Implementing nature-based and other engineering solutions to recover water from non-conventional water sources

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Abstract
Mediterranean (MED) islands and coastal areas are under pressure due to water shortage. Water reserves are depleted, while tourism in the summer months burdens the limited water sources. A persistent issue arising from the above activity is the increased seasonal loads of sewage that wastewater treatment plants (WWTPs) receive and need to cope with. On the top of that, the circular economy concept is not implemented in the MED region and particularly in small WWTPs. Water, nutrients, energy and chemicals contained in sewage are not usually valorized. At the same time, in several MED islands, energy intensive seawater desalination is applied to produce potable water thus increasing the energy demand and producing large quantities of brine water, which is not further valorized. As a consequence, activities within the concept of circular economy are required, considering the water-energy-food nexus. The HYDROUSA Horizon2020 Innovation Action project will provide innovative, regenerative and circular solutions for (1) nature-based water management of Mediterranean coastal areas, closing water loops; (2) nutrient management, boosting the agricultural and energy profile; and (3) local economies, based on circular value chains. The services provided lead to a win-win-win situation for the economy, environment and community within the water-energy-food-employment nexus.
Keywords: circular economy; Horizon 2020; wastewater treatment; water reuse

1. Introduction

The Mediterranean (MED) basin is characterized as a "hot spot" of the planet in terms of water scarcity; unequal distribution between water demand and supply, both spatially and temporally (UNEP/MAP, 2016). Several MED countries have water reserves less than 500 m^3/capita/year, ('structural shortage'), and many areas have less than 1000 m^3/capita/year (UN water stress level) (GWP, 2012). Over the past half-century, water demand has nearly doubled and its availability has declined due to various factors such as industrialization, population growth, climate change, tourism and the intensification of production in some water-demanding sectors (Scoullos & Feggarina, 2010, Kibaroglu, 2017). The latter certainly applies to the agricultural sector, which is the largest water consumer, accounting for about 80% of total freshwater consumption in the MED region (Masia et al., 2018). Moreover, the need for fresh water production from unconventional sources (seawater), has led to the development of desalination plants that severely stresses the energy grid and results in the production of large quantities of brine, which are not valorized, as they are disposed into the sea (Lattemann & Höpner, 2008). In many MED regions wastewater is discharged into marine ecosystems, without adequate treatment. Wastewater treatment plants (WWTPs), are often too overloaded to cope with the high seasonal loads, while some regions are not serviced at all. Consequently, the implementation of a sustainable water management approach in MED area is necessary more than ever, through the valorization of non-conventional water sources.

The EU Action Plan undoubtedly encourages the investigation and development of new sustainable water services based on the circular economy; closing the water cycle, while enhancing the recovery and reuse of energy and materials, with significant environmental and economic benefits. Within the framework of this Action Plan, several projects are being implemented to address water management issues. Among them, the HYDROUSA project provides innovative solutions for MED islands in terms of water/wastewater treatment and management, which will close the water loops and will also boost the agricultural and energy profile.

2. HYDROUSA project

The **HYDROUSA Horizon2020** project aims to setup, demonstrate and optimize on-site, innovative nature based solutions (NBS) for the management of a variety of water streams, including wastewater, rainwater, groundwater, atmospheric vapour water and seawater to produce valuable resources, which can then be treated to enrich the domestic water supply and be valorized to increase agricultural production and boost the economic activities of water-scarce Mediterranean areas.

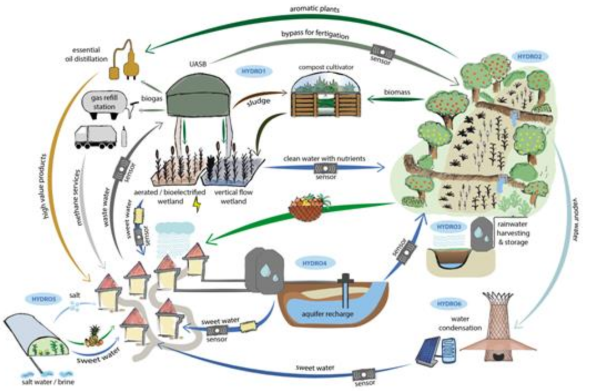

Figure 1. HYDROUSA water loops

HYDROUSA aims at closing all water loops at local level, taking advantage of local resources, promoting the concept of decentralized on-site water, materials and energy conservation, treatment and reuse. The HYDROUSA concept will be materialized by implementing 13 innovations in six demonstration sites:

- Upflow anaerobic sludge blanket (UASB), biodiverse constructed wetland (CW) and biogas upgrade for wastewater reuse and energy recovery
- UASB and bio-electrified wetland for wastewater reuse and energy recovery
- In-vessel composting system with integrated odour abatement to manage sewage sludge
- Seawater desalination by evaporation and condensation
- Water vapour condensation with passive systems to recover vapour water
- Rainwater harvesting and treatment coupled with aquifer storage

HYDROUSA technologies will start directly at TRL 5-6 (validated in relevant environment) and will reach TRL 7 (demonstration in operational environment).

Site	Specification	Issue Solved
1	Anaerobic treatment, sludge composting, water reuse, biogas upgrade	No wastewater discharge into sea; cheaper production of reclaimed water; recycling nutrients
2	Irrigation of agroforestry system with nutrient-rich water	Wastewater use for fertigation; no fertilizer import; product diversity; creating resilient ecosystems
3	Remote rainwater harvesting system	Cheap water supply in remote areas; create business case with little input
4	Domestic rainwater harvesting, aquifer storage, watering of local crops	Increase water supply; production of drinking water; aquifer recharge to reduce saltwater intrusion
5	Seawater and brine treatment to recover salt and water, produce tropical fruits	Produce sweet water from saltwater/brine; decrease import of tropical fruits; salt production
6	Water loops in eco-tourist facility	Eco-tourist facilities which are self-sufficient in terms of water, energy and food

The demonstration sites will achieve a high level of automation, real-time monitoring and control, through ICT integration. Open source/low cost sensors/actuators for monitoring and controlling water loops will result in net water savings. The whole water supply chain developed within HYDROUSA will be evaluated in environmental, social and economic terms. Transferability of HYDROUSA solutions will then be demonstrated in 25 early adopter cases of coastal areas and islands. Institutional pathways, policy drivers, barriers and opportunities for the market deployment of the project technologies and services and for the use of the recovered resources will be analyzed. Dissemination activities shall be targeted to stakeholders and include workshops, publications and presentations, clustering with other initiatives, opening events, etc. HYDROUSA will also foresee strong interaction with citizens, including gamification strategies for citizen science, info points, summer schools, hackathons, artists' and researchers' residencies, etc.

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