HYDROGEOLOGICAL ANALYSIS OF GROUNDWATER FILTRATION DISCHARGE IN THE KARASUV RIVER BASIN

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Abstract. *This article examines the issue of determining groundwater filtration discharge in the Karasuv River basin, taking into account the temporal variability of groundwater levels. As part of the study of the region's hydrogeological conditions, the water permeability indicators of soils in the experimental field were measured and assessed under field conditions. To analyze the obtained empirical data and further improve the mathematical modeling of the problem, calculations were carried out based on the solution of a differential equation using the finite difference method.*

Keywords. *filtration discharge, soil permeability, field experiments, hydrogeological conditions, finite difference method, mathematical modeling, differential equation.*

Introduction. In irrigated areas, when the groundwater level lies above the level of a river or a major canal, the filtration flow discharges into the river, causing the river to function as a drainage channel [2]. Such a situation typically arises when the filtration flow drains from the upper part and recharges from the lower part beneath the river or canal bed. If the groundwater level is higher than the land surface surrounding the river or canal, the groundwater emerges onto the surface, significantly affecting the flow regime [4]. Due to the complexity of the flow structure near the Karasuv River, surveys were conducted in selected sections of the river to assess the relationship with water levels. These surveys provide the opportunity to evaluate the heterogeneity of the rock strata and help identify sharp deformations in the flow pattern.

Materials and Methods. In order to determine the soil hydro-physical properties and water permeability characteristics of the experimental site, field measurements were conducted under natural conditions. The results related to soil permeability were collected and recorded based on in-situ field observations. During the laboratory analysis of soil samples taken from the experimental field, the mechanical composition of the soil was examined in detail. To study the variations in the water discharge of the Karasuv River and the groundwater level, observations were carried out between wells No. 88, No. 53, and No. 90. During these observations, graphs were developed to illustrate the changes in filtration discharge and groundwater level. The analysis of the variations in filtration discharge and groundwater levels along the length of the study area made it possible to assess and calculate the impacts on groundwater dynamics.

Research Results. In the study area, 70% of the soil consists of particles sized between 0.1 and 0.01 mm, 0.6% consists of coarse particles, and 29.4% consists of fine particles.

Table 1.

Hydro-physical properties of the soil

Soil Mechanical Composition	Porosity (relative to volume), %	Capillarity in Soil (relative to volume), %	Moisture Content Relative to Porosity (Field Capacity), %	Moisture Content Relative to Porosity (Wilting Point), %	Volume of Moisture Content in 1 m Soil Layer, m³/ha
sandy loam	35-40	18-23	32-49	6-8	1200-1800
medium loam	45-50	27-30	58-65	12-18	2660-2840
heavy loam	55-60	37-45	68-75	20-28	2900-3400

As a result of field experiments, the water permeability coefficients of soil layers were measured. Figure 1 below illustrates the results obtained from the experimental site.

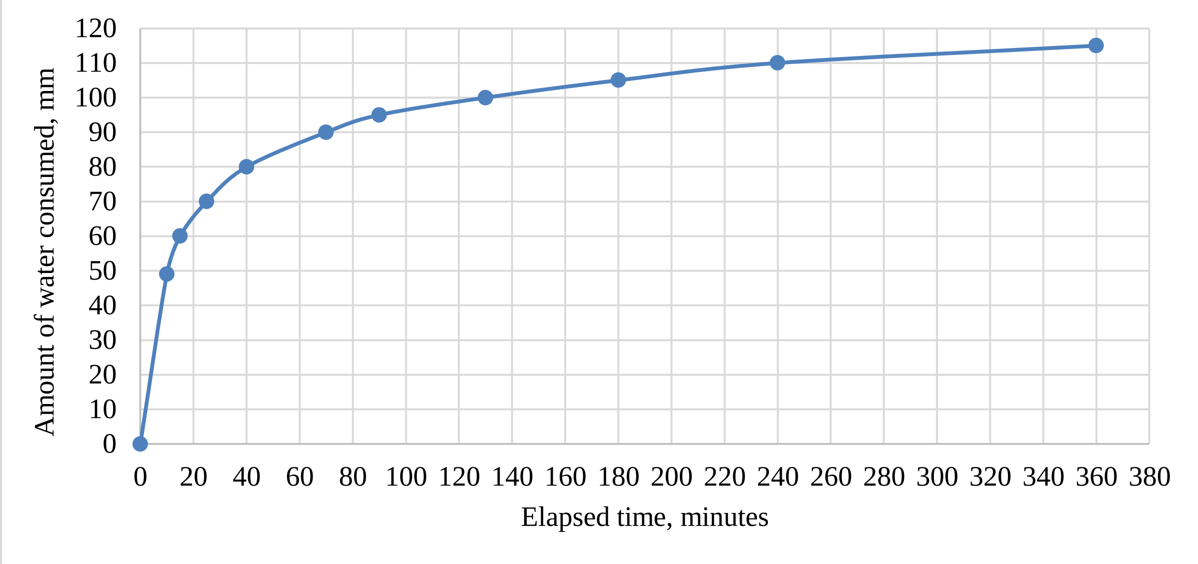

Figure 1. Results of field determination of water permeability characteristics of soils in the experimental area

The mechanical composition of the experimental field soils was determined at four points using the conversion method according to N.A. Kachinskiy's classification. The results of field and laboratory analyses for determining the mechanical composition of the experimental field soils are presented in Figures 2, 3, 4, 5, and 6.

Figure 2. Laboratory analysis of soil samples taken from the experimental field

The analysis results aimed to determine the quantities of components of various particle sizes in the soil's mechanical composition. Specifically, the amounts of sand, clay, silt, and sedimentary materials in the soil were identified, and their relative proportions helped to assess the mechanical properties of the soil.

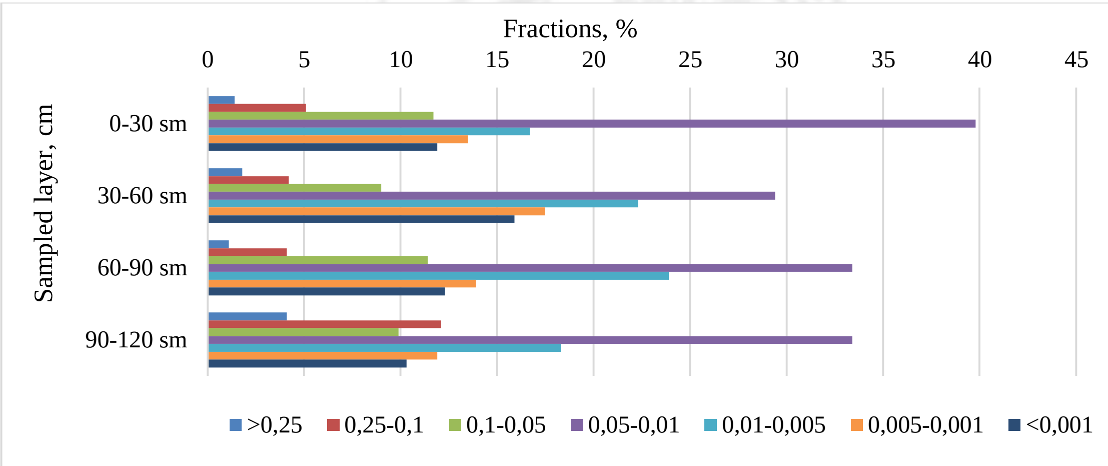

Figure 3. Mechanical composition of soil from Experimental Field 1

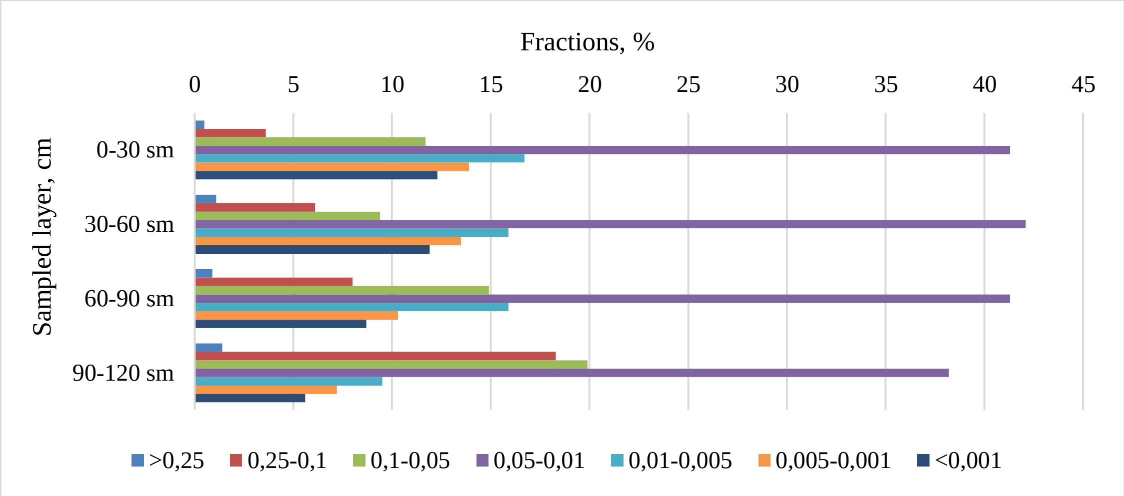

Figure 4. Mechanical composition of soil from Experimental Field 2

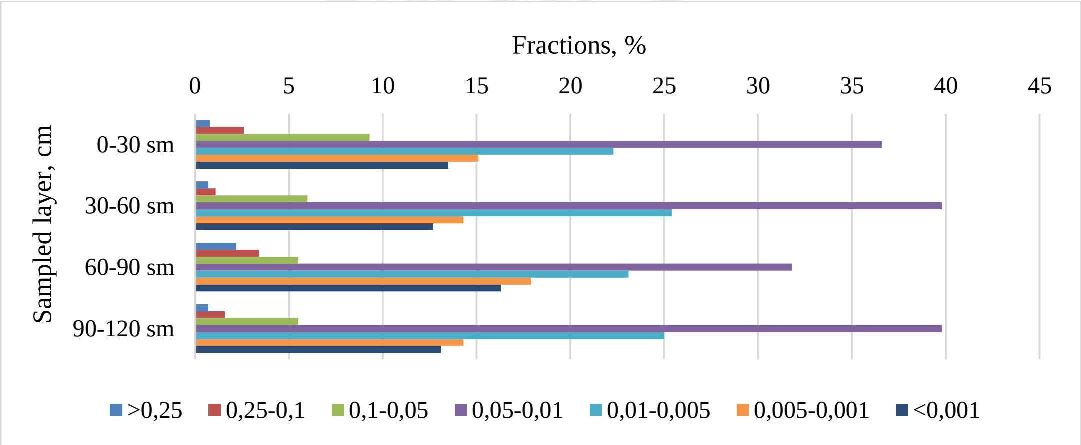

Figure 5. Mechanical composition of soil from Experimental Field 3

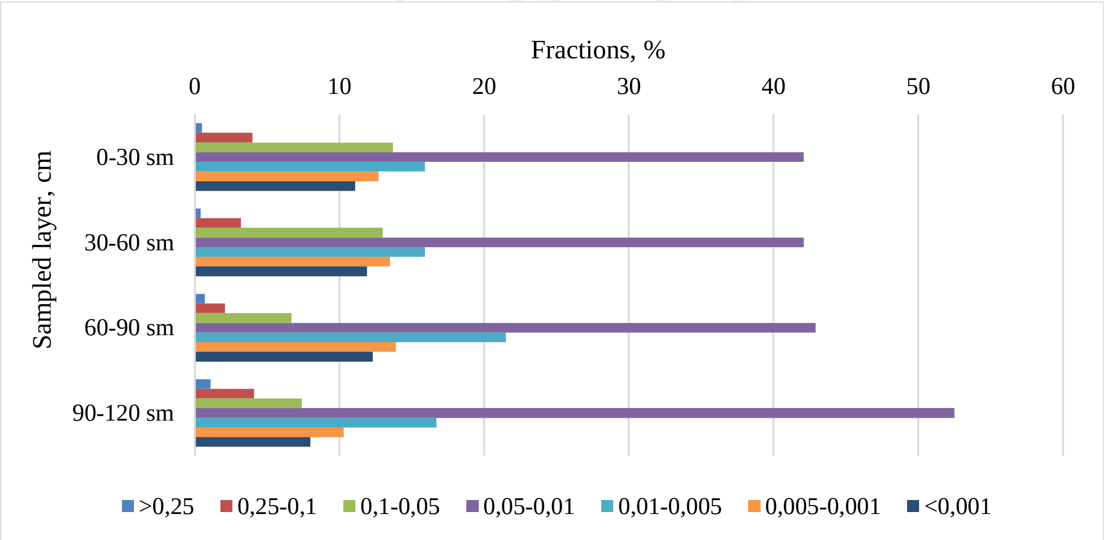

Figure 6. Mechanical composition of soil from Experimental Field 4

According to the results of the research conducted to determine the mechanical composition of the experimental field soil, it was found that the soils mainly consist of medium and heavy loam. Based on observed data on changes in the hydrological regime of the Karasuv River, graphs illustrating the relationship between river water discharge and groundwater levels from 2010 to 2023 were developed. To analyze the impact of the river's hydrological regime on groundwater level fluctuations, a graph depicting the correlation between river water discharge and groundwater levels was plotted (Figure 7).

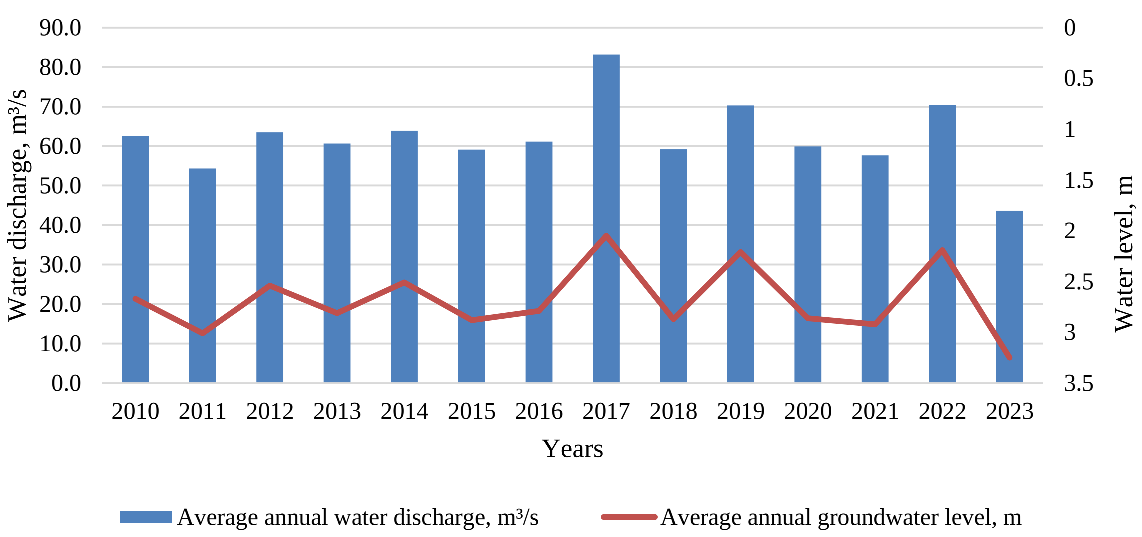

Figure 7. Graph of changes in Karasuv River discharge and groundwater levels (2010–2023)

Figure 7 illustrates the changes in average annual water discharge and average annual groundwater levels in the selected area for the period 2010–2023. Data analysis shows that during this period, there is a dynamic interrelationship between water discharge and groundwater levels, with significant fluctuations observed in different years.

Specifically, in 2017, the average annual water discharge reached its highest value of 83.2 m³/s, representing a notable increase compared to other years. At the same time, the average annual groundwater level rose to 2.05 meters. Conversely, in 2023, the average annual water discharge decreased to 43.7 m³/s, one of the lowest values recorded during the entire observation period. In that same year, the groundwater level dropped to 3.25 meters, marking the lowest point.

Overall, throughout the analyzed period, a consistent correlation between water discharge and groundwater levels was observed, with increases in water discharge corresponding to rises in groundwater levels.

Based on the observed data, the filtration rate is calculated using the above-mentioned formula (1) [3]. Considering the selected conditions, formula (1) can be expressed in the following form:

$$q_d = T * I + \mu \frac{F}{t} \qquad [\frac{m^2}{sutka}] \qquad (1)$$

Here:
q_d- filtration amount (per one pagonometer);
μ- soil permeability coefficient; μ =0.02
t-time (duration of observation) t = 10 days
T- the hydraulic conductivity of the layer is calculated as follows:

Initially, the changes in the difference of elevations between the river and the observation well over the distance were examined, and based on this, the variation of filtration rate along the distance was determined (Figure 8).

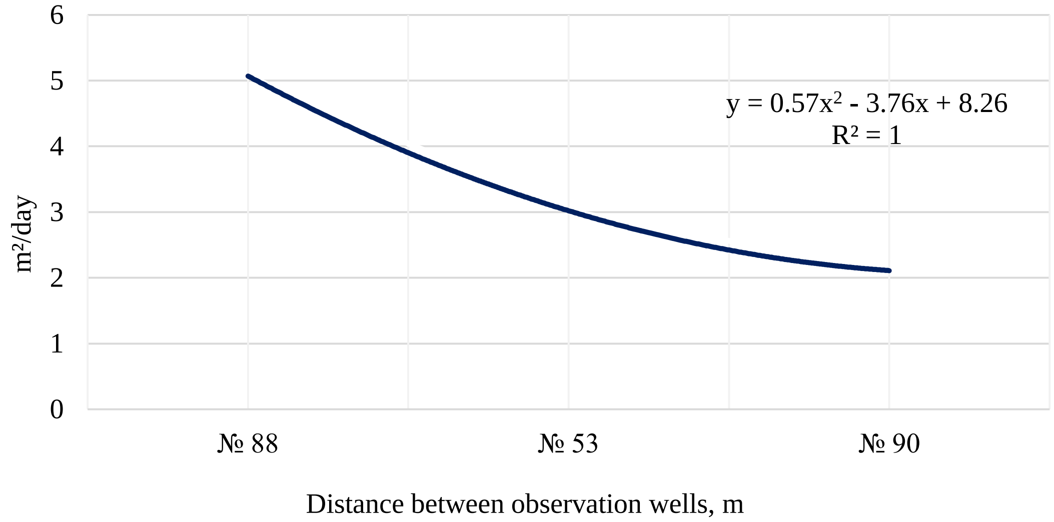

Figure 8. Graph of filtration rate variation along the distance from observation well No. 88 to wells No. 53 and No. 90

To determine changes in groundwater levels at the observation wells, this parameter was studied in relation to the water level of the Karasuv River. Within the scope of the research, filtration rates at Lindsay well No. 90 and Polygon well No. 88 were determined using hydrogeological methods, and a correlation graph between them was constructed.

As a result of the conducted scientific investigations, the impact of the Karasuv River water level on groundwater levels in the irrigated areas was established, and the dynamics of these changes were evaluated. The research findings provided deeper insight into the hydraulic connectivity between the river and groundwater.

Conclusion. During the study, the dynamics and hydrogeological characteristics of groundwater in the irrigated areas of the Karasuv River basin were analyzed.

- The mechanical composition and water permeability properties of the soil were examined both in the field and laboratory conditions. The results showed that 70% of the soil in the area consists of particles sized between 0.1 and 0.01 mm.

- The relationship between the water discharge of the Karasuv River and the changes in groundwater levels was investigated. Data from 2010 to 2023 revealed significant fluctuations in water discharge and groundwater levels. It was found that the variations in average annual water discharge and groundwater level corresponded to each other, with the highest discharge recorded in 2017 and the lowest in 2023.

- The correlation between filtration rate and the hydrogeological influence of the river was analyzed, and the filtration amount was determined based on hydrogeological data. Calculations showed that the filtration rate varied from 2.11 to 5.07 m^3/day.

The research results identified hydraulic connections between the Karasuv River and groundwater. This relationship provides essential scientific foundations for effective management of the region's hydrogeological conditions and water resources.

References

1. Belov K.V., Voloshin V.R., Cherepanskiy M.M. Regionalnaya gidrogeologiya: uchebnoe posobie dlya vuzov. – SPb.: Lan, 2024. – 196 s.
2. Yusupov G.U., Xolbaev B.M. Geologiya va gidrogeologiya asoslari. – Toshkent, 2003. – 281 b.
3. Kovalev S.G., Khabibullin R.R., Lapikov V.V., Abdyukova G.M. Obshchaya geologiya s osnovami gidrogeologii i gidrologii. – Ufa, 2006 g.
4. Belcher W.R., Sweetkind D.S. Death Valley regional groundwater flow system, Nevada and California: hydrogeologic framework and transient groundwater flow model. – U.S. Geological Survey Professional Paper 1711. – 2010. – 398 p.
5. Chen Z., Nie Z., Zhang H., Cheng X., He M. Groundwater renewability based on groundwater ages in the Heihe valley alluvial basin, Northwestern China // Acta Geologica Sinica. – 2004. – Vol. 4. – P. 560–567.
6. Fatkhulloev A.M., Khamrokulov J.S., Tuykulov M.I. Vliyanie antropogennykh faktorov na kolichestvennye izmeneniya stoka reki Karasuv v razlichnykh gidrologicheskikh usloviyakh. Zhurnal Ekonomika i socium - 2025 - №1 (128). s. 577-585. Saratov, Russiya.