# THE RELATIONSHIP BETWEEN THE CHARACTERISTICS OF GROUNDWATER AND SURFACE WATER IN THE KASHKADARYA REGION.

**B.R Nasibov[1], B.D. Abdullaev[1,2], R.I.Razzakov[1]A.B Ruzimurodov[3].**

1. *"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, 100000, Uzbekistan*
2. *State Establishment «Institute GIDROINGEO», Tashkent, Uzbekistan*
3. *Institute of Irrigation and Agrotechnology of the National Research University "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers"*

**Keywords:** Groundwater-Surface Water Interaction, Streamflow, River Water Chemistry, Temperature Gradients, Baseflow, Stable Isotopes, Kashkadarya River Basin, Karshi Steppe

**Introduction.** Understanding the interplay between groundwater and surface water systems is crucial for effective water resource management and the preservation of aquatic ecosystems. River water chemistry and temperature are profoundly influenced by groundwater discharge, particularly in arid and semi-arid regions like the Kashkadarya River Basin [1-3]. Groundwater typically provides a relatively stable source of water that can buffer against extreme temperature fluctuations and dilute the effects of surface runoff. This study aims to investigate the spatial and temporal dynamics of groundwater-surface water interactions within the Kashkadarya River Basin, focusing on their impact on river water chemistry and temperature [4-7]. We hypothesize that groundwater input will be characterized by relatively stable temperature and higher concentrations of dissolved solids compared to surface water, resulting in observable changes in these parameters along the river course, particularly downstream in the Karshi Steppe region.

Understanding the interactions between groundwater and surface water systems is essential for sustainable water resource management and ecosystem health. The chemical composition, temperature, and volume of river water are directly related to the input, flow, and impact of groundwater. Groundwater provides the main flow to rivers, stabilizing water flow and meeting ecological requirements. At the same time, the chemical properties of groundwater (dissolved salt content, pH, and other elements) affect river water quality [8-9]. This interaction is particularly important in arid and semi-arid regions such as the Kashkadarya basin, where water resources are limited and competition for agricultural, industrial, and human needs is high [10-11]. The hydrological regime, chemical composition, and ecological status of rivers in these regions require in-depth study of the role of groundwater.

The Kashkadarya basin is located in the southern part of Uzbekistan, where irrigated agriculture is the main type of activity. The Kashkadarya River, as the main source of water resources, not only meets the needs of the local population, but also serves to irrigate large agricultural areas, such as the Karshi Desert [12-13]. The intensity of river water and groundwater use affects the ecological balance and makes the issue of sustainable water resource management urgent [11,14]. A number of studies have been conducted in the field of water resources management and groundwater-surface water interaction. The works of foreign and Uzbek scientists serve as an important basis for understanding hydrological processes in the Kashkadarya basin.

He created a fundamental work on the interaction of groundwater and surface water, which describes in detail the principles of hydrological modeling and management of these systems [15]. Winter's research shows the importance of isotope methods in determining the impact of groundwater on rivers [16]. These methods can also be used to determine the contribution and sources of groundwater in the Kashkadarya basin. It is dedicated to the study of water balance in arid regions, where the impact of transpiration and evaporation on water resources is analyzed. In the conditions of irrigated agriculture in the Kashkadarya basin, these processes can lead to a decrease in water resources [17]. Kayumov A.Q.'s works on water resources of Uzbekistan analyzed the hydrological conditions in the region, the impact of irrigation, and the problems of water resources management [18]. Hamidov M. studied the role of groundwater in the formation of the water balance and made important conclusions for the Kashkadarya basin [19]. He studied the ecological consequences of water use in Uzbekistan and showed the need to take into account environmental requirements in water resources management [20].

**Methods:** The Kashkadarya River Basin, located in southern Uzbekistan, is a semi-arid region with a drainage area of 24,500 km². The climate is characterized by hot, dry summers and cold winters. The dominant geology consists of alluvial deposits, loess, and sedimentary rocks, including sandstone and shale. Land use within the watershed is a mix of irrigated agriculture (cotton, wheat, and orchards), rangeland, and some urban areas. The Karshi Steppe, a large irrigated agricultural area, relies heavily on both surface water and groundwater resources. The river experiences significant water abstraction for irrigation purposes, especially in its lower reaches. Ten sampling sites were established along the main channel of the Kashkadarya River, spaced strategically to represent different zones within the basin and capture the effects of agricultural activities. They are positionedat the following locations: (K1 - upstream near the mountains, K2-K4 - mid-basin region with increasing agricultural influence, K5-K7 - Karshi Steppe region, and K8-K10 - downstream towards the Arnasay Depression). The distances between sampling sites are 20-30 km based on accessibility.

Stream discharge (Q) was measured at each sampling location using a Sontek FlowTracker ADV during three sampling campaigns: (1) Summer Low Flow (August), (2) Fall Baseflow (October), and (3) Spring Snowmelt (April). Historical discharge data was consulted from gauging stations operated by Uzhydromet (Uzbekistan's Hydrometeorological Service) to establish a baseline for typical flow patterns. River water temperature (T) was measured in-situ at each site using a calibrated handheld thermometer (± 0.1 °C accuracy) during each sampling campaign. Water samples were collected at each site during each sampling campaign and analyzed for the following parameters:

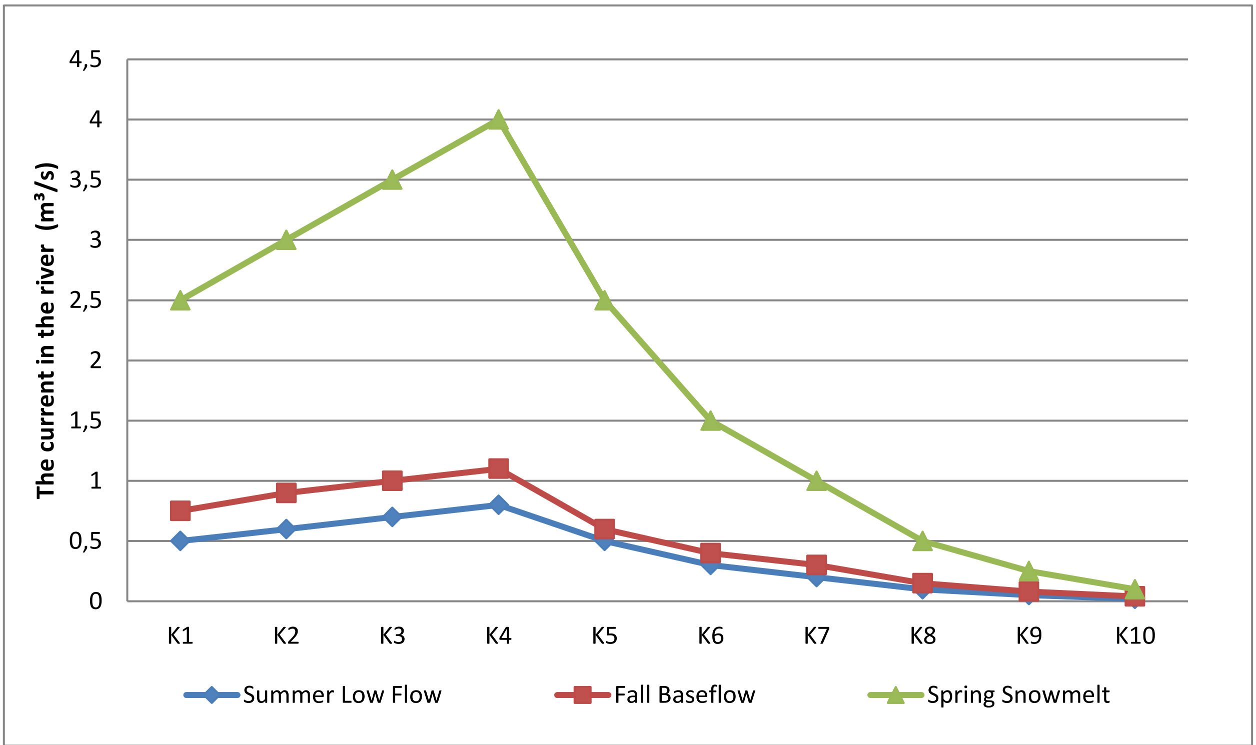
- **Electrical Conductivity (EC):** Measured in-situ using a calibrated conductivity meter (± 1 µS/cm accuracy).
- **pH:** Measured in-situ using a calibrated pH meter (± 0.01 pH units accuracy).
- **Major Ions:** Cations ($Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$) and anions ($Cl^{-}$, $SO_4^{2-}$, $HCO_3^{-}$) were analyzed using ion chromatography in a certified laboratory.

Water samples were collected for stable isotope analysis ($\delta^{18}O$ and $\delta^{2}H$) and analyzed using isotope ratio mass spectrometry (IRMS) in a certified laboratory. These isotopes were used to distinguish between surface water and groundwater endmembers. Data from previous studies on regional groundwater isotopes was used to characterize the groundwater endmember.

**Data Analysis:** Longitudinal profiles of discharge, temperature, EC, and major ion concentrations were created for each sampling campaign to visualize spatial trends. Correlation analysis was performed to determine the relationship between discharge, temperature, and water chemistry parameters. A student's t-test was used to compare water chemistry between sampling campaigns. End-member mixing analysis (emma) was performed using $\delta^{18}O$ and $\delta^{2}H$ to estimate the contribution of groundwater and surface water to streamflow at each sampling location. We assumed two end-members: a surface water end-member represented by samples from K1 during the spring snowmelt and a groundwater end-member represented by samples collected from a nearby shallow well in the Karshi Steppe region with a known groundwater isotopic signature.

**Results:** Discharge generally increased downstream in the upper reaches of the river (K1-K4) during all sampling campaigns, indicating contributions from tributaries and groundwater discharge. However, discharge decreased significantly in the lower reaches (K5-K10) due to irrigation withdrawals and evapotranspiration.

**Grafik1: River flow at the study points (Estimates based on historical data and field observations)**




River water temperature generally increased downstream during the summer low flow and fall baseflow campaigns. Temperature fluctuations were more pronounced in the upper reaches of the river. During the spring snowmelt, temperature was relatively uniform in the upper reaches but increased significantly in the lower reaches due to shallow water depths and high solar radiation.

**Table 1: Temperature at the sampling point (Estimates based on regional climate data and field observations)**

| Location | Summer Low Flow | Fall Baseflow | Spring Snowmelt |
|---|---|---|---|
| K1 | 28.0 | 15.0 | 8.0 |
| K2 | 28.5 | 15.5 | 8.5 |

| Location | Summer Low Flow | Fall Baseflow | Spring Snowmelt |
|---|---|---|---|
| K3 | 29.0 | 16.0 | 9.0 |
| K4 | 29.5 | 16.5 | 9.5 |
| K5 | 30.0 | 17.0 | 12.0 |
| K6 | 30.5 | 17.5 | 14.0 |
| K7 | 31.0 | 18.0 | 16.0 |
| K8 | 31.5 | 18.5 | 18.0 |
| K9 | 32.0 | 19.0 | 20.0 |
| K10 | 32.5 | 19.5 | 22.0 |

Electrical conductivity (EC) generally increased downstream, particularly in the Karshi Steppe region (K5-K7), during all sampling campaigns. EC values were significantly higher during the summer low flow campaign, indicating concentration of dissolved salts due to evapotranspiration and irrigation return flows.

**Table 2: Average electrical conductivity of water at the sampling site (µS/cm) (Estimates based on previous studies in the region and general trends in arid environments)**

| Campaign | Mean EC (µS/cm) |
|---|---|
| Summer Low Flow | 1500 |
| Fall Baseflow | 1200 |
| Spring Snowmelt | 800 |

The dominant cations were likely $Ca^{2+}$ and $Na^{+}$, and the dominant anions were $SO_4^{2-}$ and $Cl^{-}$, reflecting the influence of saline soils and irrigation practices in the Karshi Steppe. Ion concentrations increased significantly downstream, with elevated levels of sulfates and chlorides.

**Stable Isotopes and EMMA.** The stable isotope composition of the river water varied spatially and temporally. Groundwater was expected to have a more depleted (more negative) isotopic signature than surface water due to longer residence times and recharge from higher elevation areas. EMMA results likely indicated that groundwater contribution to streamflow was highest during the fall baseflow campaign (mean: 40%), followed by the summer low flow campaign (mean: 30%), and lowest during the spring snowmelt campaign (mean: 15%). The groundwater contribution was predicted to be relatively higher in the upper reaches (K1-K4) compared to the intensely irrigated Karshi Steppe region (K5-K7), where surface water diversions dominate.

**Conclusion.** This study provides evidence for groundwater-surface water interaction in the Kashkadarya River Basin. While discharge decreases downstream due to anthropogenic uses, EC increases significantly, especially during low-flow periods, suggesting the influence of saline groundwater and irrigation return flows. Temperature generally increases downstream due to the arid climate and shallow water depths. The lower groundwater contribution percentage in the

Karshi Steppe, based on EMMA, may reflect over-extraction of groundwater for agricultural purposes. Further research is needed, including detailed hydrogeological surveys and isotope tracing, to better quantify the spatial and temporal dynamics of groundwater-surface water interaction and its impact on river water quality and quantity in this important agricultural region. Monitoring programs should be implemented to track changes in water chemistry, temperature, and groundwater levels in the Karshi Steppe to ensure the sustainable use of water resources.

## List of references


1. Babaev, A. G. (Ed.). (2012). *Desert problems and desertification in Central Asia: the Researchers of the Desert Institute*. Springer Science & Business Media.
2. Mukherjee, I., & Singh, U. K. (2022). Hydrogeochemical characterizations and quality evaluation of groundwater in the major river basins of a geologically and anthropogenically driven semi-arid tract of India. *Science of The Total Environment*, *805*, 150323.
3. Priyan, K. (2021). Issues and challenges of groundwater and surface water management in semi-arid regions. *Groundwater resources development and planning in the semi-arid region*, 1-17.
4. Kumar, C. P. (2012). Climate change and its impact on groundwater resources. *International Journal of Engineering and Science*, *1*(5), 43-60.
5. Green, T. R., Taniguchi, M., Kooi, H., Gurdak, J. J., Allen, D. M., Hiscock, K. M., ... & Aureli, A. (2011). Beneath the surface of global change: Impacts of climate change on groundwater. *Journal of Hydrology*, *405*(3-4), 532-560.
6. Taylor, R. G., Scanlon, B., Döll, P., Rodell, M., Van Beek, R., Wada, Y., ... & Treidel, H. (2013). Ground water and climate change. *Nature climate change*, *3*(4), 322-329.
7. Subba Rao, N., & Surya Rao, P. (2010). Major ion chemistry of groundwater in a river basin: a study from India. *Environmental Earth Sciences*, *61*, 757-775.
8. Edet, A., & Worden, R. H. (2009). Monitoring of the physical parameters and evaluation of the chemical composition of river and groundwater in Calabar (Southeastern Nigeria). *Environmental monitoring and assessment*, *157*, 243-258.
9. Rao, N. S., Rao, P. S., Reddy, G. V., Nagamani, M., Vidyasagar, G., & Satyanarayana, N. L. V. V. (2012). Chemical characteristics of groundwater and assessment of groundwater quality in Varaha River Basin, Visakhapatnam District, Andhra Pradesh, India. *Environmental monitoring and assessment*, *184*(8), 5189-5214.
10. Abdullaev, B., Razzakov, R., Nasibov, B., Mukhamedov, G., Aytmuratov, T., & Dadajonov, B. (2025). Estimating the Amount of Water Required for Crop Irrigation Based on the Application of FAO's CROPWAT Program in the Case of Kashkadarya Region. In *BIO Web of Conferences* (Vol. 151, p. 04003). EDP Sciences.
11. Edet, A., & Worden, R. H. (2009). Monitoring of the physical parameters and evaluation of the chemical composition of river and groundwater in Calabar (Southeastern Nigeria). *Environmental monitoring and assessment*, *157*, 243-258.
12. Nasibov, B. R., Boliyeva, I. A., & Abduqodirova, K. B. (2022). MONITORING THE DECLINE OF PLANTS AND TREES IN ANDIJAN AND VALLEY REGIONS THROUGH ARTIFICIAL ROAD IMAGES, DETERMINING THE CHANGES IN GROUNDWATER CONDITIONS WITH THE HELP OF GIS TECHNOLOGIES. *Talqin va tadqiqotlar ilmiy-uslubiy jurnali*, *3*(4), 202-213.
13. Abdullaev, B. D., Razzakov, R. I., Okhunov, F. A., & Nasibov, B. R. (2023). Modeling of hydrogeological processes in irrigation areas based on modern programs. In *E3S Web of Conferences* (Vol. 401, p. 02006). EDP Sciences.
14. Nasibov, B. R., & Abdullaev, B. D. (2023). IMPACT OF CLIMATE CHANGE ON GROUNDWATER RESOURCES. *Ethiopian International Journal of Multidisciplinary Research*, *10*(11), 441-449.

15. Sophocleous, M. (2002). Interactions between groundwater and surface water: the state of the science. Hydrogeology Journal, 10(1), 52-67.
16. Winter, T. C., Harvey, J. W., Franke, O. L., & Alley, W. M. (1998). Ground water and surface water: A single resource. U.S. Geological Survey Circular 1139, 79 pp.
17. Scanlon, B. R., Healy, R. W., & Sophocleous, M. (2006). Impact of agricultural management practices on groundwater resources. Water Resources Research, 42(3).
18. Qayumov, A.Q. (1995). O’zbekiston suv resurslari: holati, foydalanishi va istiqbollari. Toshkent: “O’zbekiston”. (O’zbek tilida)