
# INFLUENCE OF CLIMATIC FACTORS AND PRECIPITATION ON GROUNDWATER FORMATION IN THE REPUBLIC OF KARAKALPAKSTAN

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**ABSTRACT**

*This study analyzes the influence of climatic factors and precipitation on groundwater formation in the Republic of Karakalpakstan. Hydrometeorological observation data from the Nukus meteorological station were used in the research. The effects of air temperature, precipitation, relative humidity, and evaporation processes on the groundwater regime were examined. The analysis indicates that low precipitation and high air temperatures during the summer period significantly limit the natural recharge of groundwater in the region. For example, in June 2022 the average air temperature reached 29°C, while the maximum temperature was 43.4°C, and the total precipitation was only about 2.4 mm. These climatic conditions intensify evaporation and reduce soil moisture, which negatively affects groundwater recharge. The results of the study provide a scientific basis for the rational use and protection of groundwater resources in the Republic of Karakalpakstan.*

## Introduction

The Republic of Karakalpakstan is considered one of the most arid regions of Central Asia in terms of natural and climatic conditions. Limited water resources, environmental problems associated with the drying of the Aral Sea, and ongoing climate change processes have made rational water resource management one of the most urgent environmental issues in the region.Groundwater plays an important role in providing drinking water to the population of Karakalpakstan, as well as supporting agricultural and industrial activities. Therefore, studying the formation, dynamics, and ecological condition of groundwater is of great scientific and practical importance.Groundwater formation is influenced by various natural and anthropogenic factors. Among the natural factors, climatic conditions, precipitation, air temperature, air humidity, and evaporation processes play an important role. In arid regions, the amount of precipitation and the intensity of evaporation processes have a particularly strong influence on the natural recharge of groundwater.The climate of the Republic of Karakalpakstan is sharply continental, characterized by high air temperatures and low precipitation during the summer period and relatively low temperatures in winter. Such climatic conditions significantly influence soil moisture and the hydrological regime of

groundwater. In addition, desertification processes observed in the region negatively affect the state of water resources **[5]**.

In recent years, climate change processes have also had a noticeable impact on water resource formation. Increasing air temperatures, intensified evaporation processes, and decreasing precipitation limit the natural recharge of groundwater. This situation makes the rational use and protection of water resources even more relevant.The aim of this study is to analyze the influence of climatic factors and precipitation on groundwater formation in the Republic of Karakalpakstan using hydrometeorological observation data from the Nukus meteorological station.

**Materials and Methods**

This study analyzed climatic factors and their influence on groundwater formation in the Republic of Karakalpakstan. Hydrometeorological observation data obtained from the Nukus meteorological station were used as the main research source. Meteorological indicators such as air temperature, precipitation, relative humidity, wind speed, cloud cover, and soil temperature were used as research materials. These data were obtained through agrometeorological observations and their statistical indicators were analyzed. During the research, the following scientific methods were applied:

**Statistical analysis method.**

Statistical analysis was used to process meteorological observation data. Using this method, the average, minimum, and maximum values of air temperature, precipitation, and air humidity were determined. The obtained results were evaluated using agrometeorological analysis methods. Statistical processing of meteorological data is widely used in agrometeorology [1].**Comparative ecological analysis method.**

A comparative ecological analysis was also applied in the study. Using this method, the relationship between climatic factors and groundwater formation was analyzed. The relationships between different meteorological indicators were evaluated through comparative analysis. Ecological analysis methods are widely used to assess processes occurring in natural environments [2].

**Agrometeorological analysis method.**

The agrometeorological analysis method was used to study the influence of climatic factors on water resources and soil moisture. This method makes it possible to evaluate the relationships between precipitation, temperature, and evaporation processes in natural environments.

**Results and Discussion**

The climate of the Republic of Karakalpakstan is sharply continental, with high air temperatures in summer and relatively low temperatures in winter. Hydrometeorological observations conducted at the Nukus meteorological station in 2022 show that the regional climate significantly affects groundwater formation [7] According to the observation results, the average air temperature in June 2022 was 29°C. The maximum air temperature reached 43.4°C, while the minimum temperature dropped to 14.2°C. High summer temperatures intensify evaporation processes and lead to a decrease in soil moisture. As a result, the natural recharge of groundwater becomes limited. According to the Nukus meteorological station data, the maximum air temperature in June 2022 reached 43.4°C (Figure 1).

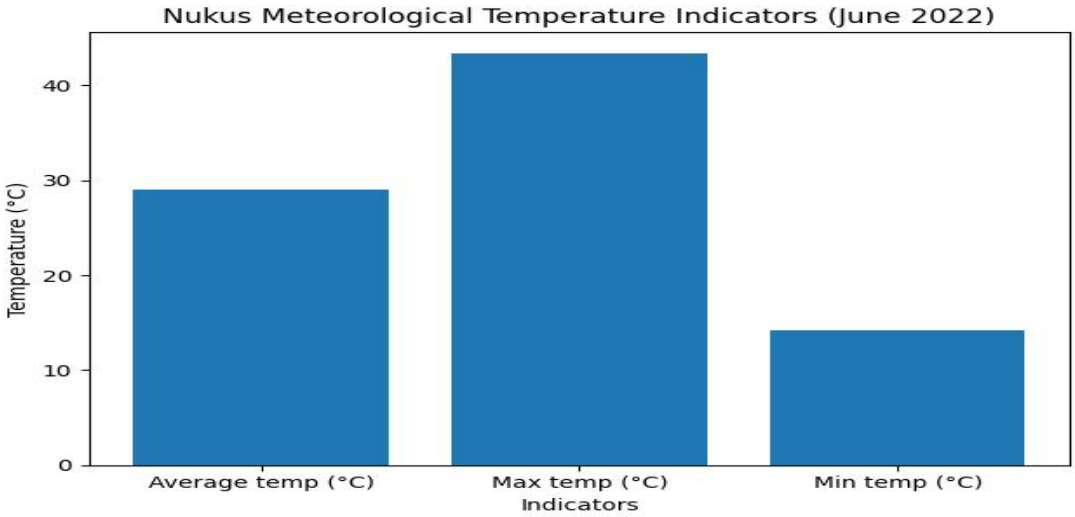


Figure 1. Air temperature indicators observed at the Nukus meteorological station in June 2022 Analysis of climatic indicators at the Nukus meteorological station showed that climatic conditions significantly influence groundwater formation (Table 1).

Table 1 Climatic indicators of the Nukus meteorological station and their influence on groundwater

| No | Meteorological indicator | Value | Influence on groundwater |
|---|---|---|---|
| 1 | Average air temperature | 29°C | High temperatures intensify evaporation |
| 2 | Maximum temperature | 43.4°C | Soil moisture decreases |
| 3 | Minimum temperature | 14.2°C | Helps maintain humidity at night |
| 4 | Precipitation | 2.4 mm | Natural groundwater recharge is low |
| 5 | Relative humidity | 26% | Low humidity increases evaporation |
| 6 | Wind speed | 2–4 m/s | Influences evaporation processes |

Precipitation in the region is very low. According to Nukus meteorological station data, precipitation in June was approximately 2.4 mm. Such a small amount of precipitation is insufficient for groundwater recharge. Therefore, the hydrological regime of the region is mainly formed by river waters and irrigation systems.Analysis of air humidity indicators showed that the average relative humidity in June was about 26%. Low humidity intensifies evaporation processes. This leads to a reduction in soil water reserves and slows down the process of groundwater formation.

In winter, climatic conditions change significantly. In December 2022, the average air temperature was −6.5°C, and on some days the minimum temperature dropped to −19.9°C. Low winter temperatures slow down evaporation processes, but the small amount of precipitation does not significantly affect groundwater recharge.

Hydrometeorological observations also recorded atmospheric phenomena such as fog, rain, and snow on some days. However, such events are short-term and do not significantly influence groundwater reserves.

The conducted analysis shows that groundwater formation in the Republic of Karakalpakstan is mainly influenced by climatic factors. High summer temperatures and intense evaporation processes limit the natural recharge of groundwater. At the same time, the low amount of precipitation is also an important factor affecting the formation of water resources [7]. The results of the study show that due to the arid climate of the region, it is very important to preserve groundwater reserves and use them rationally. Therefore, hydrometeorological observation data should be widely used in water resource management.

**Conclusion**

The results of the research showed that climatic factors significantly influence groundwater formation in the Republic of Karakalpakstan. Analysis of data from the Nukus meteorological station indicates that precipitation in the region is extremely low, which limits the natural recharge of groundwater.In June 2022, the average air temperature reached 29°C and the maximum temperature rose to 43.4°C. Such high temperatures intensify evaporation processes and lead to a decrease in soil moisture.

In winter, the decrease in air temperature slows evaporation processes, but the small amount of precipitation does not significantly influence groundwater recharge.The results of the study indicate that groundwater formation in the Republic of Karakalpakstan largely depends on climatic factors, particularly precipitation and air temperature. Low precipitation and high summer temperatures significantly limit the natural recharge of groundwater.Therefore, the development of scientifically based measures for rational water use and groundwater protection in the region is essential.

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