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Analysis of environmental problems for the Barada River basin in Syria and recommended water protection measures*Russian State Agrarian University - Moscow Timiryazev Agricultural Academy
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Barada Basin, where the capital of Syria, Damascus, is located, and hence where most of the human activities are concentrated, suffers from serious environmental problems due to the migration from rural areas, illegal settlements, industrialization, urbanization, and overexploitation of environment. Huge amounts of wastewater (domestic, industrial, and agricultural) are discharged every day to the landscape as well as into Barada and Awaj Rivers without sufficient treatment. This paper is devoted to the water pollution issues in Barada Basin. River water quality has been analyzed, some studies on the assessment of pollution in the Barada River are presented, environmental protection measures and restoration of the river ecosystem are recommended.

Keywords: water resources, waste water, sustainable development, ecosystems, pollution, water quality.

Аннотация

Столица Сирии город Дамаск расположен на территории бассейна реки Барада. Это означает, что в бассейне реки сосредоточена большая часть антропогенной деятельности. Как следствие, возникают серьезные экологические проблемы из-за миграции населения из сельских районов, незаконных поселений, индустриализации и урбанизации, а также чрезмерной эксплуатации экологических сред. Огромные объемы сточных и возвратных вод (бытовых, промышленных и сельскохозяйственных) ежедневно сбрасываются в реки Барада и Авадж без достаточной очистки, превращая единственные водные объекты в регионе в свалку отходов. В данной статье были проанализированы проблемы загрязнения воды в бассейне Барада, представлены некоторые исследования, посвященные оценке загрязнения реки Барада, природоохранным мероприятиям и восстановлению экосистемы реки.

Ключевые слова: водные ресурсы, сточные воды, устойчивое развитие, экосистемы, загрязнение, качество воды.

Syria is characterized with low water availability, which is typical for many other countries in the Middle East. The average water availability for the country is (809 m³/per* year). The main rivers are: the Euphrates River with its tributaries, which flows in the eastern part of the country, as well as the Orontes River (Al Asi), which flows in the southwestern part of the state. Large areas in the country are occupied by desert and semi-desert landscapes, where dry and drying water bodies filled with water only during precipitation (so-called wadis) are located.

The main source of fresh water in Syria is the Euphrates River. Although only 22% of the area of the river basin is located in the territory of Syria, up to 80% of the river flow of the Euphrates River and its tributaries is provide water supply in the country. The main rivers are; the Orontes (Al Asi), which flows along the border between Syria and Lebanon, and inflows into the Mediterranean Sea; the Barada River, which flows in suburbs of Damascus. The Barada River basin is the area of the internal flow. The Guta Oasis is located in the mouth of the river. The Barada River is mainly used to provide Damascus with water. Barada Basin consists of Barada River basin (2,348 km²), Awaj River basin (1,456km²), and other small river basins (4,386km²). These rivers

have their springs in the mountains located in the northwestern part of the study area and flow to the Damascus plain in the central and southeastern part of the study area. They have internal basins without any outlets to the sea. There are more than 50 springs in the studied basin which supply water for the domestic and irrigation purposes in the surrounding areas. The Barada and Fijeh are among these springs, and they are considered as the main water resources for Damascus.

Figure 1. Barada river location

Historically, the Barada River was a very important water resource. There was a large, beautiful forest, with various types of trees, called "Guta" around the river. This forest was a source of food for the people who lived around and it had a rich ecosystem. This river was not only a source of water for people, but it was also a source of inspiration and was considered as a cultural heritage. However, in recent years, the Barada has become a completely dead river. The performing analysis show, the main reasons of the above.

1. The amount of pollution exceeds the ability of the river to self-purification.
2. Climate change and a significant decrease in precipitation in this area.
3. Water intake to provide drinking water, industrial water and water for irrigation.

The Barada is polluted with sewage water. The concentration of BOD exceeded the permissible limits in most course of the Barada, especially in the downstream sites of the river, where it reached a value of 130 mg/l. The concentration of ammonium also increased 13 mg/l due to the wastewater discharge and the decrease in river flow. The amount of nitrates in some wells is increasing now (concentration is becoming higher than the permissible level for drinking water in rural areas around Damascus). Therefore the construction of more than 200 wells for drinking purposes in several regions of Ghouta (where nitrate concentrations reached 100-200 mg/l) was stopped in 2005. The total amount of pollutants discharged into the river was estimated as about 95.15 tons per day in 2005.

Most part of the anthropogenic activity is concentrated in the river basin, which creates great environmental risks due to a combination of overlapping factors, including:

- a high population in the basin area; which leads to overexploitation of the available resources;
- the discharge of large values of domestic sewage in addition to industrial effluent as a result of: the spread of slums; the expansion of urban areas; the discharge of industrial pollutants directly into the river without treatment; small and micro enterprises opening;

- excessive use of fertilizers and pesticides; use of waste water for irrigation (3); and failure to apply modern irrigation techniques and modes.

Increasing water use in the region, using surface and groundwater for industrial purposes resulted in water decrease which is available for agriculture, as well in water quality deterioration. Water intake mainly from underground water bodies resulted in further groundwater depletion and pollution. Development of food industry contributes organic compounds, which requires analysis of their oxidation and study of dissolved oxygen decline in water, as well as status and composition of aquatic organisms. Marble factories also discharge their wastewater into the Barada resulting in water quality deterioration. Wastewater of marble plants contains suspended solids which increase water turbidity and hinder sunlight penetration, affecting aquatic organisms. Irrigation also contributes to the water quality deterioration as the diffuse flow containing pesticides comes to the river from the fields.

Figure 2. Industry influence (certain chemical pollutants such as chromium, lead and cadmium)

Sustainable solution should be found taking into account the following factors: economic growth; damage to natural resources; environmental degradation, as the river is still under the influence of pollutant discharge. There were many studies on the topic of the research, but the goal was the same and focused on the restoration of the ecosystem of the river basin. (4)

- In the study (R. MELHEM, Y. HIGANO, 2009), a mathematical model aimed at environmental situation improvement in the Barada region by studying pollution, taking into account economic aspects. A number of recommendations were made that could decrease pollution impact, including: investment into construction of wastewater treatment plants, taxation of companies that exceed the limits of pollutant discharge into the river according to the Syrian Environmental Protection Law № 12 of 2012, which takes into account socio-economic status of each zone of the basin and public awareness to reduce pollution in the basin, at the same time all stakeholders of water use must contribute to the pollution reduction.
- In the another study (Falouh J., Mark J. Levin (2000)) a mathematical model describing the relationship between the ecosystem and the economy in the river basin monitoring the concentrations of heavy metals such as chromium, cadmium, and lead which is discharged by industrial firms in the region annually is developed. It was found that concentrations of above pollutants exceeded

permissible limits. The risk of excessive pollution for the environment and for the people health in the area is considered and analyzed.

Table 1

Analysis of the possibilities of existing mathematical models to estimate ecological and economic aspects in the catchment area of the Barada

Model Name	Authors	Main equation and necessary initial data for the calculation	Notes
Total amount of pollutants	R. MELHEM, Y. HIGANO	$TB_P^B(t) = JB_{1p}(t) + TB_{2p}(t) + TB_{3p}(t) + TB_{4p}(t) + 0.4 TB_{7p}(t) + 0.5 TB_{8p}(t)$ where: $TB_P^B(t)$: The total amount of pollutant coming to the Barada in the certain time t .	This model calculate the total amount of contamination discharged to Barada.
Water balance and water quality	R. MELHEM, Y. HIGANO	$F_1^B(t) = Q_B + R_I + W_I(t) + G_I - E_I - DW - Ir_I$ where: Q - the amount of spring water flowing into the Barada; R - the average annual precipitation. W - volume of wastewater dumping into the Barada; G - annual groundwater pumping from wells; E - average annual evaporation; Ir - the annual volume of water used for irrigation.	The following equations calculate the flow of the water between the borders of zones where Barada goes through in order to calculate the water quality at those borders.
Economic model	Mark J. Levin	$\sum_j N_{ij}(t) = \tau_i P_i(t)$ τ_i : The percentage of working population in zone i .	It is assumed that the ratio between the population and the number of workers in each zone is constant.

- A scheme for regulating the river Barada flow has been proposed (W. Ghada, 2011) by creating three models for three parts of the riverbed in order to increase river flow of the river. Alternative cross-sectional designs were proposed according to the nature of each part, taking into account general rules, ecological and social bases.

Characteristics of the three research areas.

1. The first area of the research.

It extends from the source of the Barada to the Al-Teqiya with a length of 5.9 km.

Figure 3. Satellite image showing the river flow in the first studied area

The regulation of the river flow was accomplished by sewage treatment plant projects' development in the nearby residential areas and discharging the treated water into the river.

2. The second area of the research.

It is located between Umayyad Square and the Victoria Bridge with a length of about 2.1 km.

Figure 4. Satellite image of the second study area

It was proposed to construct a summer channel to prolong river flow period during the periods when water levels are low, so that the water would not stagnate and become a source of insects and odors. This channel proved its efficiency during the last ten years.

3. The third area of research.

This area is about 6.2 km long and 21 to 14 meters wide. River flows in the ancient Damascus. A drainage management project was carried out in this part, which included the construction of two sewers on the both sides of the river to collect sewage residues and to prevent them from entering the river.

Figure 5. Satellite image of the third study area

Therefore the issues of water quality control in the Barada, as in other rivers of Syria, are very significant nowadays. At the state level, water ecology issues are under the jurisdiction of the Ministry of Environment, the Ministry of Water Resources, the Ministry of Agriculture and Agricultural Reform of Syria.

The authors' analysis of the previous research, data and measures did not reveal detailed information on the (national) system programs and annual results of water quality monitoring in Syria. This can be explained that monitoring is not carried out due to the tense political situation in the country. It was also noted that there are no normative documents regulating monitoring and environmental protection activities in Syria, either in English or Arabic. A study was conducted on the anthropogenic pollution of the river, as well as a comparative analysis of the mathematical models used to assess the pollution of the river and the results of projects to reduce the pollution of the river and to provide river conservation in some parts of the river.

1. Melhem R, Higano Y. Policy Measures for River Water Management in Barada Basin, Syria. Institute of Life Environmental Science, University of Tsukuba. | Request PDF [Internet].
2. M. Haddad - The Case of the Barada River, Syria.pdf [Internet]. [cited 2020 Apr 28].
3. Policy Measures for River Water Management in Barada Basin, Syria | Request PDF [Internet]. [cited 2020 Apr 27].
4. Ministry of Environment: Syrian Standard for Wastewater Discharged to Sewerage System, Ministry of Environment Document. [Электронный ресурс]. – Режим доступа: <https://wedocs.unep.org/handle/20.500.11822/12504>.
5. Bakshtanin A. M., Ratkovich L. D., Markin A.M., Glazunova I. V., et al. under the general editorship of L. D. Ratkovich V. N. Markin-Water management systems and water use-Textbook-Moscow: INFRA-M LLC-2019. - 452 p.
6. Shawaf S. (2000): The Contamination of Barada River, Ministry of Irrigation documents, Damascus (Arabic).
7. W Ghada. Problems of regulating river streams in Syria – case study.pdf [Internet].