WebGIS as a decision-support tool to draw up action plans for the reuse of treated wastewater

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Summary: The ENI CBC Med funded **AQUACYCLE** project brings the ambition to develop a decision-support tool in the form of a WebGIS that will guide users to optimum wastewater reuse action plans. Developed as an open-source software, the WebGIS brings a visual aid and enables users to define criteria that permit the comparison between alternative scenarios for reuse. Feedback on the initial prototype WebGIS platform has been incorporated ahead of the organization of participatory events, which will invite local communities to bring their suggestions as well as preferences for the reuse of treated wastewater. These 'bottom up' action plans will be scrutinized in terms of their cost-effectiveness and presented for feedback from decision- and policy-makers in a further follow-up series of stakeholder events.

***Keywords**: Treated wastewater reuse action plans, WebGIS, decision criteria.*

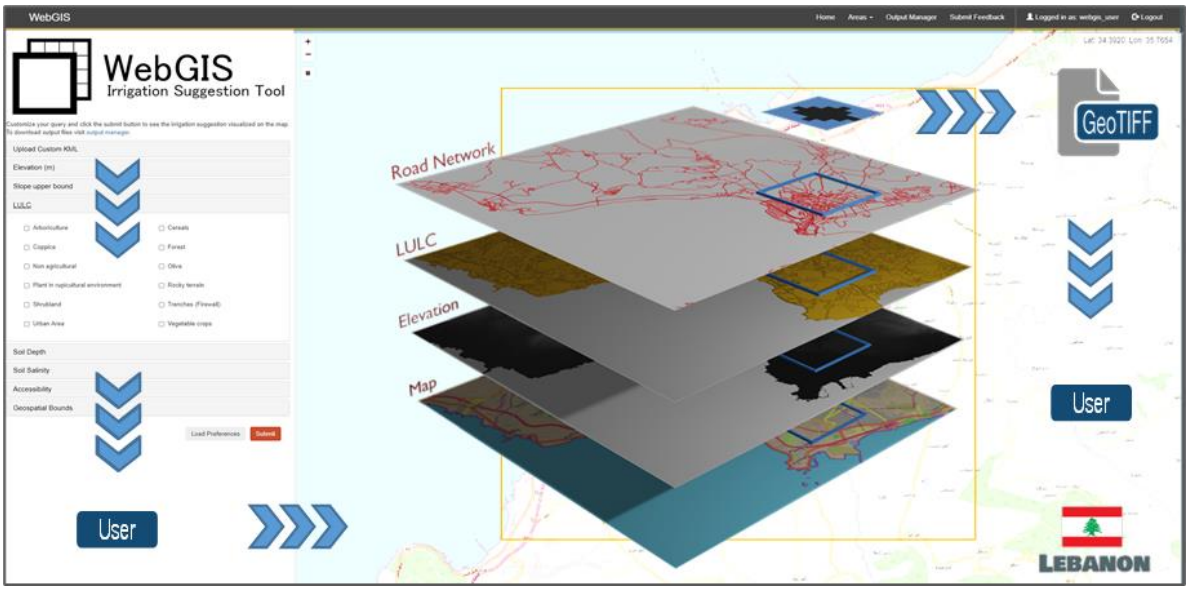
Overall aim and intended functionality of the WebGIS

The WebGIS that is under development in **AQUACYCLE** is envisaged as a decision-support tool to guide on the drawing up of optimum water reuse action plans for the three locations where the project's eco-innovative wastewater treatment technology will be demonstrated. As shown on the satellite images below, these include a site to the south of Tripoli in Deddeh, Koura owned by the Real Estate Company, SANABEL, in Lebanon, and at the sites of the existing wastewater treatment plants of Blanca in the Murcia Region of Spain and of Bent Saidane in the Zaghouan Governorate in Tunisia.

Fig. 1 Satellite images of the demonstration location sites in Lebanon, Spain and Tunisia

The main functionality of the tool is intended to provide support to planners and decision-makers in the water, agricultural, and urban planning sectors. Alternative scenarios for reuse in agriculture as well as for urban landscaping, will be compared in relation to their cost-effectiveness. To this effect, the tool incorporates a set of digital maps, as well as satellite imagery, that bring into assessment the terrain topography, land cover and/or land use, surface water drainage network, location of groundwater bodies, road network, administrative boundaries, and more. Users can carry out customized queries by applying case-specific criteria, and visualize the corresponding result.

The WebGIS is built solely on open-source tools and technologies, such as Django[1] (an open-source high-level Python Web framework), PostgreSQL[2] (an open-source object-relational database system) and a series of python packages publicly available on Python Package Index (PyPI)[3]. This enables migration to further hardware installations with minimum cost, guarantees freedom from lock-in, facilitates incorporation of third party developed open-source solutions, while in turn allows third party developers to build further solutions on top of this tool.



Our target users of the WebGIS and inherent assumptions for users to keep in mind

As with any software, it is clearly important that users should have the required skills and expertise to correctly define the relevant criteria for reuse and to then also correctly interpret the results issued by the decision-support tool. This implies that users should have a sound knowledge of the area under investigation, not only from a geographical but also from a hydrological and hydrogeological point of view. It is assumed that **the quality of the treated wastewater – at all times - meets the latest regulatory requirements** for the envisaged reuse applications in EU Member States[4], or meets the requirements as set by the regulatory authorities in the Mediterranean Partner Countries, i.e. Lebanon and Tunisia. In this context, it should be borne in mind that a possible malfunctioning of the wastewater treatment plant or any other type of disruption of the treatment process may render the treated effluent to not abide by the regulatory requirements in force. Any remedial actions as would be required to restore the wastewater treatment to function properly and within the constraints brought by the prevailing regulatory requirements for the envisaged reuse application(s) are not within the scope of the intended functionality of the WebGIS.

Alternative starting points for the development of decision-support criteria

Two distinct alternatives can be foreseen to determine the most cost-effective wastewater reuse action plan: (1) the treated effluent is first pumped to a higher elevation, or (2) the distribution network is designed to start at the same elevation as the outflow of the treatment plant. In **AQUACYCLE**'s eco-innovative wastewater treatment system, this second alternative is determined by the third and last component in the treatment process, i.e. the solar disinfection unit. The first alternative applies to the demo-location in Spain where the treated effluent is first pumped to an existing reservoir that provides water for irrigation purposes. In both instances, this brings the opportunity to develop an in-built functionality of the WebGIS, which determines all areas that can potentially be reached by gravity flow. For obvious reasons, the use of gravity flow to reach the intended irrigation areas would *de facto* bring a more cost-effective solution among alternative scenarios for the reuse of treated effluent.

Water allocation priorities

The drawing up of a(ny) wastewater reuse action plan should give due attention to determine whether a portion of the treated effluent should be used to ensure the environmental minimum flow is maintained at all times of the year in a nearby stream or river as the case may present itself. Ensuring environmental minimum flow is a priority requirement in the context of the EU Water Framework Directive which requires water bodies to be restored and also maintained in good ecological and chemical status.

Microbiological quality requirements for wastewater reuse in agriculture

Only irrigation with water having less than 100 units of faecal coliforms (E. coli) in 100 ml is safe for the irrigation of crops that are eaten raw[4]. Typically, rivers show E. coli concentrations that are much higher than this, yet farmers can use it without any restriction in place. The EU Bathing Water Directive[5] establishes "excellent water" when it has less than 500 units of E. coli, considering it remains safe to swallow this concentration when bathing. Therefore, in comparison, the new regulation[4] is clearly adopting a highly 'safe' limit on the presence of E. Coli. With the notable exception of the Region of Murcia in Spain, the majority of wastewater treatment plants around Europe do not cater for tertiary treatment, i.e. disinfection. This makes it highly complicated for conventional treatment systems to comply with the requirements for the irrigation of crops likely to be eaten uncooked, such as lettuce and strawberries. Aside from this, also cultural or religious considerations and even public perception may bring a barrier to the use of treated effluent for the irrigation of this type of crops.

Feedback on initial prototype WebGIS and next steps

A first series of workshops addressed to decision-makers and treatment plant operators in which an initial, prototype version of the WebGIS was presented for feedback brought to the attention that particularly in Lebanon and Tunisia, there was a strong demand for training on the decision-support tool to be provided as part of our forthcoming project activities. In the forthcoming, second series of workshop the targeted audience will be farmers and local community representatives in the three demonstration sites, who will be invited to provide inputs towards the drawing up of treated wastewater reuse action plans. Aside from reuse in agriculture, applications towards urban 'greening' for the well-being of the community will be encouraged. This approach will bring insights into stakeholder preferences and also alternative scenarios for reuse applications. In a next step, these 'bottom-up' action plans for reuse will be compared in relation to their cost-effectiveness. Finally, decision- and policy-makers will be presented with our 'bottom up' approach and its outcomes in a final, third series of workshops.

Shifting the paradigm on treated wastewater

AQUACYCLE aspires to change the paradigm of viewing wastewater as an unsafe effluent, to that of an abundant all-year-round resource that has multiple uses. The authors consider that there are three key points influencing this ambition: 1) Scarcity of available fresh water resources which is set to worsen as a result of climate change, 2) Affordable cost of the wastewater treatment technology itself as well as of the capital and operational expenditure (OPEX) for the reuse of treated effluent and 3) Confidence in the treated water quality, not least among consumers and therefore among society as a whole. Keeping in mind that the required quality for reuse of treated effluent is stricter when it comes to growing food crops that are eaten uncooked compared to fodder crops or trees for urban landscaping, the latter aspect clearly links up with society's confidence in the entities that are responsible for overseeing the monitoring of treated effluent quality.

Within this overall context, the collection of 'bottom up' inputs to action plans for the reuse of treated effluent is designed to demonstrate how local communities can become active participants in the local planning process of their water and land resources.

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