europe.

The benefits of the Action will be of scientific and technological, economical, and of course societal character. Addressing the knowledge gaps and establishing norms and guidelines

will enhance the development of trust required to enable fuller implementation of wastewater reuse. This will have a significant added value in the economy of the countries trying to establish solid water balances, avoiding at the same time investment in more expensive and energy-exhaustive means like for example water desalination, import of water, etc. Undoubtedly, the society has much to gain from this Action including sustainable water resources, clean environment and health protection.

The NEREUS COST Actions' objectives, actions, progress, results, and activities are presented on the project website (<http://www.nereus-cost.eu> and http://www.cost.eu/COST_Actions/essem/Actions/ES1403). Dissemination via Twitter (https://twitter.com/NEREUS_WWreuse) and LinkedIn (<https://www.linkedin.com/groups/COST-Action-ES1403-Nereus-6934609/about>) already takes place.

Perspectives

Facilitating the integration of research from several disciplines undertaken in Europe countries, NEREUS will generate important scientific and economic benefits. In bringing together scientists, companies, water and wastewater related authorities, stakeholders, and legislative bodies to collaboratively identify and discuss pertinent issues, it is building the integrated platform required to enable identified measures to be implemented. Hence, the Action will have enormous social benefits, as the resulting information will directly influence and support decision-making in the EU member states as well as

enhancing food and water safety. The economic benefits stemming from this Action are multiple, from the facilitation of wastewater reuse as a vital practice in establishing sustainable water balances and potentially to reductions in health-related expenses from the release of contaminants of emerging concern in the environment.

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