JOURNAL OF COMPLEMENTARY MEDICINE RESEARCH, 2020
VOL 11, NO. 1
10.5455/jcmr.2020.11.01.45

REVIEW ARTICLE

Open Access

Managing the Innovative Water Supply in Urban Economy

Bagrat H. YERZNKYAN[1,], Karine A. FONTANA[2]

[1]Dr. of Sci. (Economics), Professor,Chief Researcher, Head of the Laboratory, Central Economics and Mathematics Institute, Russian Academy of Sciences,

[2]Candidate of Economic Sciences, Senior Researcher, Central Economics and Mathematics Institute, Russian Academy of Sciences, Moscow, Russia **JEL**: O32, R00 (A13, D43, D71, H42, L13, R58.

ABSTRACT

Research of prospects for achieving sustainability of urban water supply systems as an integral part of the urban management system in order to reduce pressure on water resources and ensure continuous access of the population to quality water through the formation of an effective water management system and innovative water supply.

Goal. Development of proposals for assessing the effectiveness of urban water management and highlighting the stages of the study of the feasibility of introducing innovative water supply from the standpoint of ensuring the sustainability of urban development in the direction of *“cities with water”* (i.e., the reuse of treated wastewater and the implementation of projects of automatic irrigation systems in the urban economy).

Method or methodology. Analytical and logical methods, theoretical developments on water resources efficiency management in their interrelation with other sectors of the urban economy were used. The methodology of the research is based on the provisions of the general theory of systems and institutional economics.

Results. It is shown that effective water management is an important element for overcoming the barriers to achieving sustainable development of the water sector and cities in general, as well as mitigating the negative impact of global trends. Suggestions are given for assessing the effectiveness of urban water management. Imperative requirements are formulated for integrating the water management complex into a single urban management system in order to smooth out the fragmented practice of managing various sectors of the urban economy that has developed in practice. It was emphasized that the achievement of sustainable urban development is impossible without innovative water supply - the introduction of the principles of a circular economy and the best available technologies in the urban economy. Automatic irrigation systems are an example of using the best available technologies for innovative water supply, which allow achieving significant savings in urban water resources, as well as use treated wastewater when irrigating urban areas. It is emphasized that such systems, with their proper design, installation and maintenance, can become an effective element in the environmentally sustainable development of urban economy in the direction of *“smart cities”, “cities with water”*, which also satisfy technological, social, environmental, economic, institutional, cultural requirements. It is shown that the practice of reuse of treated wastewater should be taken into account when developing a long-term strategy for the development of urban water management, taking into account socio-economic circumstances, environmental and climatic conditions, cultural and religious preferences, existing legislation, participation in international projects, as well as political readiness for their consideration and implementation. The constraining factors of the introduction of wastewater reuse and automatic irrigation systems (including those using treated wastewater) were highlighted -

ARTICLE HISTORY

Received February 23 2020, Accepted March 17,2020 Published June 25, 2020

KEYWORDS

Effective management, urban water resources, integrated approach, access to information, rational use of resources, innovative water supply, reuse of water, urban economy, sustainable development, circular economy, treated wastewater, automatic irrigation systems, water stress, legal and institutional framework, «*water hierarchy*», alternative water sources, environmental risks.

Contact Bagrat H. YERZNKYAN Central Economics and Mathematics Institute, Russian Academy of Sciences,

The lack of a clear policy defining wastewater reuse as part of water resources, the institutional framework for the implementation of such projects, reliable quantitative and qualitative data, limited financial resources, environmental risks, as well as the lack of culture of maintaining landscape areas, and the lack of specialists for designing, modernize and maintain such systems. Suggestions are given for conducting a comprehensive phased study of the feasibility of introducing the practice of reuse of treated wastewater and automatic irrigation systems, which takes into account not only the expenditure and return on such projects, but also provides the opportunity to assess the effectiveness of using both of them in conjunction with the environmental reasonableness of their application, cultural and historical aspects, social priorities, quality of life in the city, economy and budget of the city.

Scope of the results. They can be used by the executive structures of the municipal economy in the management of the city water management complex, as well as other state and local government bodies, in researches related to water supply and drainage, in the solution of ecological issues.

Conclusions. It is proved that sustainable urban development is impossible without rational use of water resources, taking into account the principles of the *"water hierarchy"*, building an effective management system and using innovative water supply with elements of a circular economy (reuse of treated wastewater and the best available technologies (in particular, automatic irrigation systems)) Achieving these goals is impossible, among other things, without the free exchange of information between participants in the water process, the objectivity and transparency of WR management assessments, taking into account structural and market drivers.

Proposals have been developed to assess the effectiveness of water resources management from the perspective of incorporating theoretical developments in the field of water supply into the general theory of city management and integrating water management strategic measures into the systemic practice of urban economy

It is shown that the reuse of treated wastewater is one of the alternative sources of water in regions with limited water resources, which should be considered as part of the *"water hierarchy"* and sustainable development of water management in the framework of water management. And the effectiveness of projects using TWW, incl. in AIS, reflects specific urban tasks, taking into account the expansion of urban boundaries, population growth; local legislation, financial opportunities.

The problems that hinder the expansion of the practice of reuse of treated wastewater and the wider introduction of automatic irrigation systems are identified. This is the lack of a clear policy defining wastewater reuse (RW) as part of WR; legal and institutional framework for the implementation of such projects; financial resources; environmental risks. Studies related to water RW are complicated by the lack of reliable quantitative and qualitative data, their fragmentation, and often their closeness. As for the AIS, one of the limitations of the wider implementation of modern AIS (including the use of TWW) is due to the lack of a common culture and knowledge of public officials about the advantages of these systems and the lack of an appropriate structure for their further operation and modernization.

Definitions are given to understand the content of the work. Other terminology may also be found in studies of other authors, which is also correct.

Automatic irrigation systems (AIS) - systems that are an engineering complex (engineering equipment with varying degrees of automation - from a simple timer to remote control using specially developed IT technologies for such systems), designed to supply water to plants in conditions of limited rainfalls and providing for an accurately calculated volume of water for irrigation each kind of plants (water consumption is calculated on the basis of the evapotranspiration coefficient [2].

Reuse of water (RW) - the use of water, coming from treated urban wastewater (domestic wastewater or a mixture of domestic graywater and industrial wastewater, located within city borders and having a common collection system) of a certain quality, intended for it further use in limited applications taking into account legislation and potential risks to public health and to the environment.

Direct RW refers to the supply of treated wastewater to the consumer using appropriate infrastructure, in particular, a dedicated pipeline.
Indirect RW refers to the withdrawal of water from natural water sources for subsequent use, where previously (partially) treated effluents were discharged.
The planned RW refers to systems organized for the supply and use of treated wastewater, in accordance to their further use.
Unplanned RW refers to uncontrolled RW of wastewater after discharge into natural reservoirs.
This work refers to the planned direct RW of treated wastewater (TWW).
Urban sustainability is a complex, multifaceted concept aimed at prosperity, successful development of the city, improving the quality of life of citizens, which cannot be solved without recognizing the relationship between different urban functions and systems. In the work, sustainability is understood in a broad sense, including the environmental component, i.e. incorporation into the development strategy of urban economy (UE) "environmental requirements as its most important organic component, along with requirements of a different kind - socio-economic, technological, cultural and historical, etc." [14].

INTRODUCTION

In conditions of increasing water stress, one of the important directions of water policy is to achieve the sustainability of the functioning of the urban water sector (UWC) and to develop measures to reduce the existing and prevent the predicted pressure on water resources (WR), on one hand, and ensure population's continuous access to high-quality water, on the other.
Achieving these goals implies, among other things, effective management of WR, the implementation of a multi-level, coordinated approach to managing WR as an integral part of urban economy (UE) management, taking into account the principle of *"water hierarchy"* [5]. According to this principle, saving water should be a priority, based also on a wider introduction of innovative water supply. Additional water supply methods should be considered as options when the possibilities for increasing the efficiency of water use have been exhausted. For example, when the demand for water exceeds the supply and capacities of the UWC, it is necessary to plan an additional water supply infrastructure, namely, the WR TWW (which is an important element of the circular economy).
Blueprint to Safeguard Europe's Water Resources emphasizes the need to promote the effective use of WR and reduce pressure on the aquatic environment through effluents reuse [6]. This concept was developed in the report of the European Commission, *Communication "Closing the Loop – an EU Action Plan for the Circular Economy"*, which emphasizes: "in addition to measures to increase the efficiency of water use, the use of treated wastewater in a safe and cost-effective environment is a valuable but unused means of increasing water supply and mitigating pressure on over-exploited water resources in the EU" [4].
In the context of the topic under consideration, the authors emphasize the issues of effective management of urban WR and innovative water supply, including the introduction of the principles of a circular economy (namely, WR TWW) and the modern best available technologies (BAT) (namely, automatic irrigation systems (AIS) in the UE).

Effective WR management is a key topic on the global agenda and is a prerequisite for sustainable development of cities, "*Water Wise City*". A feature of such cities is, on one hand, the full restoration of resources in wastewater treatment systems and the development of the principles of a circular economy, on the other hand, the inclusiveness and coordinated interaction of all interested parties, which contributes to integrated decision-making.
Effective management of WR also implies coordination of strategic decisions regarding WR with decisions in other sectors to eliminate potential contradictions in city development strategies; minimize environmental damage within and outside the city; ensuring social justice and economic efficiency; and reliable water supply of the city.
An important condition for the implementation of effective WR management is the free exchange of information between participants in the water process, the objectivity and transparency of WR management assessments. Such assessments should represent a process of dynamic, continuous analysis and take into account *structural drivers* (causing shifts in the management paradigm of WR - the state of the environment, demographic trends, technological progress) and *market drivers* (pushing for the development of new management approaches - shortage and pollution of WR, political reforms, financial constraints) [11]. Such assessments contribute to a better understanding of the current state of the WR management system and provide an opportunity to analyze the adequacy of existing management tools to solve the tasks and the effectiveness of the implementation of the developed plans; to establish WR management priorities during different time intervals; to determine the financial needs and sources of financing to achieve the sustainability of the city's water storage complex, etc.
Integrating the stages of conducting such assessments presented in [15], we list them:
Definition of "*stakeholders*", including the circle of

institutions contributing to the management of WR, water end users, public and scientific organizations. Building a database[1] (including the collection, processing, diagnostics, storage of information) and the selection of a "*leading organization*"[2] to coordinate these processes.

The choice of indicators that should act as a link between data and management decisions makimg (for more details on "*water resource indicators*" see [7]).

Development of an "*action plan*", which should reflect the current situation, goals, priorities, method of achievement, the degree of intervention at the current, medium and long-term stages [2]. The "*action plan*" should be coordinated with the city development strategy in order to achieve the efficient use of the resources forecasted in the city programs.

Monitoring to identify the impact of policies in the water sector on other areas of the city system; informing "*interested parties*" of the correctness of the decisions made, the need to adjust the "*action plan*" and determine the degree of intervention.

Definition of a "*financing plan*" for understanding, from which sources the achievement of goals will be achieved. The "*financing plan*" should be coordinated with the "*action plan*".

Ensuring access of "*interested parties*" to the results of evaluations.

Innovative water supply refers to the provision of water to the population of the city and UE using the latest achievements in the field of knowledge and technology economics related to the sustainable development of UE, taking into account the *institutional* and *technological* components. The first includes the rules, regulations, standards, without which the implementation of technological solutions cannot be applied, the second includes technological solutions concerning new technological structures and which can find application in the water management system (WMS) and UE [14].

An example of the implementation of the technological component of innovative water supply can be the search for solutions to improve water treatment technologies (for its further RW) to a level where this process becomes less expensive compared to existing treatment systems; introduction of a *looped system* of water supply, which is characteristic of a circular economy. In such systems, the use of water is cyclical, which contributes to a higher efficiency of its use [3]. Another example is the introduction of BAT, allowing the rational use of WR in the UE, for example, AIS with the possibility of using TWW in them

RW TWW. Innovative water supply defines sewage as an important resource, which can be a reliable source of water of a certain quality in the required volume. RW TWW[3] can have a beneficial effect on the environmental situation by reducing wastewater discharge and water extraction from natural water sources; contributing to saving of fresh water (in applications where water quality requirements can be reduced) and fertilizers (reclaimed water contains organic carbon and a number of nutrients, so less fertilizer will be required for plants growth), as well as financial means (traditional wastewater treatment involves removal nitrogen and phosphorus, which is an expensive process that can be eliminated if water is reused for plants irrigation).

The effectiveness of such projects is a reflection of specific urban tasks, therefore, the RW of TWW should be considered as part of the integrated management plan for WR within the framework of the sustainable development of the urban water supply complex, and the decision on the RW of water should be based on the results of a system analysis, assessment of the effectiveness of WR

[1] An example of collecting and processing city data is the Boston City Score platform, launched in 2015 (City of Boston, City Score, https://www.boston.gov/cityscore) - an online tool that allows you to accumulate city information, reflecting the effectiveness of Boston as a city and its governance system. In particular, the platform allows you to evaluate data on 21 indicators and make a comparison with target indicators. The city's website publishes relevant reports for the past day, week, month and quarter, so that everyone can get acquainted with relevant information on the effectiveness of city management. A similar platform is also implemented in Los Angeles, New York and Houston.

[2] In Russia, there was a situation where the intersection and duplication of powers of executive authorities in the management of BP, the lack of a single coordinating body led to the fact that the country does not have an effective management system and a single approach in the field of military equipment [Tsvetkova L. Ecology: A textbook for students of higher and secondary educational institutions studying in technical specialties and directions. / L.I. Tsvetkova, M.I. Alekseev, F.V. Karamzinov and others; under the general. ed. L.I. Flower. M.: ASBV; SPb.: Khimizdat, 2007. - P.98 (in Russ.)], and the exchange of information between these structures is incomplete and often has a closed departmental character.

[3] TWW can be used when watering lawns, flower beds, golf courses; flush toilets; washing roads, vehicles, windows; mixing pesticides and herbicides; in air conditioning systems; fire protection; construction (dust control, concrete production), etc.

management and alternative water supply options (in including the base - "do not change anything").

Projects involving WR TWW should include the development of standards and requirements for the quality of TWW, the definition of areas (applications) of use and be aimed at improving the environmental situation in the city, including reducing wastewater discharge into water bodies.

The economic effect of the implementation of the RW TWW projects is greater when the existing water supply system is out of date, it is planned to carry out capital work on its reconstruction or to construct new micro districts (which implies the organization of the corresponding infrastructure[4]). In addition, it makes sense to consider wastewater treatment projects when a modern wastewater treatment system is already operating near the city, so the costs of improving and modernizing wastewater treatment plants will be minimized.

AIS in the environmentally sustainable development of UE. As noted earlier, environmental sustainability in relation to the development of the urban water economy means incorporating it into the strategy of environmental requirements as its most important organic component, along with socio-economic, technological, cultural and historical components. Such development is a concrete expression of the practical application of the environmental imperative, which serves to express the idea of the desired state of society, "capable of ensuring the development of civilization within the given environmental conditions within the framework of the environmental imperative" [10].

Bearing in mind the requirements of the environmental imperative, AIS occupy a very noticeable niche in the developed countries' UE and are widely used in watering parks, lawns, flower gardens and other municipal territories, as well as sports grounds, golf courses. With proper design, installation and maintenance, AIS can become an effective element in the environmentally sustainable development of UE in the direction of "*cities with water*", which also meet technological, social, environmental, economic, aesthetic requirements. The software component of the AIS allows them to be integrated in the implementation of the concepts of "*smart city*" as an element of the city's WR management.

In their economic essence, AIS are private goods, the consumers of which can be representatives of business, government, society both inside and outside the city[5]. Policy makers and local authorities responsible for UE can use AISs to produce social (collective, locally public) goods, such as urban green landscapes. In this understanding, AISs, being private goods, can act as factors in the production of social goods.

Modern AISs can significantly reduce the amount of water compared to traditional types of irrigation, allowing to solve the problem of saving WR[6] [9]. The environmental advantage of AIS in the UE is that they provide additional air humidification, which is important for maintaining the microclimate and ecological background of the city (where the only way to solve the problem of air pollution («*micro particle pollution*») is to humidify and green the urban environment) [13].

Implementation of AIS projects in the city also allows saving energy and fuel (as opposed to irrigation vehicles), rational use of labor resources (urban AIS can be managed through a single dispatching center connected to city weather stations, which avoids switching on AIS during precipitation or immediately after their end)).

The use of TWW in such systems gives an additional economic effect due to the reduced use of fertilizers, which, along with the environmental benefits mentioned above, makes the use of TWW for irrigation of urban areas an attractive solution.

Watering using AIS is widely used in developed countries, especially in arid regions with a high rate of water stress, where in the summer months urban water consumption can increase by 40-60% due to landscape watering. In these situations, TWW RW can reduce drinking water consumption by up to 50% [9]. In addition, there is an increasing practice when residential complexes and business centers are equipped with local wastewater treatment systems (excluding sewer) for their on-site RW, in particular in AIS. Similar practices are widespread in Japan and the United States.

As for Russian cities, we have to admit a lack of culture of maintaining landscape areas using modern BAT, as well as innovative water supply. This means that the decision on the introduction of AIS, especially with the use of TWW, turns out to depend not only, and probably not mainly, on the available budget and confidence in the economic benefits of implementing such projects, but on the behavior of public officials, whose actions can be both competent or not, not to mention the

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[4] These statements are based on the fact that WR TWW provides for the organization of a double distribution system with a network of water pipes for the supply of TWW to the consumer, parallel to the drinking water supply.

[5] The paper considers the intracity segment of the TSA market - the segment "residential & commercial" (ResCom), focused on the needs of the population and the needs of commercial and municipal entities, including in the field of sports located within the city.

[6] The principles of the "water hierarchy" in practice using BAT.

temptation to obtain personal advantages from the taken decision. Such behavior (*"rent-seeking behavior"*) can become a real obstacle to the implementation of AIS and RW TWW.

Stages of the study of the feasibility of the projects of RW TWW and AIS. Despite the positive prospects of projects using AISs in the UE and their incorporation with the principles of the circular economy (RW TWW), it is necessary to develop a scientifically based methodology that allows substantiating the effectiveness of the application of RW projects TWW and AIS, including using TWW.

As for projects of RW TWW as themselves, their economic feasibility (*Treated Wastewater Reuse*) is still not well understood. The main reason is that the internal and external economic consequences of the implementation of such projects cannot always be quantified appropriately [12]: while the internal consequences can be converted into monetary units, external factors require the use of specifics economic methods to assess their quantification.

We see the need for a comprehensive study in this area, which would take into account not only the cost and cost-effectiveness of such projects, but would also provide the opportunity to assess the effectiveness of the use of both AIS and RW TWW in the UE in conjunction with the environmental reasonableness of their use , cultural and historical aspects, social priorities, the city budget, investment projects, etc.

Conducting such studies and their results are, first of all, relevant for city structures where projects are financed from the city budget and a feasibility study of the project's effectiveness is required. The research results can also be used in developing strategic decisions aimed at the effective management of WR and the integration of water supply system into a single city management system in order to achieve the environmentally sustainable development of UE in the direction of "*smart cities*", "*cities with water*".

We outline the following stages of such a study:

Conducting feasibility studies (FS) taking into account the geographical, regional, climatic, aesthetic, cultural, historical and other features of the city, as well as the coefficient of water stress. FS allows you to identify issues related to RW TWW and AIS and pre-evaluate if the projects are a viable solution to the tasks.

Assessment of the WR market and its demand for water of specific quality, taking into account alternative water supply options (including the basic one - "do not change anything") for comparisons. As alternative projects, those that are actual and perspective for the development of city WR need to be verified, if they are feasible from a technical, political and juridical point of view.

Identification of the areas of potential use of the RW TWW/AIS and requirements for water quality. Taking into account the requirements for the level of wastewater treatment and its quality, BAT and methods for wastewater treatment should be determined; parameters of the water distribution system and parameters of connection to it for consumers, etc.

Defining the scope of legal identification, bearing in mind that partnerships between various structures, commercial and state enterprises may require the creation of a so-called "service area" through the jurisdiction of the organizations participating in the project, which can help reduce potential costs.

The development of a model apparatus to justify the need for the implementation of RW TWW and AIS in the UE. The results of this stage will provide a scientific justification for the need to implement similar projects in cities, taking into account their characteristics and the experience of other cities. The model apparatus should provide for the possibility of its adaptation to the UE of various cities, taking into account the available statistical base, current regulations, and local legislation. Therefore, for practical use, models must have an open architecture in order to provide the possibility of building up functions, increasing the adequacy, and increasing the accuracy of the description of real modeling objects.

Conducting an economic assessment of "cost-benefit[7]" (The Cost Benefit Analysis). Such an assessment will determine not only the financial benefit, payback period, taking into account the costs of the development and implementation of projects, their subsequent operation, but also to assess other cash and non-monetary costs and benefits both for the place of direct implementation of the projects and the surrounding region for a certain period planning. In particular, when assessing the non-monetary value of a project, environmental and social costs and benefits are taken into account after a certain period of time. For potential investors, financial analysis is the most effective, helping to decide on participation in the project and developing an investment strategy. As for decision-making at the city level, in addition to the results of financial analysis, it is important to assess the social and environmental consequences of the implementation of such projects, which is consistent with the goals of decision-making aimed at improving the quality of life and the well-being of

[7] See also: Greywater Reuse in Urban Areas A dissertation submitted by Mark Wiltshire University of Southern Queensland, Faculty of Engineering and Surveying, 2005; Economic Evaluation for Water Recycling in Urban Areas of California by Rhodora Narvarte Biagtan Bs (University Of California, Davis), 1993, Mba (University Of California, Davis) 2007.

citizens, preserving natural resources and natural environment.

Assessment of the impact of RW TWW and AIS on the index of quality of life and possible potential negative impacts on the environment using quantitative and qualitative indicators. Within the framework of the study, it is possible to consider a similar effect on the quality of life index according to the criteria proposed by the OECD [8]and monitor the dynamics of this index to assess the socio-economic efficiency of the use of RW TWW in the UE as a whole, and in particular in conjunction with AIS.

The choice of the discount rate to control costs and benefits when taking into account the time value of money. The size of the rate may depend on several factors, including inflation, state policy on price regulation, the introduction by local authorities of additional measures to stimulate investment and preferential tariffs, etc.

Development of a methodological apparatus for choosing an effective option for attracting private investors and their further participation in co-financing projects at various stages of its implementation, including in the frame of realization of urban beautification and landscaping programs, national and local environmental programs. This stage should include an assessment of the effectiveness of municipal-private partnerships in such projects.

The definition of financing sources is one of the main questions, as involving private investment is a serious task for the realization of such projects, even if in most of cases the viability of a project depends mainly from the political will and from the state or local financing.

It should be noted that no matter how carefully the calculations are made, the situation is assessed at each stage, decisions are still made under conditions of uncertainty, because not all parameters involved in the analysis can be forecasted. Analysts are forced to resort to subjective assessments of these parameters for the future or use various combinations of *"forecasted variables"*. Therefore, decision-making in the face of uncertainty should be separately analyzed, and decision-makers should have a vision of the possible consequences when making certain decisions. In this case, the experience of other cities can be used to assess potential risks and identify possible ways to overcome them.

On the whole, the success and effectiveness of the TWW and AIS projects using TWW, within the framework of sustainable development of urban water supply systems, reflects specific local tasks and priorities, meeting the demand for water resources in the face of growing water stress and environmental degradation in cities; solving socio-economic problems, taking into account the expansion of city borders, population growth; local legislation, financial opportunities, the effectiveness of urban WR management, taking into account the principles of the *"water hierarchy"* and the inclusion of the population in solving urban problems, etc.

Therefore, it is important to use all available potential in the discussion, evaluation and implementation of such projects, in particular: professional and human resources; legislative and legal framework, system of subsidies and discounts; institutional development and organizational management; expanding the range of financial services; raising public awareness; scientific potential.

Final remarks. WR management must be carried out in various directions, taking into account the principle of "*water hierarchy*". Namely, by reducing the specific consumption of WR, reducing water losses during transportation and delivery to consumers, using innovative water supply with elements of a circular economy - in particular, WR TWW and AIS.

At the same time, one of the important directions of water policy is to achieve the sustainability of the functioning of the water and wastewater treatment complex and develop measures to reduce pressure on water resources and ensure continuous access to quality water.

Achieving these goals implies, among other things, effective WR management, which is impossible without the free exchange of information between participants in the water process, objectivity and transparency of WR management assessments, taking into account structural and market drivers.

Currently, in almost all countries there is a practice of "unplanned indirect RW", which the population often does not know about. And in the absence of information about the benefits of the "planned direct RW TWW", the population continues to have a negative attitude to the use of TWW. On the other hand, policymakers do not always take into account RW as an element of the "*water hierarchy*" in managing WR and developing a sustainable development strategy for water supply, which should be based on the principle "*for different purposes - different water*" (formulated in 1958 by the Economic and United Nations Social Council).

The effectiveness of projects using TWW, incl. in AIS, it is a reflection of specific urban tasks, meeting the demand for WR in the face of growing water stress and environmental degradation in cities;

[8] OECD Environmental, Outlook to 2050, OECD Publishing, OECD. – 2012

solving socio-economic problems, taking into account the expansion of city borders, population growth; local legislation, financial opportunities, therefore, the RW of TWW should be considered as part of a plan for the integrated management of WR within the framework of sustainable development of urban water supply, and the decision on RW should be based on the results of a system analysis, assessment of the effectiveness of WR management and alternative water supply options (including basic - "do not change anything").

However, the expansion of RW practices is facing a few regulatory, economic, social and institutional problems. In particular, the lack of a clear policy defining wastewater RW as part of WR; legal and institutional framework for the implementation of such projects; financial resources; environmental risks. Studies related to RW are complicated due to the lack of reliable quantitative and qualitative data, their fragmentation, and often their closeness.

As for the AIS, one of the limitations of the wider implementation of modern AIS (including the use of TWW) is due to the lack of a common culture and knowledge of officials about the advantages of these systems, as well as an appropriate structure for their further operation and modernization.

The authors made suggestions for conducting a comprehensive phased study, proposing relevant proposals to justify the need and prospects for the application of the RW TWW and AIS projects (using TWW). The work emphasizes the importance of conducting a comprehensive study in this area, which would take into account not only the net costs of expenditure for such projects, but would also provide the opportunity to evaluate the effectiveness of using both AIS and TWW in UE in conjunction with the environmental reasonableness of their use, cultural and historical aspects, social priorities, the city budget, investment projects.

In the context of growing environmental problems around the world and aggravation of global challenges for humanity in the field of water supply, Russia still does not pay enough attention to the issues of the rational use of WR, in particular in the UE, the search for alternative ways to supply water (for example, TWW) and water saving through a wider use of AIS (which may including use of TWW). In the Russian Federation there are a number of problems of a general nature, requiring the adoption of large-scale measures of current and long-term nature in the field water use and supply organization and of integrated planning and effective management of WR, the introduction of innovative water supply technologies using the principles of circular economy and BAT.

We emphasize that in order to achieve positive results in the rational and efficient use of WR, the uninterrupted supply of clean water to the population, it is necessary to provide for a set of interrelated measures implemented jointly by state authorities and local self-government, private business, the financial sector, and scientific organizations. It is necessary to bring the concept of RW, including in AIS, in front of politicians, officials directly involved in managing WR, start an open discussion involving the public and explaining the benefits and risks of such projects.

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