# Isotopic characteristics ($\delta^{18}O$ and $\delta D$) of surface and groundwater as an additional tool for searching quality drinking water (Western part of Novosibirsk Region, Russia)

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**Abstract** Lack of quality drinking water is a problem for the western part of the Novosibirsk Region (Russia), where the total mineralization of water varies from 1.5 to 3-4 g/L and sometimes higher. The search for near-surface aquifers with high-quality groundwater can be successfully carried out using electrical tomography. To understand the relationship between groundwater of different depths, the isotopic characteristics ($\delta^{18}O$ and $\delta D$) of the waters of existing wells was studied. The groundwater studied is likely to have a common origin.

## 1 Introduction

Lack of quality drinking water is a problem for many regions of the planet. It is also relevant for the western part of the Novosibirsk Region (Russia), where the total mineralization of both groundwater and surface water is predominantly high and varies from 1.5 to 3-4 g/L and sometimes higher. The high salinity is mainly due to the marine geochemical conditions of sedimentation of aquifers. In this region, especially in small settlements, groundwater from deep aquifers is a main source of water both for agriculture and for drinking purposes. However, water supply from shallow zones is becoming increasingly important. Lack of quality groundwater in the region is caused not only by natural factors, but also by insufficient state of water resources exploration [1]. The search for near-surface aquifers with high-quality groundwater can be successfully carried out using geophysical methods, in particular, electrical tomography [2, 3]. The geophysical methods have a drawback, i.e. they only allow to outline an area saturated with low-salinity water. However, the geological structure of the region is such that it can be an outline of a lense formed by meteoric water, which accordingly will have a minor reserve of water, especially given the arid climate of the region. However, it is also possible to find a reservoir that is a paleochannel with a more or less constant inflow of fresh water.

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Isotope methods are widely used to assess the sources of groundwater supply [4, 5, 6, 7]. The light stable isotopes of the water molecule (H and O) are ideal tracers for estimating the recharge areas and flow path of groundwater. Isotopic ratios ($\delta^{18}O$ and $\delta D$) in water are indicative of meteoric water amount and mark both the origin of groundwater and the interaction of surface and groundwater. Earlier researchers have obtained $\delta^{18}O$ and $\delta^{2}H$ values for surface water and precipitations of Barabinsk lowland [8, 9], and for bottom sediments of Lake Chany during studying of paleoclimatic conditions [10]. Isotopic characteristics of groundwater for the western part of the Novosibirsk Region have never been analyzed before.

# 2 Geological and Hydrogeological settings

## 2.1. Geology and geomorphology

The western part of the Novosibirsk Oblast is geologically a platform cover composed of Mesozoic and Cenozoic sediments with total thickness from 1100 to 2700 m. The history of sedimentation is characterized by two stages of the marine transgression in the Late Jurassic and the Early Paleogene. The continental regime was re-established in the second half of the Tertiary period. Lithologically, the entire stratum is represented by the alternation of various sandstones, clays, siltstones, sands, and aleurites.

Quaternary sediments are represented by sands, clays, sandy loams and loams of various origin. The eroded Neogen surface is covered with Early-Middle Quaternary deposits, which also form the ancient river valleys. Before the onset of Upper Quaternary sedimentation, erosion occurred and formed the alluvial plain. At this time, the valleys of the modern river network started to form.

The relief of this area is very slightly dissected. The depth of the cut of rivers and lake basins does not exceed 1.5 - 2 m. The area is characterized with gently rolling topography with low ridges oriented from the southeast to the northwest, which is typical of the entire southern part of the West Siberian Lowland. Depressions between low ridges are filled with lakes, marshes and salt marshes. The Barabinsk lowland is characterized by pitted micro-relief, represented by small saucer-shaped depressions. Researchers of the paleoclimate of the Barabinsk lowland point out the peculiarity of the formation of the Lake Chany [11], largest lake in the area. The rivers that feed the lake flow through chains of saucer-shaped depressions, former lakes that briefly existed at different times during the Holocene. These depressions accumulated a significant part of the river runoff and thereby affected the water balance of the Lake Chany.

## 2.2. Hydrogeology

Groundwaters. The territory is part of a complex West Siberian artesian basin. In the vertical section of the basin, there are two hydrogeological units, different in terms of the formation of groundwater, separated by a thick (up to 400-700 m) regional aquiclude of Cretaceous-Palaeogene age. The upper hydrogeological unit (thickness up to 300-350 m) includes aquifers of Quaternary, Neogene and Palaeogene sediments. The lower hydrogeological unit has considerable thickness (up to 2000 m and more) and contains hydrogeological subunits of Cretaceous, Jurassic and Triassic age. The main sources of groundwater suitable for drinking and domestic water supply are the aquifers of the Quaternary alluvial sediments, certain formations of Neogene and Paleogene sediments, and certain formations of Cretaceous aquiferous complexes.

Surface water. The Barabinsk lowland has more than 2500 lakes, which differ in shape, size of the lake basin and water table, and chemical composition of water. The depth of most lakes is not more than 2-3m. About 80% of them are endorheic lakes. All lakes, especially small ones, are extremely sensitive to meteorological changes. In the study area, most of the lakes are to some extent mineralized.

The geological and hydrogeological structure of the territory contributes to the wide distribution of groundwater with a total mineralization exceeding the maximum allowable concentration for quality drinking water (<1 g/L). Also, regional hydrogeochemical features include elevated content of chlorides, sulfates, sodium, magnesium, and iron.

## 3 Hydrogeochemical and isotopic characteristics

Ten water samples from various sources were analyzed. Groundwater taken from pumped wells at different depths (6 samples), and surface water from the river Om', and three lakes (Fig. 1). Samples for cations, anions, stable isotopes were filtreted (only for isotope analysis) and collected in glass bottles and stored at 4°C. The samples have been analyzed for pH, TDS, major ions ($Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$, $Fe_{tot}$, $Cl^-$, $CO_3^{2-}$, $HCO_3^-$, $SO_4^{2-}$ , stable isotopes ($\delta D$, $\delta^{18}O$) of water.

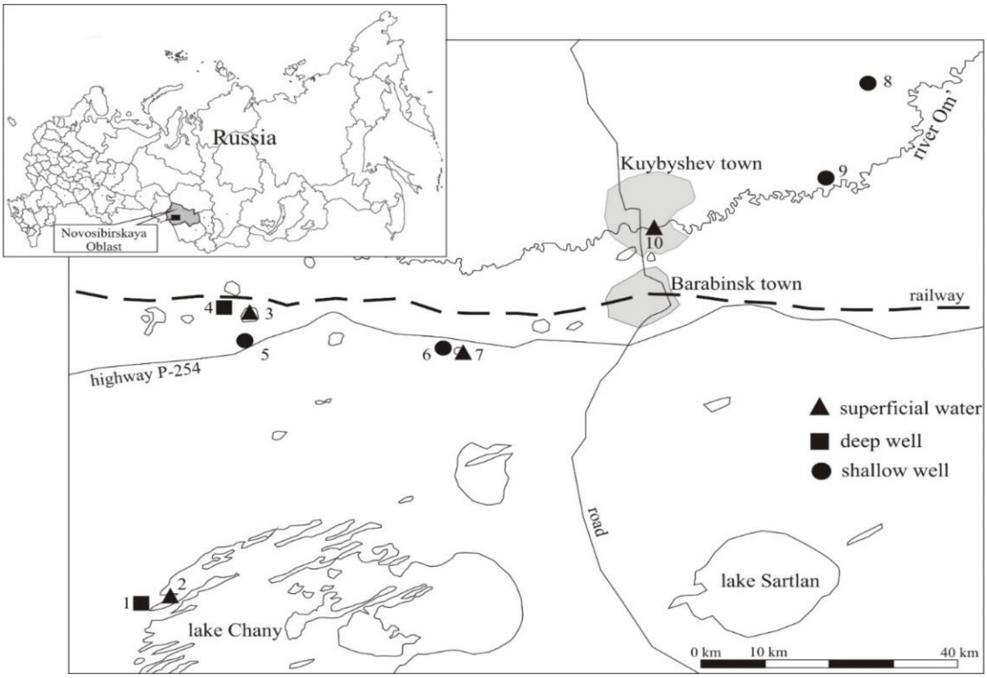

**Fig. 1.** Location of study area with locations of water samples.

### 3.1. Methods

The cations were determined using flame-atomization atomic absorption on a Solar (Thermo Electron Corporation, USA) atomic-absorption spectrometer. Anions were analyzed by titration. pH of the water samples were measured both in the field and in the laboratory.

Isotopic analysis was performed using mass spectrometry to determine the ratios of stable $\delta D$ and $\delta^{18}O$ isotopes in water using a Stable Isotope Ratio Mass Spectrometer

Finnigan MAT 253, equipped with sample preparation units Finnigan GasBench II (for oxygen analysis) and Finnigan H/Device (for hydrogen analysis). Methods: Water Equilibration ($^{18}O$) for oxygen, and reduction of water to hydrogen in H/Device for hydrogen. Standards used: VSMOW2 (IAEA: $\delta D_{VSMOW}$ = 0%; $\delta^{18}O_{VSMOW}$ = 0%); SLAP2 (IAEA: $\delta D_{VSMOW}$ = -427.5%; $\delta^{18}O_{VSMOW}$ = -55.5%); GISP (IAEA: $\delta D_{VSMOW}$ = -189.5%; $\delta^{18}O_{VSMOW}$ = -24.8%). When determining the isotopic composition of standards, error is estimated to be not more than 0.1 ‰ for oxygen, and not more than 2 ‰ for hydrogen.

### 3.2. Hydrogeochemistry

Chemical composition of groundwater and surface water is shown on the fig. 2. The water of the lakes is characterized by very high mineralization (2.8 - 13.2 g/L), mainly chlorides, sulfates, and sodium and magnesium cations. pH of lake water varies from 8.5 to 9.1.

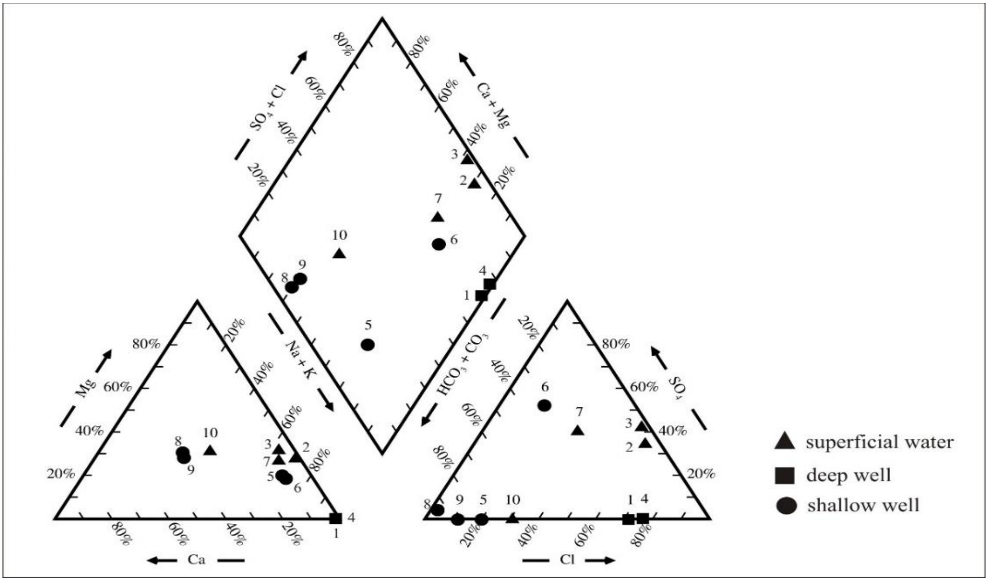

**Fig. 2.** Water samples on Piper Diagram.

Water samples from deep wells (600 - 1200m) are very similar in composition, despite the fact that the wells are apart from each other. Salinity of these water samples is 2.1–2.3 g/L due to high concentrations of chlorides, carbonates, and sodium cations, and the pH is 8.4-8.5. These are typical waters of the Cretaceous aquifers, widely used in the area for drinking and agricultural needs. The waters of shallow wells have a pH of 7.3-7.9 and a significantly lower salinity of 0.7 - 1.7 g/L. The main anion is bicarbonate, and the main cations are sodium and calcium, they originate from the confined Quaternary and Paleogene sedimentary aquifers.

### 3.3. Isotopic chemistry

Isotope analysis data are plotted on LMWL (from the IAEA website [12]) (Figure 3).

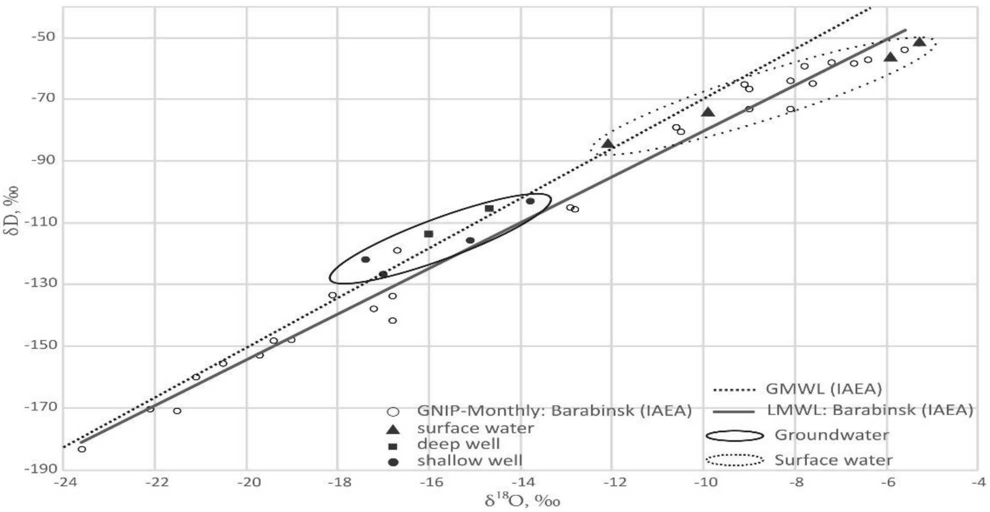

**Fig. 3.** Our data on GMWL (for Barabinsk, from the IAEA website).

The groundwater studied is likely to have a common origin. Aquifers with a markedly different origin have not been detected.

Further explanations will be given in the presentation.

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