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Climate factors of groundwater formation: a case study of the Lower Don

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Abstract. Natural factors play an important role in the formation of the chemical composition and allocation of hydrogeochemical classes of groundwater in the Lower Don basin. The most resistant to human effects are groundwater of Sarmatian complex. The prospect of improving the quality of drinking water supply is associated with the involvement of groundwater in water management, but they are characterized by high hardness. Groundwater is influenced by geology, climate, biology, soil, and etc. Understanding the groundwater regime and pathways is essential because groundwater join and mixes with river water.

1 Introduction

Groundwater is an essential source of quality drinking water in lower part of Don region. The formation of groundwater is caused by various factors. Groundwater here is directly related to surface waters predominantly recharged by the Don river bank infiltration. Understanding the groundwater regime and pathways is essential because groundwater join and mixes with river water. Groundwater is influenced by geology, climate, biology, soil, and etc. These changes are reflected in the formation of groundwater. One of the main factors are precipitation. However, the formation of their regime is significantly influenced not only by the vertical water exchange through the aeration zone, but also by the lateral redistribution of water occurring in heterogeneous layers with different filtration properties. The complex influence of all the regime-forming factors causes a large variety of regimes recorded at different sites, and the instability of the regime for each time series. Intensive industrialization in this zone is combined with intense agricultural activity. This threaten pollution to the Don River.

2 Study area

Rostov region is located within the flat area, which caused a weak drainage of the upper part of the sedimentary cover. The study area is located in the south-west part of Russia. The altitude of this area ranges from 0 to 200 m. The maximum height is confined to the hills – Donetsk ridge and Kalachevskaya, minimum – to the lower Don lowland and Manych lowland. The determining regional factor influencing the formation of the groundwater is the geological factor. Other natural factors (relief, climate) are also of great importance [1-8].

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Fig. 1. Location of the study area.

Geologically, south part of the Rostov region has an anomalous structure for artesian basins. Sedimentary rocks (chalk) are isolated from atmospheric feeding by young weakly permeable sediments of the upper part of the section – Maikop clays (Oligocene – Miocene). Here is widely development weakly permeable Quaternary deposits. The sediments range from 40 m up to 100 m in the basin centre [8].

Orographic conditions can be assessed as favourable for providing relatively high values of groundwater recharge. In most parts of the region, the depth of the vertical dissection of relief is more than 50 m. Especially strongly dissected upland and the Donets ridge, where the depth of erosion is 100-150 m, reaching on separate sections of the 200 m, and its frequency is 0,3-0,5 km/km^2.

Groundwater resources in the Bottom basin are small, due to its geographical location in the zone of insufficient moisture in the South of the European territory of Russia. The average groundwater resource module for the basin is 1,6 l/(s*km^2) [9-13].

3 Results and discussions

Rostov region is located in a temperate continental climate on the border of semi-desert and steppe climatic regions, and characterized by limited opportunities to replenish natural resources of fresh groundwater. Rostov region receives a significant amount of heat. The annual value of total solar radiation is 111-113 kcal/cm^2. The duration of sunshine varies from 2067 (Millerovo) to 2149 h (Rostov on Don). It provides long frost-free (8-9 months) and vegetation (6-7 months) periods. These climatic conditions are favorable for infiltration supply of groundwater for most of the year. The absence of infiltration is possible only during the freezing of the upper part of the aeration zone – in winter. The average annual temperature in the Rostov region is 8.2 ° C, varying from 9.5 ° C in the South to 6.5 ° C in the North. Its isotherms extend sublatitudinal, consistent with the distribution of the radiation balance. The coldest month in the region is January (-6,5 º).

The average January temperature rises from the north-east (-8,8°) to the south-west (-4,8°), as shown in Table 1. The coldest period (the average daily temperature drops up to -5º and below) in Rostov on Don lasts 42 days. The warmest month is July (+23º). The average temperature in July varies more from 21,7° in the north-west to 24,4° in the Manych lowland because of its elongation from south-east to north-west, coinciding with the direction of movement of hot and dried air masses from the south-east. In summer, the air temperature can rise significantly above the average long-term. The warmest period (average daily temperature above +20º) in Rostov on Don is 76 days. Negative average monthly temperatures are observed from December to March. From December to January the temperature drops by more than 2º; in February there is a slight increase of 1º, the transition to March is already a significant increase in temperature by 5º. Positive temperatures are observed from April to November. The most intense temperature increase is observed from April to May by more than 7º, then the growth rate drops to 4º in June and 3º in July. August is characterized by a slight decrease in temperature by less than 1º, in September - November its rate increases to 7º for each month [13-16].

Table 1. Temperature and precipitation in Rostov region.

Station	Temperature, °C		Precipitation, mm		Year	
	January	July	January	July	Precipitation	Temperature
Veshenskaya	-8,8	22,6	26	53	444	6,9
Morozovsk	-7,7	22,8	25	42	377	7,4
Rostov on Don	-5,7	22,9	35	51	483	8,7
Azov	-4,8	23,6	42	60	500	9,3
Tselina	-5,5	22,9	30	48	435	8,7
Salsk	-4,9	23,8	32	50	453	9,4

The average annual rainfall in the region is 424 mm. It is undergoing significant changes, decreasing from south-west, west to east and southeast. The largest annual precipitation is observed in the extreme south-west (more than 500 mm). Precipitation 450-500 mm is to the north and northeast of this territory. The north-western part of the region allocated higher annual precipitation totals of over 450 mm, on most of the territory during the year falls 400-450 mm in the extreme eastern part of the valley of the Manych received 400 mm. To the southeast is the smallest average annual amount of precipitation (350 mm). The decrease in annual precipitation in the east and southeast of the region caused by intrusions of continental temperate and tropical air masses. The average number of days with precipitation in the region is 122 per year. Their number is reduced to 110 in the Manych valley. Most of the precipitation (267 mm, 63% of the annual amount) is in the warm period (April - October). A reduced share of precipitation (less than 60%) distinguishes the northern coast of the Taganrog Bay and the Lower Don. The maximum average monthly precipitation ranges from 44 to 65 mm. Western and northern parts of the region characterised by the maximum precipitation (July), in the eastern and south-eastern is in June, and only in Proletarsk it is observed in May.

Not only is the amount of precipitation important for the groundwater supply, but also the frequency, intensity and, other conditions. Summer rain do not play a big role, as they rapidly flow into ravines and rivers. Wetting of the soil is small. Autumn rains penetrate into the soil very deeply. Snow falling on the wet frozen soil does not affect the supply of groundwater, as in the spring snowmelt water is not able to seep into the soil. The flat landscape, composed of easily water-absorbing rocks, makes it very difficult to drain, facilitating the seepage of precipitation into the soil and their evaporation. In the steppe regions, where the thickness of the snow cover is small, and strong winds demolish from the fields a large amount of snow in the ravines, the supply of groundwater snow slightly.

There is a positive trend of average annual air temperatures for Lower Don, amounting to 0,18° C. During the observed period, there is a positive trend in temperature and a negative trend in precipitation. There is a negative trend for precipitation. At the same time, there is a decrease in the depth of groundwater in the territory. This phenomenon is associated with anthropogenic impact.

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Table 2. Temperature and precipitation in Rostov region.

Observation period, years	The gradient of the trend		Groundwater level change
	Temperature, °C/year	Precipitation, mm/ year	
1986-2015	0,18	-8,3	0,36
1986-1989	0,93	-62,7	0,57
1990-2015	-0,04	8	0,28

Observations of groundwater levels in the city are conducted from 1986 to 2015. Lowest value of groundwater level is 18,2 m (1986) and the highest 16,83 m (2000). It should be noted the progressive increase in the groundwater level. Some periods of ground water level stabilization (1988 – 1990, 1994 – 1996) are noted [13-15].

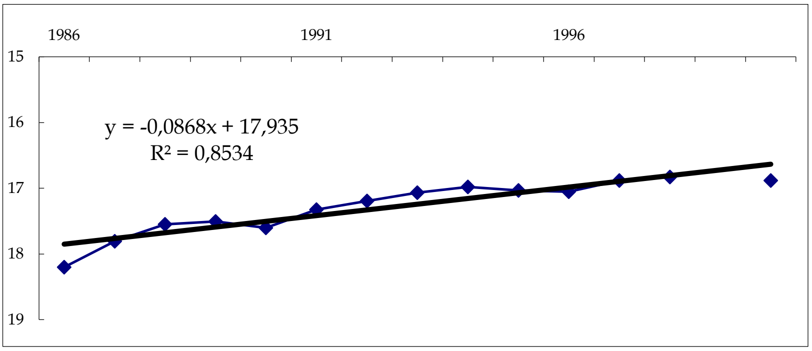

Fig. 2. Changes in groundwater level.

Dynamics of temporary changes in groundwater in southwest of Russia is characterized by a long-term increase in the level. Meteorological factors have a little effect on the groundwater level change, as opposed to technogenic influence. Here there is a gradual rise in the level of groundwater under the influence of artificial and natural factors. This leads to soil subsidence and possible deformation and destruction of buildings, which is observed in the eastern part.

A comparative assessment of the climatic and anthropogenic components in the formation of groundwater levels. It is revealed that as the anthropogenic pressure on the territory increases, the role of the meteorological component in the formation of the groundwater level decreases.

In natural, weakly disturbed conditions, the share of the meteorological factor in the formation of the groundwater level is 60-80 %, with the leading importance of relative humidity and evaporation. In Lower Don the leading role in the variability of groundwater level is played by the factor caused by technogenic influence, the share of meteorological influence is reduced from 80% to 20%.

The dynamics of temporary changes in groundwater in Lower Don is characterized by a long-term increase in the level. Main factors are connected with anthropogenic influence, such as infiltration of leakage of technic water, industrial and domestic wastewater.

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