# STUDY WATER CYCLE PROCESS ON THE TERRITORY OF GEORGIA

*Melikadze G., *Todadze M., *Tchankvetadze A., **Chitanava R., **Gaprindashvili M., *Chikadze T.

*Mikheil Nodia Institute of Geophysics of Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia
**National Environmental Agency, Tbilisi, Georgia
melikadze@gmail.com

***Abstract.*** *Application of environmental tracers was using in the assessment of water cycle process and groundwater vulnerability will be elaborated. Was starting organization monitoring network for study spatial-temporal variation of stable isotope on the territory of Georgia.*

***Key words****: stable isotopes, monitoring network, seasonal variation.*

## Introduction

Monitoring of isotopic tracers over the country would provide the essential information which is currently not available in Georgia and expand the opportunities for both research and practical recommendations related to the hydrological cycle and water management. Stable and radioactive isotopes (18O, 2H, 3H) of the water molecule provide the information which may otherwise be difficult or impossible to obtain, e.g., example on the time spent by the water in an aquifer, altitude of groundwater recharge area, contribution of river or snowmelt waters to the production wells, or identification of old waters recharged during other climatic conditions [1-5].

## Material and methods

The project of Georgian Scientific foundation FR-18-10092 "Mapping environmental tracers for the assessment of water resources in Georgia under Changing Climatic Conditions" consists in the regional application of isotopic and hydrochemical methods for a better understanding of water cycle process and links among groundwater's, surface waters and pollution sources.

The main aim of the project is Analysis of spatial and temporal distribution of isotopic and geochemical composition of natural waters in Georgia, identification of perspective water resources and their potential vulnerability. Organize new and use of existing monitoring networks for determining the background and character of variations isotopic and geochemical composition.

In the frame of project, from the 2019, the temporal (monthly) sample collection for isotopic analyses carried out in the existing networks of Geological Hydrometeological Departments of National Environmental Agency (NEA) of Ministry of Environmental protection and Agriculture. Their network consists 8 GNIP (Global Network of Isotopes in Precipitation) and 4 GNIR (Global Network of Isotopes in Rivers) stations. Furthermore, monitoring network of Geological department that includes 34 boreholes and 6 springs. Supplementary data hydrological and meteorological data from the existing networks (e.g. precipitation amount, air temperature, river discharge, results of chemical and isotopic analyses, water conductivity and pH) will be used too. Based on the existed agreement between mentioned above organization and Institute of Geophysics, carry out sampling for isotope by NEA, which will be carried out for analysis in the Institute of Geophysics. In addition, Union water Company monthly collect samples for analyses stable isotopes. Besides, Institute of Geophysics monitoring network included the deep boreholes monitoring network (www.hggrc.net), which covered all the territory of Georgia and where carried out monthly sampling campaign for chemical and isotope analysis. The existing and newly obtained data are using for assessment temporal variation of stable isotopes and geochemical parameters (background, seasonal variation etc.)

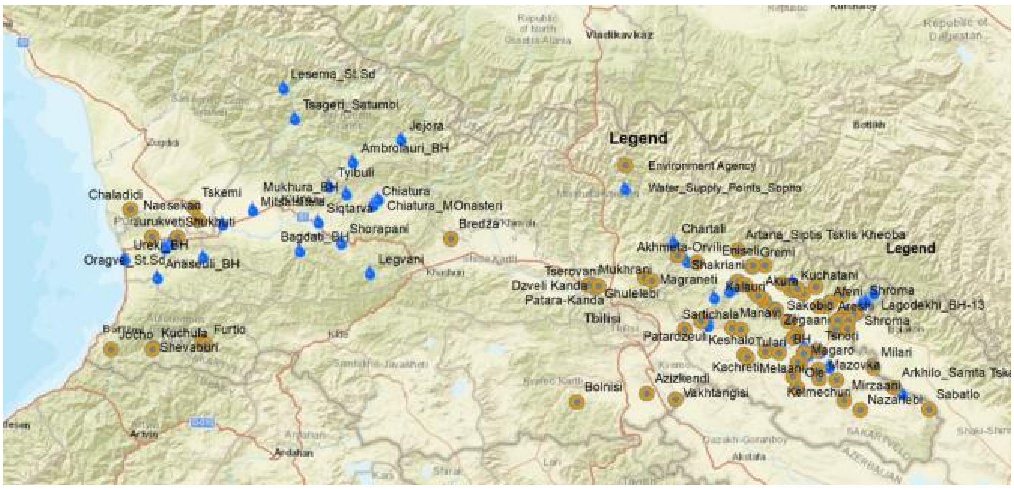


*Fig. 1. Location monitoring network on the territory of Georgia.*

*surface water monitoring station; Shallow groundwater monitoring station.*

For example, demonstrated variation of parameters on the Tbilisi metrological station, as one of station from the GNIP network.

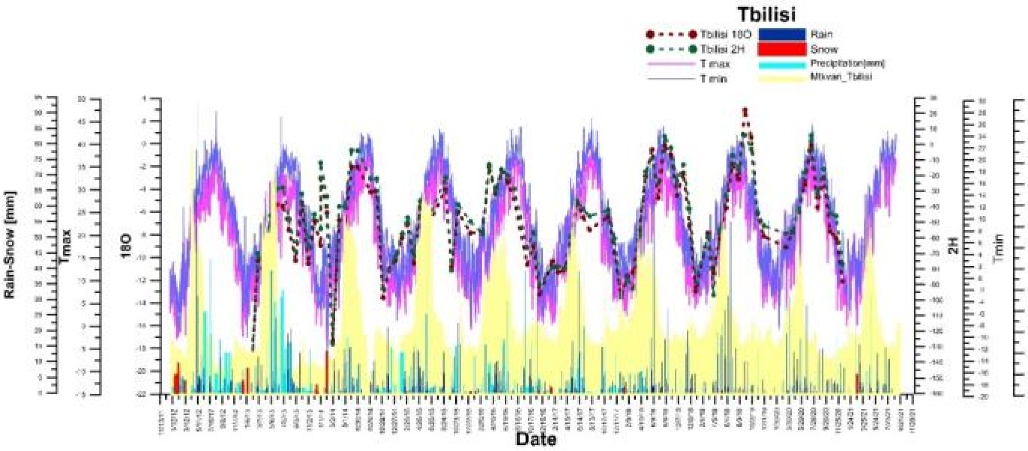


*Fig.2. Variation of parameters on the Tbilisi metrological*

Variation of atmospheric precipitation at the Tbilisi Meteorological Station since 2012 year: rain and snow (blue and red vertical lines), maximum air temperature (crimson line), minimum temperature (blue line), stable isotopes 18O (red dashed line) and 2H (blue dashed) and river flow (yellow) variations.

The join material allows for the tracking of seasonal variations. An analysis of the change in the isotopic composition of the atmospheric precipitation was made. The obtained results reveal that the precipitation falling in the form of snow is isotopically light, which is completely regular. The values of 18O vary from (-35) to (-5), and the value of 2H varies from (-90) to (-10). Precipitation in the form of snow is very little, because the air temperature rarely falls below zero.

Average annual and monthly values of δ18O, δ2H stable isotopes in sediments, as well as ranges and amplitudes of δ18O and δ2H changes were calculated for these stations. The national meteorological water line (NMWL) for Georgia and local meteorological water lines for individual precipitation stations were determined by linear regression using all monthly values. NMWL represents the covariance of the countrywide spatial variation of δ2H-δ18O values.

Monthly river water samples were collected between 2013 and 2022 from several major rivers, including the Rion River in western Georgia and the Mtkvari River in central Georgia and the Alazani River in eastern Georgia.

Complex information on the isotopic composition of precipitation and river runoff was used to estimate the river's recharge area, their places of origin, and the mean transit time the water in the catchment.

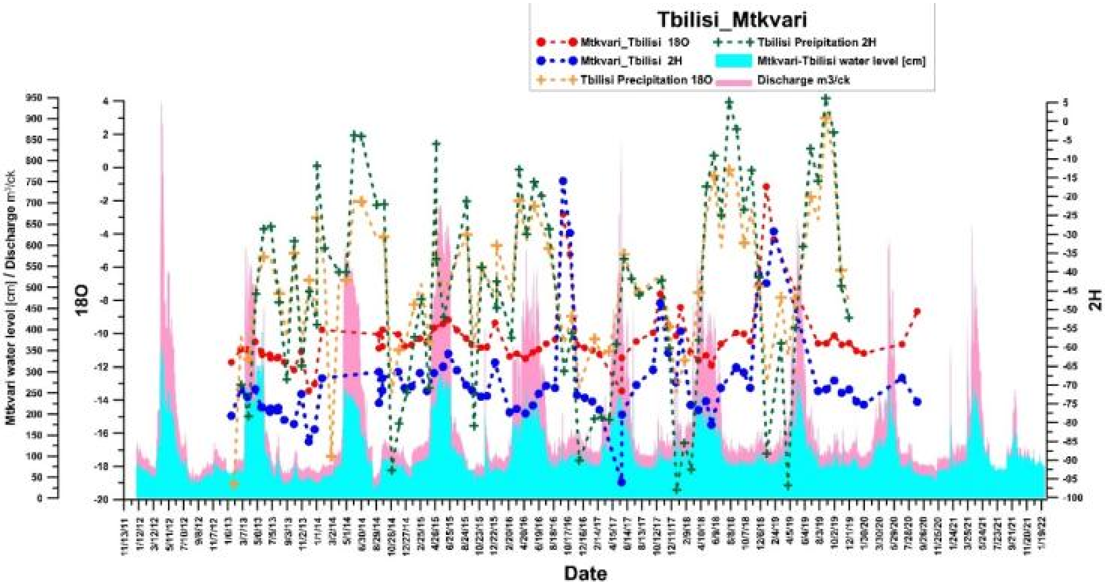


*Fig. 3. Variation of parameters in river Mtkvari*

The figure shows the variations of the water level (orange curve) and discharge (crimson) in the Mtkvari River, which coincide with the variations of the isotopic composition of the river (red and blue) and the isotopic composition of the atmospheric precipitation (green and yellow dots).

In order to study the development of processes in underground waters, hydrochemical and isotopic tests were performed periodically (once in 1-1.5 months) in the wells. Below is an example of graphs of isotopic composition changes in one of the Gurjaani wells.

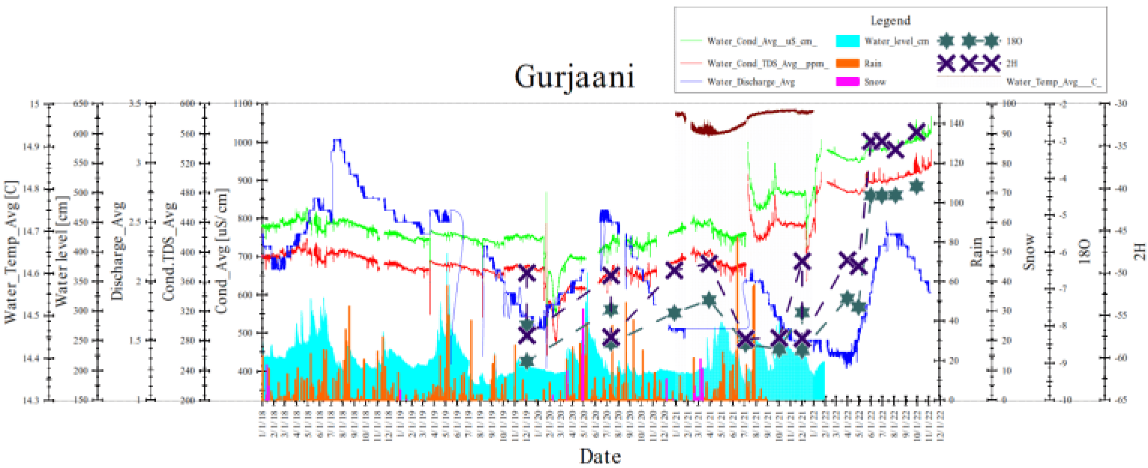


*Fig. 4. Variations of underground water parameters in the Gurjaani borehole.*

The figure shows the variations of atmospheric precipitation (brown) and discharge (dark blue) in the Gurjaani well completely coincide with the variations of isotopic composition (black star and cross), temperature (brown), river water conductivity (green) and total mineralization (red) in the river.

At the same time, in the change of the chemical and isotopic composition of the waters, a clear regularity was observed. The isotopic composition of atmospheric precipitation is characterized by the lightest "young" composition. The isotopic composition becomes "heavier" along with the displacement towards the direction of moving in surface and further underground waters. This indicates the direction of water flow.

Using stable isotopes, it is possible to follow this process and determine the mean transit time of water flow. This can be done by comparing the isotopic composition of water. In particular, by combining the isotopic composition of atmospheric precipitation at the meteorological station with the isotopic composition of the river station or groundwater boreholes of the study area.

"Method of sinusoidal curves" was used to determine the average time of groundwater flow according to the exponential model. For this, sinusoidal curves were build with the data of individual stations and the corresponding analysis was carried out. Specifically, the curve of isotopic data in atmospheric sediments of Bakuriani station and the isotopic data curve of river water at Likan station were compared. Among them, the Bakuriani station is located at a higher point, and Likan is 1099 m above sea level.

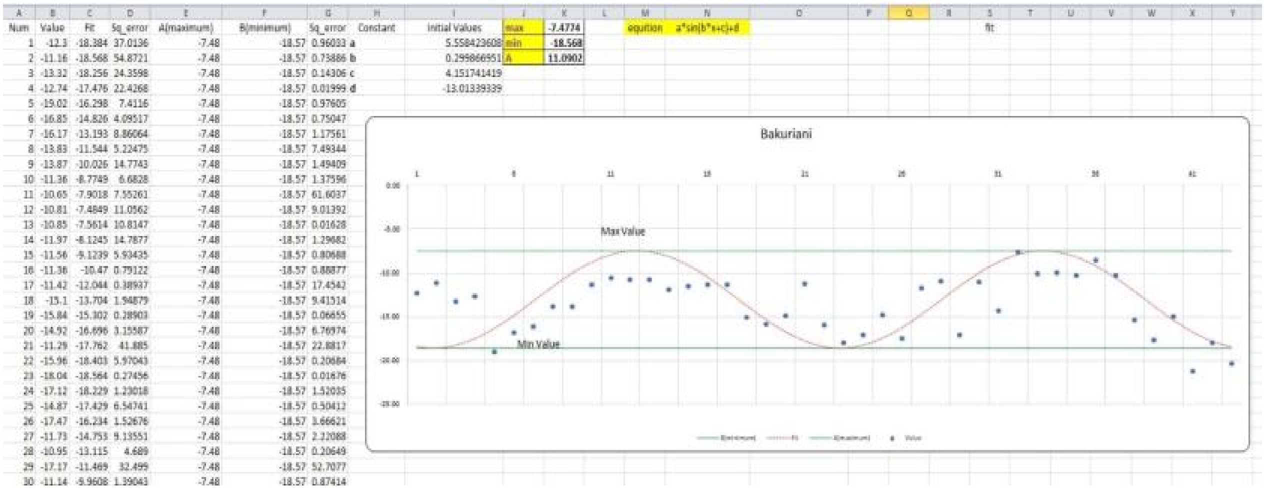


*Fig.5. Sinusoidal graph of change of monthly isotopes data of precipitation in Bakuriani station*

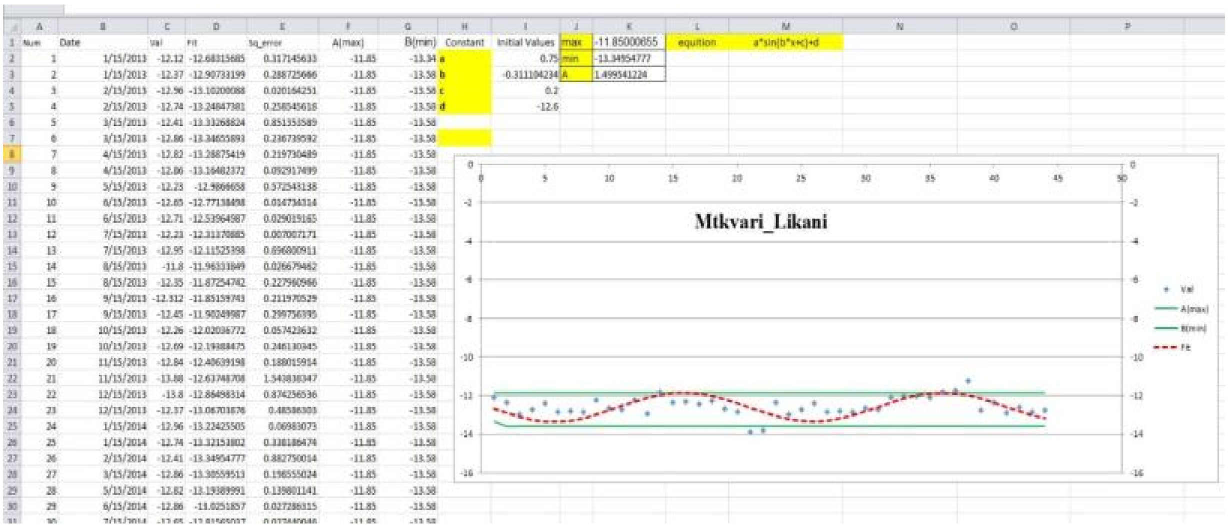


*Fig.6. Sinusoidal graph of monthly isotope data changes on Mtkvari river*

A –isotopic value of precipitation

B - isotopic value of river

To calculate the mean transit time, the average value of precipitation was used as "input" data, and the isotopic value of the Mtkvari River was used as "output" data, and their dependence on each other was determined through the formula.

A - isotopic value of sediments

B - isotopic value of river water

MTT= sqrt/(2*PI())

From where sqrt=SQRT(1/f2-1), f=B/A, 1/f2= 1/POWER

The movement time calculated by the simple sinusoidal wave method was determined that the mean transit time of the water flow from the infiltration of the sediments into the soil at the Bakuriani station to their unloading in the Mtkvari river (near Likan) is about 1 month.

Conclusions:

Isotopic composition of water in the study area evolves according to a line parallel with the global meteoric water line. Studded average value of stable isotope ($^{18}O$-$^{2}H$) and its relationship. Fixed isotope value in difference water source (precipitation, surface and groundwater) and following evolution of groundwater isotopic composition in the space (pathway from recharge to the discharge area) and temporal (seasonal variation) variation.

## References


[1] Melikadze G., Chelidze T., Zhukova N., Rozanski K., Dulinski M., Vitvar T. Using nuclear technology for environmental safety and sustainable development of water resources in Borjomi region (Southern Georgia). // Journal of Georgian Geophysical Society, ISSN: 1512-1127, Issue (A), Physics of Solid Earth 13a, 2009, pp. 17-25.

[2] Melikadze G., Chelidze T., Jukova N., Malik P., Vitvar T. Using Numerical Modeling for Assessment of Pollution Probability of Drinking Water Resources in Borjomi Region (Southern Georgia). // In: Climate Change and its Effects on Water Resources, Issues of National and Global Security (Baba A., Tayfur G., Gunduz O., Howard K.W.F., Fridel M.J., Chambel A., eds.), NATO Science Series. Springer. ISBN:978-94007-1145-7. Chapter 29, 2011, pp. 267-275.

[3] Vitvar T., Aggarwal P.K., Herczeg A.L. Global Network is launched to monitor isotopes in rivers. // EosTrans. AGU 88. 2007, pp.325–326.

[4] Melikadze G., at al. Preliminary result of stable isotopes monitoring in the Alazani-Iori catchment. // Journal of Georgian Geophysical Society, ISSN: 1512-1127, Issue (A), Physics of Solid Earth, v.17a, 2014, pp. 39-46.

[5] Melikadze G., Zhukova N., Todadze M., Vepkhvadze S., Vitvar T. Result of numerical modelling of groundwater resource in the Shiraki catchment". // Journal of Georgian Geophysical Society, ISSN: 15121127, Physics of Solid Earth, v. 17a, 2014, pp. 102-108.



**Acknowledgments:** The authors thank the Rustaveli National Scientific foundation for financial support of the project #FR-18-18-10092 "Mapping environmental tracers for the assessment of water resources in Georgia under Changing Climatic Conditions".