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INNOQUA: Innovative Ecological On-Site Sanitation System for Water and Resource Savings †

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Abstract: INNOQUA, an EU-funded project through the Horizon 2020 research and innovation programme launched in June 2016, aims to meet this challenge by promoting sustainable water sanitation technologies capable of performing a whole water treatment cycle.

Keywords: wastewater solutions; lumbrifilter; daphniafilter; ultraviolet; BioSolar purification; monitoring and control unit; freshwater ecosystems

1. Introduction

INNOQUA will accelerate the path to market of a modular set of innovative, patent protected, award winning and scalable fully ecological sanitation solutions that address wide market needs in rural communities, for agricultural industries, for sustainable home-builders or collective housing owners and for developing countries worldwide. The modular system is based on the purification capacity of biological organisms (worms, zooplankton and microorganism) and sorption materials bringing ecological, safe and affordable sanitation capacity where it is needed most while fully addressing the thematic and cross cutting priorities of the EIP on Water.

The project will perform demonstration scale deployment and resulting exploitation of the system to include commercial development, technology integration, eco-design, controlled environment pilots (in NUI Galway facilities in Ireland and UDG facilities in Spain), real use demo sites and market uptake preparation in several EU and non-EU countries (France, Italy, Ireland, Romania, UK, Ecuador, Peru, India and Tanzania), and further preparation for post project uptake.

Such an integrated solution is innovative and has not been employed in the past. This integrated but modular solution for the final reuse of wastewater is particularly attractive for small to medium remote water stressed European communities with high water demand for either agriculture and/or the conservation of natural freshwater ecosystems. The INNOQUA system also fosters sanitation provisioning for remote or high-density areas or where sanitation is not readily available (e.g., low-income countries). The system is aimed at being a sustainable solution for 'zero' wastewater production with the complete reuse of wastewater. The system is ideal for small to medium scale situations where an integrated solution for the treatment of wastewater is required to reduce the waste directed to surface freshwaters for the attainment of good quality water, as stated by the Water Framework Directive. The robust but efficient technologies are also ideal for deployment in markets where resources are limited and skilled staff unavailable.

2. Challenges

The INNOQUA project aims at answering the growing need for protection and improvement of natural water resources. This challenge is related to the fact that worldwide, about 2.5 billion people

are without sanitation facilities. Still, almost 1000 children under 5 die each day from diarrhoea caused by inadequate water, sanitation and hygiene. In EU, depending on the country, the percentage of EU population connected to central water supply systems ranges from 53.5 to 98.8%. However, despite the fact that the EU Framework Directive (EU WFD) obliges all countries to achieve the "good status of all the waters" in their territories, there is a gap of 10–15% of the population, corresponding to about 20 million rural inhabitants, who will remain without proper sanitation systems after 2015.

INNOQUA—the project acronym—is an innovative, patent protected, award winning and scalable, fully ecological sanitation solution, available in multiple modular configurations adapted to local contexts and markets. This type of integrated solution for the treatment of wastewater has not been employed before. Due to its modular configuration, the INNOQUA system addresses the water treatment needs of decentralised facilities, water stressed communities, rapidly expanding cities and industries both in developed and developing countries to reduce pressure on aging wastewater networks while supporting sustainable population growth by reducing water and energy consumption.

These technologies resemble natural cleaning processes and are based on the purification capacity of earthworms, zooplankton, and alternatively microalgae and sunlight exposure. As a consequence, the three main INNOQUA objectives are to:

- Integrate individual low cost, sustainable and biologically-based water sanitation technologies capable of performing a whole water treatment cycle and available in multiple modular configurations adapted to local contexts and markets.
- Demonstrate across 11 countries in 4 continents the long-term viability of innovative, modular and sustainable solutions for wastewater treatment in real environment, to support the commercialisation of the proposed solutions in order to encompass pre-commercialisation challenges of innovative water solutions and to start stimulating economic growth, business and job creation in the water sector both inside and outside Europe.
- To eco-design and optimise the proposed solutions to increase the sustainable performance of the water sector through an optimised environmental performance (reduced water consumption, increased resource efficiency, reduced carbon footprint, etc.), a socially accepted and affordable wastewater treatment system.

3. Technologies

3.1. Lumbrifilter

The "lumbrifiltration" is an alternative treatment method of organically polluted water. The principle is based on the vermifilter degradation of domestic water pollution by the association of earthworms *Eisenia fetida* and *Eisenia andrei*, and microorganisms (aerobic bacteria). Lumbrifiltration is efficient for wastewater, but also industrial and agricultural wastewater treatment heavily charged with organic matter, such as cannery and dairy. In China, lumbrifilters had been found to be generally good for swine wastewater treatment, municipal wastewater treatment, and domestic wastewater treatment. Lumbrifiltration has been proved to be effective at municipal scale in Combaillaux, France and individual scale in Bordeaux, France respectively by the INNOQUA partners Lombritek and Nobatek.

3.2. Daphniafilter

Natural purification systems have been used for years to improve the quality of wastewater before discharge or reuse. Purification marshes are a workable solution for changing the quality of the effluent from STPs to 'usable surface water'. Based on this observation, the University of Girona has investigated the purification mechanisms performed by Daphnia sp. and especially their role in the reduction of suspended solids and pathogen bacteria. After several years of testing and experiments, they have demonstrated that Daphniafilter constitutes a technically feasible and competitive (in terms of cost and efficiency) innovative tertiary treatment.

3.3. BioSolar Purification

The Bio-Solar purification technology intensifies, in closed photoreactors, ecosystems services occurring at the air/water interface. The BSP technology combines organic wastes degradation, dissolved hazardous compounds removal and faecal contaminants destruction in photobioreactors, using sunlight and CO_2 to intensify natural photosynthesis. The special design of photobioreactors allows purification of 100 to 2000 L wastewater per m^2 exposed to sun and per day according their shape and sunlight recovery means. Water circulation and air + CO_2 injection system are designed to use less than 0.5 KWh per m^3 of treated water. Overall wastewater treatment is achieved by 5 biological and solar phenomena intensified in a photoreactor and is comparable to an advanced oxidation natural process through photosynthesis performed by microalgae.

3.4. Ultraviolet

Berson designs and manufactures ultraviolet (UV) disinfection systems for municipal drinking water and wastewater treatment plants worldwide. Since the founding in 1972 Berson has been a pioneer in UV science and technology, providing UV systems with a reputation for technical innovation, quality and service. Their UV systems are the result of continuous investment in R&D and partnerships with universities and industry. Berson applies the latest lamp and lamp driver technology in combination with newly designed highly efficient UV reactors that have been developed to have the optimal hydrodynamic conditions to achieve an evenly distribution of the UV light through the water to be treated. As a result, Berson can guarantee the amount of UV radiation each particle is exposed to and the log reduction, based on the different UV dose response of the microorganisms in question.

3.5. Monitoring and Control Unit

INNOQUA Monitoring and Control Unit is a portable low-cost monitoring and control platform responsible of collecting and analyzing data about the operational status of INNOQUA wastewater treatment system through the combination of different sensing technologies. It will be capable of capturing key operational metrics such as pH, dissolved oxygen (DO), conductivity (salinity), oxidation-reduction potential (ORP), temperature, ions concentration to measure different chemical and physical water quality parameters.

4. Expected Impact

INNOQUA will demonstrate comprehensive technological, economic, environmental and societal benefits of the innovative bio-based modular water treatment system and will:

- Enhance confidence among end-users and stakeholders regarding the long-term sustainable benefits of the system in a range of realistic applications and location
- Widespread market uptake both inside and outside Europe via new business generation
- Economic benefits estimated in 28 M€/y increased revenues,
- 560 full-time jobs and 1000 MWh/y (or 21,100 €/y) of energy savings
- Promote European leadership in addressing worldwide off-grid sanitation needs
- Generate LCA positive impacts regarding chemical and resources use
- Reduced stress on and solution for the EU aging water infrastructure
- Reduce release of untreated/poorly treated wastewater and avoid GHG emissions equal to 625 Tons CO_2 eq/y
- Improve sanitation and health conditions in both rural and underdeveloped regions
- Foster the aims of EU strategies (EIP on Water, SPIRE PPP, EU ETV programme)

5. Conclusions

INNOQUA will demonstrate comprehensive technological, economic, environmental and societal benefits of INNOQUA is a Horizon 2020 EU-funded project involving 20 partners that seeks

to demonstrate in real conditions a modular system for water treatment based on the purifying capacity of biological microorganisms (earthworms, zooplankton and microalgae).

The configuration of the system will be adjusted according to the targeted markets in order to answer the most possible market needs. The final objective of the project is to provide an ecological water sanitation system for rural areas and communities, for industries with specific characteristics (such as agriculture and aquaculture), for sustainable home-builders or collective housing owners and for developing countries worldwide.

Under the coordination of Nobatek, a renowned French Research and Technology Organisation, 20 partners from 11 countries located all over the world are working on the integration of the different technologies into a single modular system, its testing and demonstration in real conditions.

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