Evaluation results of the wastewater treatment system of small settlements in Syria

M A Saied and N S Serpokrilov

Don State Technical University, 1, Gagarina square, Rostov-on-Don, Rostov Region, 344002**,** Russia**.**

E-mail: e-ms-87@hotmail.com

Abstract. The results of the environmental evaluation show the deterioration of water quality in the main river basins of Syria as a result of untreated domestic wastewater or insufficiently treated wastewater, commercial and industrial wastewater from certain activities. The sewage system, especially in small settlements, suffers from several problems such as: long sewer lines, errors in the design of treatment plants and the choice of treatment method, lack of qualified personnel, frequent power outages, large fluctuations in the flow and concentrations of wastewater pollution. 98% of treatment plants in small settlements operate with extended aeration activated sludge, which does not meet their requirements and does not provide high efficiency of wastewater treatment. One of the recommended solutions for the development of a wastewater treatment system in small settlements in Syria is considered rotating biological contactors RBC, which are the best option and most meet their requirements.

1. Introduction

According to statistics, most human activities using water produce wastewater. As the total demand for water increases, the amount of wastewater generated and the general pollution of the world are constantly growing. More than 80% of the world's wastewater and more than 95% in some least developed countries are disposed of without treatment. As a rule, after discharge of wastewater into water bodies, they either weaken, either migrate to the riverbed, or seep into aquifers, where they can affect the quality and, consequently, the availability of fresh water reserves [1]. In Syria, focused efforts have recently been made to treat wastewater and its reuse, which helps to improve conditions and prevent health disasters in addition to the importance of reusing treated water for various purposes, since Syria lacks water resources.

These efforts have become urgent due to the recent deterioration of the environmental situation in Syria. As the results of the environmental evaluation show that wastewater is usually discharged into rivers, lakes and dams, which are often used for irrigation, as sources of drinking water or to feed groundwater. It is known that developed countries began to move to wastewater treatment for more than a hundred years, but the experience of Syria in this area began only a few years ago [2]. Although sewer networks have been implemented in many cities and towns, there has always been a significant deficit in the number of treatment plants, especially in small settlements, since the percentage of the population served by sewer networks in urban areas is 95%, while only 46% in rural areas. The number of people served by wastewater treatment plants, according to 2004 statistics, is estimated at only 24%. Accordingly, the tenth and eleventh five-year plans in Syria have allocated a huge budget

for the development of the water supply and sanitation sector and the achievement of a number of goals by 2020, the most important of which are:

a. Sustainable management of drinking water sources, ensuring safe and clean drinking water for present and future generations.

b. Reduction of physical and administrative water losses.

c. Reimbursement of operational and maintenance costs for drinking water and sanitation services.

d. Reuse of wastewater in other manufacturing sectors [3].

2. Relevance and objectives

After several years of the implementation of the tenth and eleventh five-year plans, there is an urgent task to analyze the current state and evaluate the design and operation of the wastewater treatment system in small settlements and develop recommendations and solutions for its future development.

3. Evaluation of the public water quality in Syria and its main sources of pollution

Table 1. The study results of the main sources of water pollution and its quality problems

Name of the basin (province)	Water pollution problems	Major pollution load
Barad and Awaj basin (Damascus and its environs)	• Pollution of surface water used for irrigation.	• Domestic and commercial wastewater. • General factories with a lot of contaminating loads.
	• Groundwater pollution for irrigation and water supply.	• Leakage of river water contaminated by household, commercial, and industrial wastewater. • Leakage of irrigation water taken from surface waters contaminated with domestic, commercial and industrial wastewater.
Assi River Basin (Homs, Hama, and Idlib)	Surface water pollution.	• Domestic and commercial wastewater. • Public plants which have a huge amount of polluted loads.
Coastal basin (Latakia and Tartus)	Pollution of water sources for water supply.	• Liquid waste from olive presses that are small and widely scattered. • Domestic wastewater treatment plants and untreated domestic wastewater.
	Marine pollution (bacterial pollution).	• Untreated domestic and commercial wastewater.
Al-Belih and Al-Khabur River Basin (Al-Hasaka)	Pollution of irrigation water sources.	• Domestic and commercial wastewater.
	Water pollution in the environment.	• Public factories with a lot of contaminated loads.
Euphrates river basin ((Aleppo - Quick river) and Raqqa and Deir ez-Zor).	Pollution of irrigation water sources.	• Domestic and commercial wastewater.
	Water pollution in the environment.	• public factories with a lot of contaminated loads.
Yarmouk basin (Daraa, Sveida and Kenitra).	Groundwater pollution.	• Domestic, commercial and industrial wastewater.

Most of the territory of the Syrian Arab Republic consists of desert hills, and due to the lack of rainfall in this country there are not enough water resources. The rapid increase in outflows from rural areas and the transition to industrialization led to water shortages in urban areas [2, 4]. The Syrian government is trying to solve the environmental problems associated with water and achieve a water supply level of up to 100%. Therefore, from the very beginning, it is planned to develop sewer systems and treatment facilities to control water pollution, enhance the use of water resources and restore the cost of sewer work. The Syrian government called for the renewal and revision of the main provincial plans in this area, however, the lack of specialized offices in the relevant ministries led to strong pressure on them, so the Syrian government requested technical assistance from the Japanese government.

The Japan International Cooperation Agency (JICA) sent a research team to Syria and prepared a detailed report on Syrian environmental reality. This report is considered the cornerstone of Syria's sewer system development plan. The study area included six major river basins in Syria. The results of the environmental evaluation and the study of water quality in the main river basins of Syria indicate a significant pollution of surface and groundwater as Table 1 shows. This occurs as a result of untreated domestic wastewater or insufficiently treated wastewater, commercial wastewater from enterprises, and also the leakage of industrial wastewater from certain activities, such as olive presses, meat processing plants, paper mills, tanneries.

Industrial wastewater are characterized by high concentrations of organic contaminants of BOD and ammonia nitrogen NH_4-N. The value of BOD of industrial wastewater from olive presses and breweries reaches 10,000 mg / l or more. At the same time, in paper mills, meat processing and yeast plants, it is 2000 mg / l and in milk processing and tanneries 800 mg / l, NH4-N values in industrial wastewater from olive presses, tanneries and yeast reaching more than 200 mg / l [4]. From here we conclude that it is important to increase the efficiency of treatment plants and to intensify the biological treatment process. The latter process contributes to the removal of organic substances and nitrogen compounds in wastewater through the development of new methods and technologies and more advanced construction structures in order to obtain high-quality treated wastewater and reduce pollution from water resources.

4. Evaluation of the current state of the wastewater treatment system in small settlements in Syria

Repeatedly, many problems arose in connection with sewage treatment plants in Syria, especially in small settlements, in terms of choosing the treatment method, designing and operating plants. Therefore, the Syrian experience in the field of wastewater treatment was unclear, without a clear or thought-out strategy or giving the designer the freedom to choose a treatment method and the required degree of treatment [2, 5]. The most important wastewater treatment problems for small settlements in Syria are:

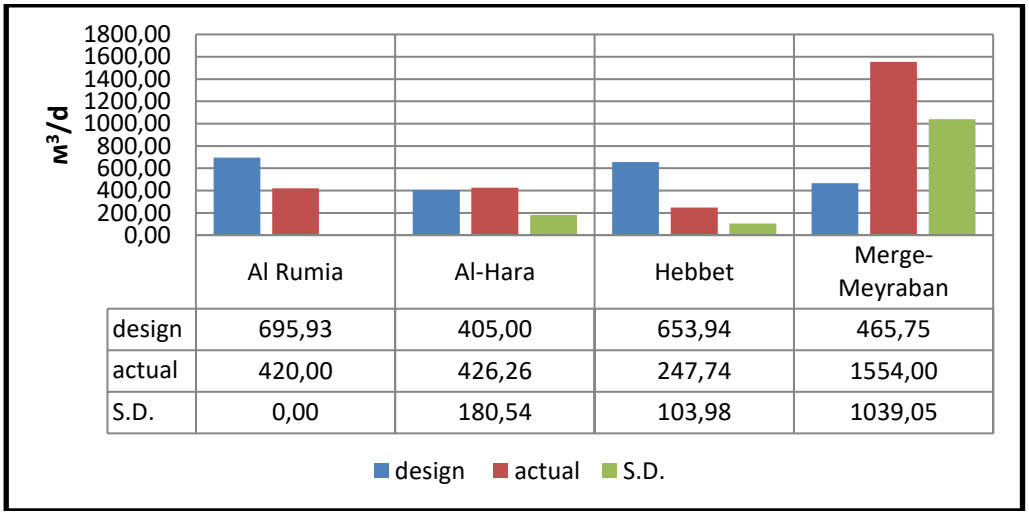
- The use of centralized wastewater treatment plants for wastewater treatment, which require very long sewage lines with tens of kilometres to transfer wastewater from scattered communities to wastewater treatment plants, which leads to high costs for the construction of long sewer lines.
- The process of transporting wastewater over long distances leads to a change in the characteristics of wastewater, and as a result, the design of the treatment plant by the calculated values is greater than the actual values and, therefore, increases the costs necessary for the construction of plants and the acquisition of larger land areas.
- Lack of qualified personnel for the operation of treatment plant equipment.
- Frequent power outages, especially in emergency situations in the country.
- Relatively high pollution loads and large fluctuations in wastewater flow rates and concentrations of pollutants.
- Problems associated with the choice of wastewater treatment method, since three methods have been identified for wastewater treatment in Syria: conventional activated sludge, biological filters and activated sludge with extended aeration. Conventional activated sludge is not applied in

practice to small settlements, and biological filters do not provide high processing efficiency compared to extended aeration. The extended aeration method was adopted as a single strategic option for wastewater treatment in small settlements, where studies show that the generalization of this method is 98%, without taking into account a few exceptions. At the same time, various types of other suitable methods and modern solutions for small settlements with small cost and simple operation, suitable for the conditions of developing countries, have not been adopted, such as biological treatment with attached biofilm on submerged inactive biomass carriers or rotating biological contactors [2, 5].

5. Evaluation results for the design and operation of wastewater treatment plants in small settlements

The results of evaluating the effectiveness of the design and operation of wastewater treatment plants in small settlements in Syria using the activated sludge with extended aeration method showed significant problems in their design and operation, which are as follows:

- The lack of flexibility of this method, since a large discrepancy between design and actual parameters leads to the design of plants larger or smaller than the required size. Figures 1, 2 and 3 show the results of comparing design and actual parameters with the standard deviation values at four treatment plants in the city of Latakia: Al-Hara; Hebbet; Al Rumia; Merge-Meyraban.
- High energy consumption, especially since aeration tanks consume about 80% of the electricity needed for the plant.
- Poor process control due to lack of qualified personnel.
- Long and continuous operation of aerators and pumps leads to frequent malfunctions of these devices, which can lead to high costs for operation and maintenance.
- The method is incompatible with any changes in future legislation.
- Treatment efficiency is very sensitive to changes in concentrations and fluctuations in wastewater flows, especially those resulting from demographic changes in some areas due to emergency situations in the country.
- Treatment efficiency is very vulnerable to frequent power outages. They reach more than 6 hours a day, especially in emergency situations in the country.
- The method requires large aeration tanks with a volume of 3-6 times more than a conventional activated sludge system.
- The method will not remove nutrients (nitrogen and phosphorus) and, therefore, it is necessary to add additional tanks to achieve the removal of nitrogen and phosphorus [6, 5, 2].



	Al Rumia	Al-Hara	Hebbet	Merge-Meyraban
design	695,93	405,00	653,94	465,75
actual	420,00	426,26	247,74	1554,00
S.D.	0,00	180,54	103,98	1039,05

Figure 1. The results of comparing the actual and design values of the wastewater flow rate at four treatment plants

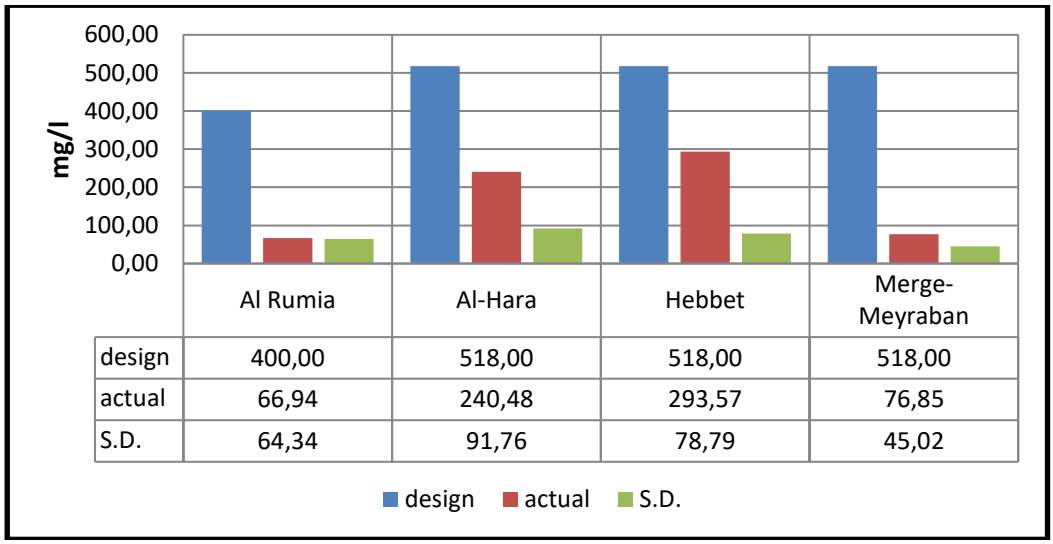


Figure 2. The results of comparing the actual and design values of the biochemical oxygen demand BOD of wastewater at four treatment plants

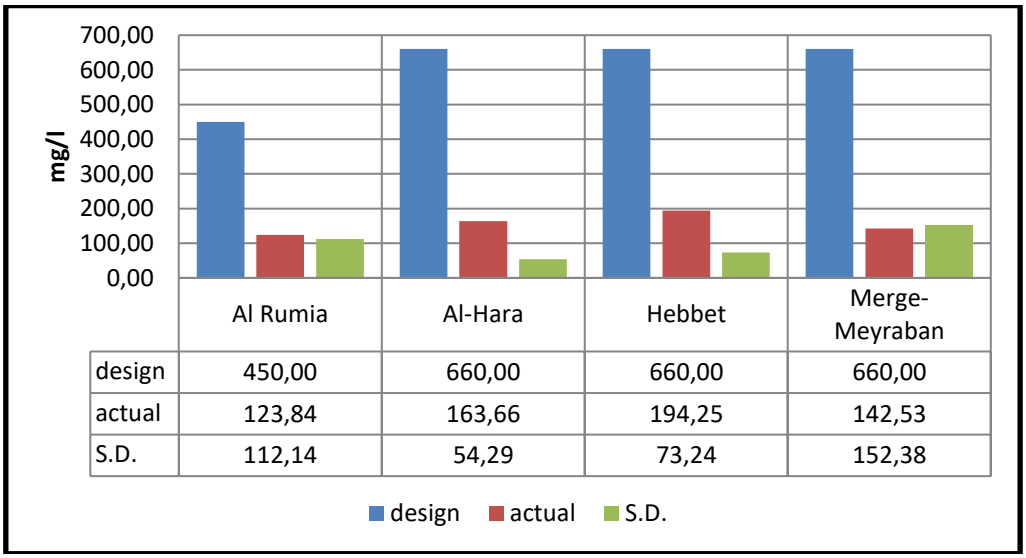


Figure 3. The results of comparing the actual and design values of suspended solids SS of wastewater at four treatment plants

6. Solutions and recommendations for the development of a wastewater treatment system for small settlements in Syria

Based on the reality of the sewage system in Syria, the design and operation problems of plants and choosing the treatment method, the Ministry of Water Resources has developed a reference guide on the methodology for studying and choosing wastewater treatment technologies in Syria, where it outlined the most suitable technologies for the conditions of Syria. One of these technologies is rotating biological contactors, which were considered a suitable option for wastewater treatment in

small settlements [7]. Rotating biological contactors (RBC) are combined facilities for biological wastewater treatment, which have features of biofilters and aeration tanks [8, 9, 10]. The advantages of this technology are:

- Relatively small footprint.
- Simplicity in construction and operation.
- Reducing the cost of electricity compared to the aeration tank 3-5 times.
- The absence of an activated sludge recirculation system, which reduces the costs required for the operation and maintenance of these pumps.
- Resistance to toxic loads.
- Typically, RBC exist in closed compartments to protect them from high and low temperatures and prevent the spread of odors, which reduces the necessary sanitary zones and, as a result, the use of these plants as a decentralized treatment method and reduce the cost of land and long sewer lines [10, 11, 12].

From the above, it can be concluded RBC are the best option for wastewater treatment of small settlements in Syria and most satisfy their requirements. However, RBC method has not previously been used to treat domestic wastewater in small settlements in Syria, it is very important to study its characteristics and technological factors that affect them.

7. Conclusion

The following conclusions were made:

- Deterioration of water quality in the main river basins of Syria as a result of untreated domestic wastewater or insufficiently treated wastewater, commercial and industrial wastewater from certain activities.
- The sewage system, especially in small settlements, suffers from several problems such as: long sewer lines, errors in the design of treatment plants and the choice of treatment method, lack of qualified personnel, frequent power outages, large fluctuations in the flow rate and concentrations of wastewater pollution.
- 98% of treatment plants in small towns operate with activated sludge with extended aeration, which does not meet their requirements and does not provide high efficiency of wastewater treatment.
- Rotating biological contactors RBC are the best option for wastewater treatment of small settlements in Syria and most meet their requirements.

References

[1] WWAP (United Nations World Water Assessment Programme) 2017 *The United Nations World Water Development Report 2017 Wastewater: The Untapped Resource* (Paris, UNESCO)
[2] Turkmani A M 2009 *National Plan for Wastewater Management in Syria - Regional Hubs and Treatment Plants* (Syria)
[3] Tenth Five - Year Plan 2006 *Drinking Water and Sanitation Sector - Chapter 15* (Syria: State Planning Commission)
[4] Japan International Cooperation Agency (JICA) 2008 *Study of the development of sewage systems in the Syrian Arab Republic* (Syria: Ministry of Construction and Housing)
[5] Saied M 2016 Features of wastewater treatment in Syria *The IX international scientifically practical conference "technologies of water purification"* (Novocherkassk: lik) pp 240-243.
[6] Saied M 2014 *Evaluating the efficiency of some wastewater systems in Latakia Governorate* Master Thesis, Tishreen University Latakia Syria
[7] *Reference Guide for Methodology of Study and Selection of Wastewater Treatment Technology in Syria* 2013 (Syria: Ministry of Water Resources)

[8] Dawod K 2003 *Improving the technology of wastewater treatment on rotating biocontactors* PhD thesis, St. Petersburg State University of Architecture and Civil Engineering St. Petersburg
[9] Shuvalov R M 2011 The results of the comparison of technological indicators when choosing the type of bioreactor for wastewater treatment in small settlements *Vestnik SGASU Urban planning and architecture* **2** 88-96
[10] Saied M 2018 Development of a photo-rotating biofilter to increase the efficiency of treatment in the closed compartments of wastewater treatment plants *Exact science* **30** 05-11
[11] Hassard F, Biddle J, Cartmell E, Jefferson B, Tyrrel S and Stephenson T 2015 Rotating biological contactors for wastewater treatment- review *Process Safety and Environment Protection* **94** 285-306
[12] Cortez S, Teixeira P, Oliveira R and Mota M 2008 Rotating biological contactors: a review on main factors affecting performance *Reviews in Environmental Science and Bio/Technology* **7** 155–172