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Tashkent International University of Education  
Turin Polytechnic University in Tashkent

## PROCEEDINGS

of the MMIT'25 International Conference

TA'LIMNING ZAMONAVIY USULLARI VA  
INNOVATSION TEXNOLOGIYALAR

MODERN METHODS AND INNOVATION  
TECHNOLOGIES IN EDUCATION

СОВРЕМЕННЫЕ МЕТОДЫ И  
ИННОВАЦИОННЫЕ ТЕХНОЛОГИИ  
В ОБРАЗОВАНИИ

29 May 2025, Tashkent, Uzbekistan

MAQOLALAR TO'PLAMI  
СБОРНИК СТАТЕЙ



## **Tashkent International University of Education**

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**Ta'limning zamonaviy usullari va innovatsion texnologiyalar**

**Modern methods and innovation technologies in education**

**Современные методы и инновационные технологии в  
образовании**

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## **SUSTAINABLE GROUNDWATER MANAGEMENT - PROBLEMS AND SCIENTIFIC TOOLS**

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**Abstract.** Although groundwater accounts for only 20% of the planet's freshwater reserves, its importance is enormous. This is due, firstly, to its high suitability for drinking, and secondly, it serves as a stable source of water, especially in arid regions. Although groundwater has the property of being stored in large quantities, the most important factor for sustainable management is the rate at which it is renewed. Approximately 800 km<sup>3</sup> of groundwater is used annually, which seems to be less than the level of global renewal, but these figures obscure problems at the regional level [1-2]. For example, about 25% of extracted water comes from non-renewable resources. Global averages can also misrepresent the level of pollution. In reality, the situation differs dramatically in each river, spring, or well. Overpumping and pollution of water can lead to the degradation of groundwater, and even to the complete cessation of its use. Due to the limited possibilities of artificial renewal, it is necessary to use this resource carefully and efficiently.

**Keywords:** *water management, aquifer, water level, soil salinity.*

### **Introduction**

To assess the state of groundwater in the catchment basin, it is necessary to determine the sustainable use of resources as a starting point. Below, we define it as a set of management practices that do not cause irreversible or quasi-irreversible damage to natural resources, such as resource water and the soil and ecosystems associated with it. Such management allows resource water to extend its service, including environmental service, for a very long time.

Water intake from groundwater reservoirs should not exceed the long-term average long-term saturation. The safety factor, of course, allows for the temporary distillation of excess water. Because abstracted quantities can be used as consumption (e.g., through evapotranspiration in agriculture) and reduce downstream flows, sustainable quantity management requires limiting to the share of filling to guarantee minimum water supply in the downstream flow. These principles are violated in many aquifers of the world[3].

#### **Filling the aquifer with excess water**

In the conditions of Uzbekistan, a steady decrease in the groundwater level is a clear sign of excessive water injection. This is especially noticeable in irrigated areas. The widespread use of groundwater for irrigation leads to an increase in pump costs and a decrease in the water level by 1-2 meters per year. This situation poses a serious threat to long-term stability, similar to the experience of Northern China or India[4].

Agricultural irrigation constitutes the main part of the republic's water resources. Overall, 70-80% of water use is for irrigation needs, while drinking and household needs account for a much smaller share. This leads to the overuse of the level of natural renewal in relatively arid and semi-arid climates.

Excessive pumping of groundwater disrupts their natural balance. The main danger is that as the water level decreases, soil salinization increases, pumping costs rise, water quality deteriorates, and eventually, in some areas, the use of these water sources becomes impossible. Therefore, it is necessary to strictly adhere to the principles of sustainability in the use of groundwater.

#### **Consequences of groundwater level decrease**

In the conditions of Uzbekistan, a sharp decrease in the groundwater level or pressure leads to an increase in pump costs. This situation reduces the economic efficiency of irrigation. However,

this problem is not limited to economic costs alone. A decrease in pressure can lead to soil compaction and the risk of soil subsidence in some loose layers. This can threaten the stability of urban infrastructure and buildings, especially in Tashkent or other densely populated areas.

If the groundwater level drops too quickly or deeply, the roots of aquatic plants cannot reach the water. This situation disrupts the ecological balance in the arid regions of Uzbekistan. The drying of trees intensifies wind erosion, as a result of which soil fertility decreases. In addition, as the water level decreases, swamps and natural water bodies dry up, which negatively affects local ecosystems. Therefore, when using groundwater, it is necessary to take into account not only economic, but also environmental sustainability.

#### Soil salinization

Due to the arid climate of Uzbekistan, if the groundwater level is high, the risk of soil salinization increases. If, as a result of irrigation, the groundwater level approaches the surface by 1-2 meters, the process of capillary evaporation begins. As a result, salts dissolved in water rise to the surface, accumulate in the topsoil, and fertility sharply decreases [5].

This problem cannot be solved even with artificial drainage, especially in areas with low water permeability. Today, one-third of irrigated land in the world suffers from salinization, which is also widespread in Uzbekistan. Even if the salinization process is stopped, soil restoration will take a long time. Therefore, in order to prevent salinization of irrigated lands in Uzbekistan, it is necessary to control groundwater, strengthen land reclamation measures, and implement effective drainage systems.

#### Determination of groundwater saturation rates

Groundwater saturation is the most important parameter for stability in arid and semi-arid regions. Nevertheless, it is not yet possible to measure this important hydrological quantity with sufficient accuracy. Re-saturation is not directly measured, and indirect methods lead to various uncertainties. Moreover, in dry climates, rainfall and regeneration occur very irregularly. Integral methods, such as the Wundt method, based on the analysis of low river runoff, are very useful in humid climates, but do not work in arid zones where low runoff is usually zero. In the hydrological water balance method, the difference between precipitation and evapotranspiration is calculated when long-term, average, and surface runoff saturation are neglected. Since both of these quantities are of the same magnitude and the result is uncertain, their error becomes even more uncertain. The balance method can only be applied when there are long time series of balance components, since in this case systematic errors are gradually eliminated, and the result can be achieved with a small number of errors.

Methods based on Darcy's law, in which the flow through the cross-section of the aquifer  $Q$ , cross-sectional area  $A$ , hydraulic conductivity  $K$ , and hydraulic gradient  $I$  are calculated as follows [7]:

$$Q = A * K * I. \quad (1)$$

The chloride method is often successfully used in arid regions. In this method, the method of wind precipitation of sea salt aerosol is used. The concentration of chlorides in the formed soil water increases as a result of evaporation and transpiration. If the surface runoff is negligible, the increase in concentration is proportional to the rate of evapotranspiration, and the rate of re-saturation can be determined by the following formula:

$$R = \frac{(C_p * P + D)}{C_B}, \quad (2)$$

where:  $C_p$  - chloride concentration in rainwater,  $P$  - precipitation, and  $D$  - dry precipitation of chloride.  $C_b$  - concentration of chloride below the upward flow plane. It can be approximately calculated based on its concentration in shallow groundwater. The method requires long-term monitoring of wet and dry precipitation of chloride, and there should be no other underground evaporating source of chloride [6].

The problem of soil salinization reveals another key economic aspect. For slow processes such as salinization, for which the time scale can easily be 40 years or more, the usual economic optimization is incapable of accounting for future penalties. Future-oriented alternatives to classical optimization are required, such as limitations on the final value of agricultural land and its salinity. Of course, the state can eliminate this shortcoming with regulatory documents that are restrictive to the optimization problem.

### **Conclusion**

Sustainable management of aquifers is a pressing problem in many countries. New scientific tools can help in solving it, both in analyzing the sustainability of current management and in determining strategies and measures to achieve sustainability. Models always play a role in this task. The new generation of the model can use new data sources such as environmental observers, remote sensing data, and geophysical data. However, he will have to not only simulate an average deterministic situation, but also analyze the uncertainty of his predictions with a stochastic approach in order to remain reliable.

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An abstract graphic featuring a complex network of interconnected nodes and lines, resembling a molecular structure or a digital network, set against a dark blue background. The nodes are represented by circles of varying sizes, and the lines are thin, light blue, creating a web-like pattern that fills the upper two-thirds of the page.

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