Desalination and filling of river waters on the Don basin sandy lands: geoecological component

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Abstract. The research purpose is to assess the mesorelief geoecological significance in the desalination and filling of the river waters of the Kazanskaya-Veshenskaya sand massif. The studies were carried out on the watercourses of the eastern (Kumylga, Khopyor, Srednaya Elan', Sukhaya Elan', Malaya Peskovatka, Peskovatka rivers and spring in the Shakinskaya oak grove) and western (Otrog spring and situated in Kazanskaya forestry spring; Peskovatka, Elan rivers) parts of the massif. It is established that the underground runoff is 70% of the amount runoff through open watercourses (or 89 thousands m^3). In October, the total daily flow through the Kazanskaya-Veshenskaya sand massif is 216 thousand m^3. The annual groundwater supply is equal to 141.6 million m^3. A third of this water is discharged in two spring months. The remaining 99.1 million m^3 are discharged into the groundwater during the remaining 10 months. On average, this amounts to 330 thousand m^3 per day.

1 Introduction

Small rivers and springs of the Don River basin are an important natural resource. Management of these resources, monitoring of their dynamics and forecasting of their state are an urgent economic task that determines the ecosystems development and human economic activity [1, 2]. The development level of the fresh groundwater forecast resources in the Don River basin as a whole is insignificant and amounts to 10.2% [3]. The groundwater reserve is also of great importance for the basin complex sustainable development. Due to the discharge of a significant amount of water from sandy massifs, the ecosystems functioning is maintained and the population is provided with fresh water [4].

Supplying of the Don basin rivers is mostly snowing type. The formation of the maximum runoff during the spring flood occurs due to intense snowmelt [5]. The washing-type water regime of sands has been formed here. The bulk of the water passes through the aeration zone in spring after snowmelt [6]. The change in the water regime in the Don basin rivers is a reflection of contemporary hydrological and physico-geographical processes occurring within the boundaries of riverbeds and catchments [7].

The purpose of the research is to assess the mesorelief geoecological significance in the desalination and filling of the river waters of the Kazanskaya-Veshenskaya sand massif.

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2 Materials and methods

The object of research is the Kazanskaya–Vyoshenskaya sand massif. The studies were carried out on the watercourses of the eastern (Kumylga, Khoper, Srednaya Elan', Sukhaya Elan', Malaya Peskovatka, Peskovatka rivers and the spring of the Shakinskaya oak grove) and western (Otrog spring and situated in Kazanskaya forestry spring; Peskovatka, Elan rivers) parts of the massif. The flow rate of watercourses and their water salinization has been measured. The average daily discharge is estimated.

When determining the indicators of incoming water from the arenas, the following information was collected: the area of sandy lands, water-physical and chemical properties of sandy soils, water regime and moisture balance, groundwater and their dynamics, spring runoff. A large amount of information is obtained from literary sources and own research [8-10].

3 Results and discussion

The surface of the Don basin sandy terraces has an ancient and complex relief. Its formation took place under the influence of various factors (accumulative and erosive activity of water and wind, destruction of sandy relief forms by animal hooves, deforestation, plowing of light soils that are unstable to wind erosion, etc.). The distribution of sand mesorelief forms by area on the Kazanskaya-Veshenskaya sand massif is presented in Table 1. [11].

Table 1. Distribution of sand mesorelief forms by area on the Kazanskaya-Veshenskaya sand massif (according to Gael A.G.).

№	Genesis type	Mesorelief forms	Area, ha
1	Illuvial-lake	loamy depressions	3325
		sandy loam depressions, undulating plains, watershed slopes	8470
2	Outflow cones of balkas and wandering rivers and their valleys	Outflow cones and river valleys	5194
		runoff hollows with spot-type forests	1706
		meadow sites	727
3	Accumulative-erosive waved-ridged plains	uneroded or slightly eroded	20628
		slightly eroded, but in places with blowouts and bumps	4994
		middle eroded, mostly middle bumped	998
4	Aeolian deflationary-accumulative sands	uneroded or slightly eroded	20276
		middle eroded, lowly bumped and middle bumped	19533
		highly eroded highly bumped	2285
		bumpy-ridged otvechno fluttering	864
Total			89000

The poverty of the Don terraced sands mineralogical composition is inherited from the indigenous sands – Tertiary and Cretaceous. Already in those distant geological epochs, the sands were subjected to the strongest hypergenesis, which was facilitated by a humid and warm subtropical climate. And, nevertheless, it is impossible to call these quartz sands absolutely barren. In them there are feldspar, mica, apatite, phosphates, glauconite,

hornblende, zircon, sphene, although in small quantities, containing both macronutrients of ash food for plants (P, K, Na, S, Fe, etc.) and trace elements.

The Kazanskaya-Veshenskaya sands are located mainly on the second terrace of the Don and stretch in an intermittent strip 12-15 km wide from the Peskovatka River near the village of Kazanskaya to the Khoper River for 90 km and concentrating mainly along the left bank of the Peschanka and Elan rivers. The first terrace is not clearly defined. Gradually it turns into a floodplain overgrown with alder, poplar and oak in elevated areas. The third terrace is loamy and covered with a sand cloak (1.0-1.5 m thick), which was inflated in the Boreal era from the side of the second terrace. According to numerous levels on different sand massifs of the Don, the following heights of terraces are common: I – 8-15 m, II – 25 m, III – 45 m. It is most likely that the 45–50-meter terrace was formed during the epoch of the Dnieper or Ris glaciation, when there was an incision into the bedrock, as well as during the Odintsovo interglacial (accumulation of alluvium). The largest expansion of the III terrace is confined to the confluence of the Don and its tributaries – Peskovatka and Elan rivers. Due to combined influence of these rivers and the Don, the chalk rocks here are eroded wider and deeper, and the sandy alluvium reaches the greatest power. Small rivers: (Chernigovskaya, Reshetovka, Gorokhovka, Zimovnaya) also have their own terraces and cones of removal into the Don floodplain.

Orographic conditions, in our opinion, allowed south-westerly winds to carry sand through the valley of the Elan River at a distance of 20-25 km and deposit it with a thickness of 1.0-1.5 m on an area of about 20 thousand hectares. This territory has a water-resistant clay horizon at a depth of 4-6 m. As a result, fresh groundwater was formed under the sandy sediment, which caused the appearance of the Shakinsky oak grove, from which a spring flows, giving rise to the Elan River.

Monitoring of the Srednaya Elan, Sukhaya Elan and Malaya Peskovatka waterflows showed that the flow was only in the Malaya Peskovatka River, the flow rate of the river was 3 l/sec (Table 2).

Table 2. Flow rate and salinization of the Kazanskaya-Veshenskaya sandy massif water flows.

№	Water flow name	Flow rate	Salinization, g/l
watercourses of the eastern part of the massif			
1	Kumylga River, vil.	0,36 m^3/sec	0.30
2	Khoper River, vil.	-	0.30
3	Srednaya Elan River, Kalinin vil.	without flow	0.40
4	Sukhaya Elan, Belogorskij vil.	without flow	0.60
5	spring in the Shakinskaya oak grove, the source of the Elan	2 l/sec	0.11
6	Malaya Peskovatka River, Losevskij vil.	3 l/sec	0.50
7	Peskovatka River, Morozovskij vil.	1 m^3/sec	0.15
watercourses of the western part of the massif			
8	spring in the Kazanskaya forestry	without flow	0.08
9	spring in the Kazanskaya forestry	without flow	0.04
10	Peskovatka River, ford across the river	0,8 m^3/sec	0.19
11	Otrog spring, Veshenskaya vil.	0,07 m^3/sec	0.05
12	Elan River, lower flow	0,6 m^3/sec	0.09
13	Khoper River, left bank along the sandy ridge	-	0.04

There was practically no water coming from the clay watersheds. The Peskovatka and Elan rivers are the only permanent watercourses of the Kazanskaya–Veshenskaya Sands. The flow rate of the Elan River is 0.6 m^3/sec. It is interesting because it is entirely formed within the sand massif. The Peskovatka River in the lower reaches has a flow rate of 1.8 m^3/sec, and

near the Morozovsky vil. – 1 m^3/sec. We associate the origin of these waters with the sands located upstream of the river. The geological conditions of the sands contribute to the fact that in their central part groundwater wedges to the surface and forms four constantly flowing watercourses with fresh water: Chernoviy, Reshetov, Zimovnaya and Dubrovaya. Some of them are quite high-capacity (0.1-0.15 m^3/sec). Approaching the Don floodplain, the watercourses disappear, and only one powerful spring (Otrog) flows along the edge of the floodplain near the Veshenskaya vill. with a flow rate of 0.07 m^3/sec.

In October, 1.47 m^3/sec of water flows from the Kazanskaya-Veshenskaya sands through open watercourses (Otrog spring, Peskovatka and Elan rivers). The daily discharge reaches 127 thousand m^3. This water is formed on the sands and flows through open watercourses into the Don River. Along the coastline of the Don, the outflow of groundwater in the form of drainage holes is also recorded.

Monitoring of watercourses has shown that underground runoff is equal to 70% of the amount runoff through open watercourses or 89 thousand m^3. In October, the total daily runoff is 216 thousand m^3 for the Kazanskaya-Veshenskaya sands. But the discharge of atmospheric precipitation along the catchments is uneven. In the summer months, it is much higher than in autumn. According to the data of the Nizhnyansky water measuring post on the Archeda River, it was found (Figure 1) that the daily flow for 10 months from May varies from 166 thousand to 307 thousand m^3, and the total flow for the period from May to February is 63.6 million m^3 (Table 3). The average daily discharge is estimated at 216 thousand m^3.

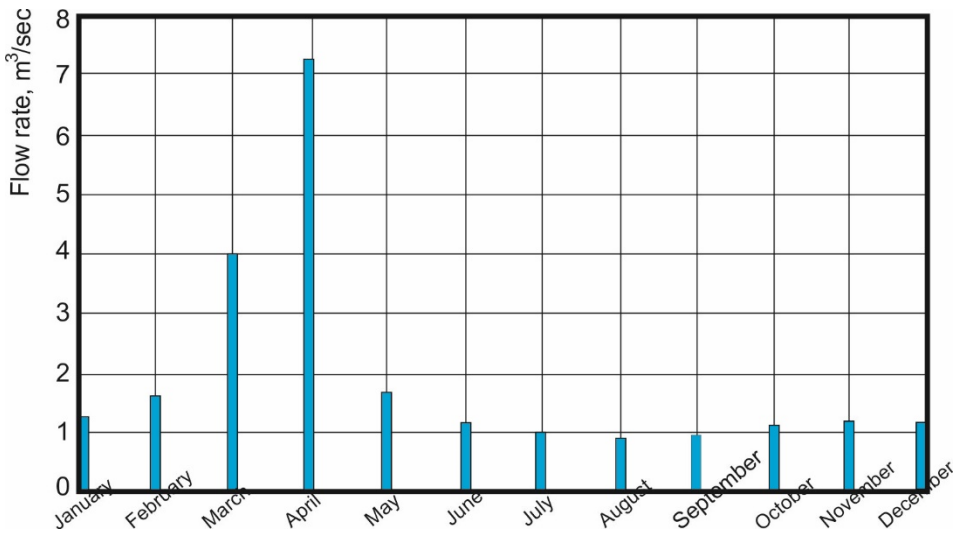

Fig. 1. Hydrographers indications on the Archeda River.

Water balance calculations for the Kazanskaya-Veshenskaya massif give the following indicators. The annual amount of precipitation is determined by Veshenskaya vil. (495 mm). The sandy massif is characterized by a washing type of water regime. The amount of precipitation reaching groundwater is estimated by us at 120 mm with fluctuations from 350-380 mm on open sands to 40-60 mm under high-altitude tree stands.

Table 3. Daily and monthly discharge of Archeda River.

Indicators	Month						
	May	June	July	August	September	October-February	In 10 months
Average monthly discharge of Archeda River, m^3/sec	1.8	1.17	0.99	0.91	0.95	1.18	–
% from discharge of October	142	99	84	77	80	100	–
Daily discharge, thousands m^3	307	214	181	166	173	216	–
Monthly discharge, millions m^3	9.21	6.42	5.43	4.98	5.16	32.4	63.63

The annual groundwater supply (based on the total area of the massif and the volume of filtered water) reaches 141.6 million m^3. A third of this water is discharged in two spring months. The remaining 99.1 million m^3 are discharged into the groundwater during the following 10 months. The daily indicator of gravity runoff on the Kazanskaya-Veshenskaya sands significantly (by one third) exceeds the water runoff outside the sand massif. This is due to the fact that ground water is consumed by forest and herbage in shallow-water positions.

4 Conclusion

The sandy massif is characterized by a washing type of water regime. The amount of precipitation reaching groundwater is 120 mm with fluctuations from 350-380 mm on open sands to 40-60 mm under high-altitude tree stands.

Underground runoff is equal to 70% of the amount of runoff through open watercourses, which is 89 thousand m^3. In October, the total daily flow through the Kazanskaya-Veshenskaya sands is 216 thousand m^3.

The annual groundwater supply of the sandy massif is equal to 141.6 million m^3. A third of this water is discharged in two spring months. The remaining 99.1 million m^3 are discharged into the groundwater during the following 10 months. On average, this amounts to 330 thousand m^3 per day.

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