Larhyss Journal, ISSN 1112-3680, n°51, Sept 2022, pp. 7-17

OPPORTUNITIES AND CHALLENGES FOR WASTEWATER REUSE IN ALGERIA

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Research Article – Available at http://larhyss.net/ojs/index.php/larhyss/index
Received June 5, 2022, Received in revised form September 5, 2022, Accepted September 7, 2022

ABSTRACT

The global water stress context urgently calls for the promotion of nonconventional water resources, including purified wastewater, to save the maximum volume of conventional water resources, as stated in Sustainable Development Goal 6 (Clean water and sanitation).

For instance, the objective of this paper is to assess the opportunities and barriers to implementing wastewater reuse in Algeria based on a specific literature review.

The results show that some pilot projects are already underway while various wastewater treatment processes are being tested throughout the country.

However, additional driver actions could be considered to optimize/generalize wastewater reuse at different territorial planning and/or development scales.

Keywords: Algeria, Sustainable Development Goal 6, wastewater reuse.

INTRODUCTION

Water issues are of critical concern in arid climates such as Algeria's. Indeed, the supply of a growing population, mostly urban, is becoming increasingly constraining and costly in economic and ecological terms (National Office for Statistics, 2020).

Algeria is also striving to deal with floods, contamination and persistent shortage risks through sea water desalination, drilling intensification and interbasin transfers. With regard to their long-term environmental impact, such measures would conflict with Sustainable Development Goal 6, which aims « to ensure safe drinking water and sanitation for all, focusing on the sustainable management of water resources, wastewater and ecosystems » (www.unwater.org).

Considering the annual volume of drinking water currently produced in Algeria (3.6 billion m^3/year), the average daily supply per inhabitant would be 65.7 m^3/inhabitant/year (i.e., 180 l/d/inhabitant) (MWRWS-a, 2020). In times of climate change, the water stress context urgently calls for the promotion of nonconventional water resources, including purified wastewater, to save the maximum volume of conventional water resources (Mostefa-Kara and Arif, 2013).

As shown in Fig. 1, the process consists of i) controlling the wastewater system, essentially domestic wastewater (gray and black water) and rainwater (green water), ii) draining, wholly or partly, toward the appropriate infrastructure for the purpose of their iii) purification/treatment/recycling process following benchmark norms and standards and finally iv) reuse or even reintroduce into the global water cycle (UN-Habitat and WHO, 2021).

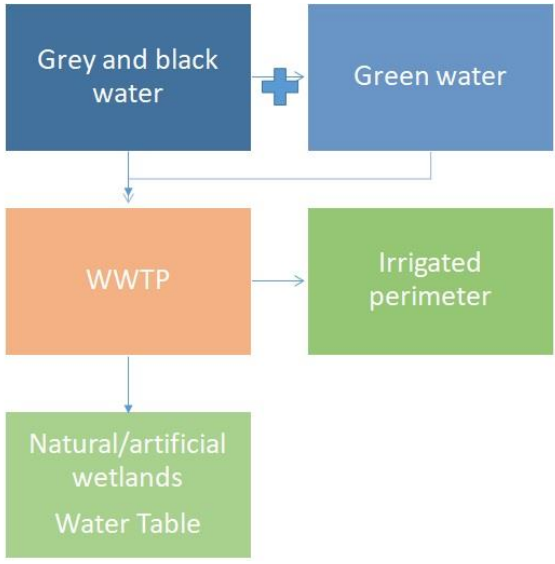

Figure 1: Wastewater reuse chain (after various documents)

Wastewater reuse (WWR) has notable environmental and socioeconomic benefits. It contributes to enhancing water autonomy, natural resource preservation, water-related cultural heritage and urban resilience in the face of hydrometeorological hazards and associated risks.

At the local/urban scale, treated wastewater can be used for i) watering public green areas (gardens, parks, and trees, including sports fields), ii) cleaning streets and washing cars, iii) supplying building sites, and iv) flushing toilets and fire hydrants (UN-Habitat and WHO, 2021; UNEP, 2021).

Opportunities to implement WWR may consist of the following two levels:

- The strategic level refers to i) the water policy consistency at different spatial and temporal scales and, consequently, ii) the cross-sector coordination and complementarity of respective development goals and iii) the sustainability of recommended solutions.
- The operating level strongly depends on i) the wastewater treatment plants' capacities, ii) the inflow and outflow quality, which should be in line with health, security and comfort norms for all life forms, and iii) the operating conditions regarding the location versus the production site, the transfer network, and types of use (e.g., electricity, heating/irrigation, public cleaning).

Ultimately, any WWR project is conditional upon two main items as follows:

1) its contextualization, which depends at least on i) local skills and know-how, including traditional knowledge and ii) the participation level of local communities.
2) its operationalization, which depends at least on i) the quantity and quality of circulating water flows and ii) the existence and performance of the appropriate infrastructure,

Thus, in short, essential prerequisites to implementing WWR are i) basic norms and standards, ii) appropriate infrastructure, iii) available separate budget and iv) committed actors with specific prerogatives, means and skills (UNEP, 2021; UN-Habitat and WHO, 2021; KUMAR et al., 2021).

In fact, in Algeria, treated wastewater issued from some wastewater treatment plants (WWTPs) performing secondary treatment based on activated sludge essentially benefits irrigation with respect to alignment with mandatory physico-chemical and biological norms (e.g., irrigated perimeters in western Algeria in the wilayas/departments of Tlemcen, Oran and Bord Bou Arreridj). In addition, a number of WWTP projects are under study throughout Algeria (e.g., in the wilayas/departments of Ghardaïa, Annaba, El-Oued).

The national WWR strategy also aims to generalize their reuse for municipal and industrial purposes (through standards, regulations, mandatory provisions) and to strengthen their introduction into the urban water cycle while optimizing the social-environmental benefits (public health, job creation, water quality preservation, water-related risk reduction/prevention) (MWRWS-b, 2020)

This paper's aim is to examine opportunities and barriers to implementing WWR as part of the sanitation system in Algeria. The method consists of a literature review referring to related legal texts and strategy against WWR requirements (i.e., policy, praxis,

infrastructure, budget, actors) and recommended health, safety and comfort norms and standards.

WASTEWATER REUSE STRATEGY IN ALGERIA (Infrastructure and Sanitation System)

From the Algeria Subscription to the World Convention on Sustainable Development in 1995, the national water policy definitely incorporated sustainable development principles (SDGs), SDG6 in particular, by promoting water saving measures, including wastewater recycling (Act No. 05-12). Accordingly, the collection, purification and reuse of domestic and industrial wastewater as well as rainwater and runoff are listed among the National Water Plan objectives, whose goal is to systematize water savings while reducing precious resource waste. It is planned to promote WWR by the rehabilitation/upgrading of WWTPs for secondary and even tertiary treatment processes from the perspective of their long-term potabilization.

The intended development of tertiary treatment will facilitate/encourage their use in vegetable garden irrigation, fish farming and some industries. Providing alignment with strict sanitary criteria, water potability is also envisaged through infiltration basins and groundwater recharge.

The existing sanitation system currently relies on 200 WWTPs and 47,000 km network lengths, so the rate connection to sewerage is 91% at the national level (MWRWS-a, 2020). Different processes and techniques (biological, chemical, physicochemical) are used to treat approximately 53% of the total volume of wastewater produced, i.e., 480 hm3/year, as shown in Fig. 2. Now, approximately 6%, i.e., 20 hm3/year, are reused for irrigation. The remaining volume of purified wastewater is transferred into natural (e.g., Wadis, lakes, Sebkhas) and/or artificial wetlands (e.g., dams) (MWRWS-b, 2020).

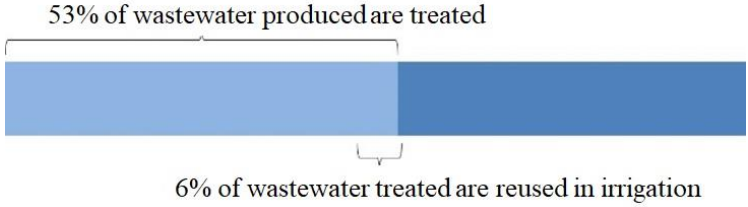

Figure 2: Percentage of wastewater treated and reused in Algeria (after MWRWS-b, 2022)

Some operating WWTPs, mainly located in northwestern Algeria, already contribute to irrigating almost 7900 ha of cultivated land (e.g., vines, olive trees, various fruit trees, wheat and barley). For instance, the Ministry of Water Resources and Water Security (MWRWS) is registering a continuous increase in irrigated areas based on purified wastewater despite a slow development of the sector, possibly due to various technical

constraints (e.g., irregular control of water quality, illegal industrial dejection, very strict health requirements/short number of authorized staff, lack of storage and/or pumping facilities, inadequate location of production vs. use sites) along with social barriers (e.g., vandalism and the general unwilligness of beneficiaries to contribute to covering expenses incurred) (MWRWS-b, 2020).

The use of treated wastewater for irrigation and watering requires i) formal prior permission, ii) the implementation of preventive measures (after a concession specifications document), iii) the maintenance of structures and iv) the regular control of water quality according to the physicochemical and biological specifications as defined by the Algerian Standards for WWR (N°17683) and the Technical Guide of Good Practices. As such, some wastewater uses are strictly prohibited in Algeria (e.g., irrigation of vegetable crops, grazing) (MWRWS-b, 2020).

Indeed, required preventive sanitary measures are prerequisites to both people handling wastewater and irrigated lands. Technical features of treatment systems are regulated according to the national standards from one hand and the final use from another hand either for agricultural, municipal or industrial purposes (Executive Decree No. 10-23).

As an additional precautionary measure, approximately 100 m spatial servitude is fixed in the vicinity of irrigated perimeters located near hydraulic structures, roads and/or dwellings (Executive Decree No. 07-149).

CONDITIONS FOR IMPLEMENTING WASTEWATER REUSE STRATEGY IN ALGERIA (BUDGET, ACTORS)

The implementation of the WWR strategy mainly depends on the sanitation system and existing infrastructure upgrading. A specific assessment program has been launched in several Wilayas/departments across the country to that end. Furthermore, the MWRWS invited academics and economic partners to develop innovative research promoting nonconventional resources, including treated wastewater, while improving water use efficiency and energy recovery from primary sludge (Aroua-Berkat, in preparation). For instance, pilot projects for energy (electricity) and/or biogas production as well as cros-season storage of purified wastewater are already underway in the wilayas/departments of Algiers, Blida and Annaba (MWRWS-b, 2020). As an example illustrated in Figure 3, the capacity of Beni Messous municipality WWTP (Wilaya/Dept of Algiers) is about to increase from 250,000 to 500,000 population equivalent. The resulting treated water is expected to be used by the municipality for cleaning roads and watering public green areas, including forests (MWRWS-b, 2020)

Figure 3: WWTP in the municipality of Beni Messous (Wilaya of Algiers) (www.amenhyd.com)

However, the space and time variability of the potential volume of purified wastewater produced appears generally difficult to control/predict due to a set of natural (e.g., water stress, low water period) and/or anthropogenic factors (e.g., transfer from the production to the exploitation site). According to the MWRWS, it therefore seems difficult to assess/concile supply and demand regardless of the final use (MWRWS-b, 2020).

Approximately one-third (~33%) of the budget dedicated to sanitation goes to the financing of WWR, which falls within the responsibility of the National Sanitation Office (Executive Decree No 01-102) and to a lesser extent to the National Irrigation and Drainage Office (Executive Decree N° 05-183).

The financial contribution of the agricultural sector is thus envisaged as well as that of other potential beneficiary sectors (e.g., local authorities and industries) (MWRWS-b, 2020).

That budget is dedicated to the construction and/or rehabilitation of existing infrastructure whose current capacity would be insufficient for various factors set out by the MWRWS as follows: i) a deficient organization (e.g., lack of cross-sector collaboration and/or coordination, noncompliance with norms and standards), ii) some technical failure (e.g., sophisticated complementary processes, lack of storage infrastructure), iii) the low support of end users (e.g., lack of communication and training), and iv) little funding (e.g., water supply remains a priority, high operating costs vs. benefits). For instance, the water sector is updating/reorganizing the legal and policy framework for cross-sector consultation and public–private partnerships (Executive Decree No 10-24).

DISCUSSION

The review of the sanitation system and WWR strategy in Algeria finally shows that the systematization of the wastewater recycling process may still be experimental although globally promising and quite necessary. Indeed, the reintroduction of treated wastewater into the production circuit in the form of nonconventional water resources and possibly biogas (renewable energy) is explicitly stated by water-related statutory documents. In the meantime, norms and standards, processes, infrastructure, necessary budget and actors in charge are formally designated. Consequently, it can be asserted that policy, economic and technical action drivers already exist in Algeria within the responsibility of public offices and authorities operating at the national level, such as the National Waste Management Office, the National Agency for the Promotion and Rationalization of Energy Use and the MWRWS. However, the question is how would the WWR strategy be concretely implemented locally?

WWR remains a government experimental pilot project, although it is cocarried by regional representatives across the country. Regional and local offices participate in the program implementation, each according to its prerogatives, focus area and own private partners. However, pilot projects still closely depend on public subsidies while deriving from a government decision-making process. In this regard, WWR projects do not appear to be technically feasible or economically viable at the local level.

Regarding water governance, cross-sector coordination proves to be of critical importance. It is one of the focal missions of the National Water Resources Advisory Board (national scale) and the Watershed Management Committee (hydrographic unit scale), which are also in charge of assessing the impact, feasibility and cost efficiency of recommended water-related measures. Both advisory bodies are composed of representatives from the government, the local assemblies, public offices, professional and/or users' associations (Executive Decree n°10-24).

In addition, it is worth noting that the national water strategy is planned at the river basin level through a Master Plan for the Development of Water Resources, while the land-use planning strategy considers administrative perimeters (Aroua, 2018). In that case, the promotion of a circular economy seems to be hard to apply, although officially adopted by all social-economic development sectors. Nevertheless, the water sector continues to strongly endorse the implementation of the Integrated Water Resource Management strategy, which is an asset for the promotion and development of WWR in Algeria.

Actually, the MWRWS seems to act in isolation, assuming the risk of inefficiency inherent in a similar approach. As an example, some policy documents related to energy transition and WWR are awaiting clarification regarding cross-sector synergy, regional solidarity and the consistency of various development programs in the short, medium and long term. However, the water sector calls for the participation of all public and private actors. According to the information authors have recently collected at MWRWS, it seems that the water sector has the necessary human means, knowledge and technical

expertise in addition to the national and international partner networks. However, it cannot fund the entire recycling chain on its own, including quality control, upgrading and/or building WWTPs.

Thus, the materialization of the following strategic principles proves to be comparatively confirmed in Algeria: i) the croos sectorality (i.e., integrated management, synergy, horizontal coordination), ii) the transversality of the governing process at different levels and planning/development horizons (i.e., national, wilayale/departmental and local, vertical coordination), and iii) the sustainability of recommended measures (i.e., promoting renewable resources, nature-based and low-tech solutions). Nevertheless, the implementation of the WWR strategy in Algeria is registering a prejudicial delay due to various factors, as cited above (i.e., lack of human, technical and financial resources). The main weakness seems generally due to disorganization and poor coordination between involved actors. Indeed, the sectoral approach persists, while private partners - little informed - remain reluctant to invest in the area. Now, the success of any WWR project relies on its contextualization, i.e., local actors are convinced, understand anticipated return and thus assume entirely.

CONCLUSION

This paper's objective was to assess opportunities and barriers to implementing WWR strategies in Algeria based on a literature review. The results show that despite some objective constraints and barriers, it can be argued that current texts governing the water sector are rather favorable.

Algeria is currently mainly supplied with groundwater. Indeed, dilling technology has facilitated the use of Albian aquifers at greater depths (350 to 500 m or more). The increasing water demand has already led to a costly overexploitation of this aquifer (including illegal drilling), resulting in a decrease in the water pressure in wells and the water table lowering in parts.

From an environmental point of view, the transfer of wastewater to a treatment plant (as well as the overflow of the sewage network) seems to constitute a critical issue as a potential source of contamination of the water table and possible serious damage to the natural environment (MWRWS-a, 2020).

Algeria, whose water resources are as precious as vulnerable, is also experiencing a rapid urbanization process, which is essentially concentrated in the north. Certainly, the abundant Albian reserve may lead to a belief in long-term water security but on the condition that risk contamination is strictly controlled. This objective can be achieved within the framework of integrated water resource management (IWRM) in parallel with the improvement/adaptation of land use and urban growth patterns.

Legal and political drivers (i.e., laws and decrees, regulations, norms and standards) do exist in fact, whereas cognitive/social-cultural, economic and technical drivers seem

generally lacking. Therefore, it can be recommended to consider three complementary drivers:

i) specific drivers related to the water sector (e.g., wastewater treatment level),

ii) cross-sector drivers supporting synergies between water and other sectors (e.g., the energy sectors for coproducing energy recovery from primary sludge),

iii) optimization drivers involving small industry, architecture, urbanism and land use planning referring to local sociocultural values and community ethics.

All these driver actions depend on the civil participation level (e.g., economic partners, local associations). According to the local customs and life patterns in Algeria, civil participation can take the form of public–private partnership, investment, and cash donations through the institution of *waqf* (dead hand), *zakat* (obligatory alms), *sadaqa* (spontaneous alms), volunteering, and donation/purchase of materials.

It is also worth noting that each action cited above simultaneously refers to several targets of the Sustainable Development Goals (SDGs), in particular SDG 3 Good health and well-being, SDG 6 Clean water and sanitation, SDG 7 Affordable and clean energy, SDG 11 Sustainable cities and communities, SDG 12 Responsible consumption and production, SDG 13 Climate action, SDG 14 Life beyond water, and SDG 17 Partnerships for the goals (Fig. 4).

Figure 4: WWR versus SDGs

In addition, Algeria can also rely on the expertise of national offices and associated regional affiliates, e.g., the National Waste Management Office, National Office for Water Resources and Renwable Energy Development Centre, among others, in setting/managing/maintaining larger facilities possibly powered from solar photovoltaic power plants and/or WWTPs producing biogas. Thus, local domestic and nondomestic water and energy needs could be partly met locally. Then, as a prerequisite, local technical skills should be strengthened through training workshops/stewardships as examples.

Finally, it is also necessary to insist on the need to prevent some critical risks, such as the following:

i) the abusive and wasteful consumption of a precious resource through the multiplication of legal and/or illegal drilling,

ii) the increase in the wastewater volume in proportion to the drinking water volume consumed, calling for a substantial increase in local treatment/purification capacities

iii) floods and various types of urban flooding that are difficult to contain *a posteriori* when quite possible to eradicate through some adapted urban planning and design patterns, e.g., a) prohibiting all construction in flood-prone areas as recommended by the traditional urban jurisprudence, b) adapting/transforming the layout of urban public areas and the road pavement surface if necessary to restore the natural infiltration and runoff rates of rainwater and floodwater toward the natural outlets.

Whatever the spatial scale considered (e.g., watershed, valley, city, district), the perspective of water autonomy and resilience in the face of climate change effects on the water cycle invokes i) the integrated management of water resources, which includes the qualitative and quantitative preservation of hydrosystems (surface and underground components) and all associated life forms (fauna and flora) in addition to ii) the prevention of hydrometeorological hazards and water-related risks.

To this end, it may be recommended that Integrated Water Resources Management (IWRM) i) incorporate the traditional tangible and intangible water heritage better adapted to the local context; ii) adopt ecological sanitation alternatives in a long-term approach (such as Waste Water Gardens); iii) support sustainable land use planning and urban design at the water basin or the bioregion scale while optimizing urbanization site locations; iv) be supported by the Water Sensitive Urban Design (WSUD) approach, whose main objective is to harmonize water use and land use patterns at different territorial scales.

Then, it would be possible to meet a greater percentage of water needs and purposes by relying on a more compliant and efficient water infrastructure and governance system.

Although no exhaustive feedback has been set up in the framework of the present paper, it is obvious that many WWR irrigating pilot projects and recycling processes, such as phytoepuration, are already experienced in Algeria (e.g., the Wilayas of Ouargla, Constantine, Laghouat, Biskra).

Therefore, the contribution of medium and small local companies is strongly recommended in developing low-tech processes adapted to the environmental/water and socioeconomic algerian context. Similarly, civil community participation and public–private partnerships should be enhanced through incentives since WWR and renewable energy-associated technology, especially solar and biomass, remain expensive.

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