ISSN 1028-334X, Doklady Earth Sciences, 2006, Vol. 406, No. 1, pp. 94–96. © Pleiades Publishing, Inc., 2006.
Original Russian Text © G.G. Matishov, D.G. Matishov, Yu.M. Gargopa, 2006, published in Doklady Akademii Nauk, 2006, Vol. 406, No. 3, pp. 361–363.

GEOCHEMISTRY

Present-Day Salt Regime in Reservoirs of the Manych River Basin

Academician of the RAS G. G. Matishov, D. G. Matishov, and Yu. M. Gargopa

Received August 25, 2005

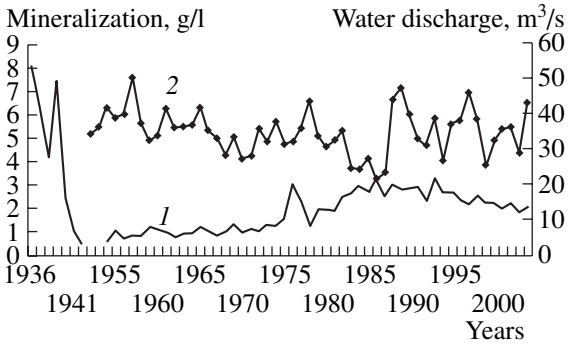
DOI: 10.1134/S1028334X06010235

The reservoir system of the Manych River basin is located in the Kuma–Manych Depression of the southern Russian region, which is characterized by an arid climate, a shortage of water resources, and the development of salt marches and saline soils. The system extends in an almost latitudinal direction for a distance of over 300 km and includes the Proletarskoe (length 180 km, area 800 km^2, volume 2 km^3), Veselovskoe (length 90 km, area 250 km^2, volume 0.8 km^3), and Ust'-Manych (length 60 km, area 70 km^2, volume 0.1 km^3) reservoirs. Their average depth ranges from 2.5 to 3.0 m. The system gives rise to natural–economic and social problems. Most important among these basins is Lake Manych-Gudilo, which represents a shallow relict marine basin in the Proletarskoe Reservoir.

An annual supply of approximately 2 km^3 of freshwater from the Don and Kuban rivers in 1948–1968 created an optimal for all kinds of economic activity (1.0–1.2 g/l) mineralization level in the Veselovskoe and western Proletarskoe reservoirs by the beginning of the 1970s. This provided environments favorable for the fattening and reproduction of valuable fish species in the natural-saline Lake Manych-Gudilo, with its freshened (3–5 g/l) western area, highly saline (up to 35–40 g/l) central area ("salt plug"), and brackish (up to 5–7 g/l) eastern area. The subsequent growth of irrigation areas and increase in the discharge of highly mineralized collector-drainage waters deteriorated the salinity regime, and the salinization of reservoirs became a dominant process by the end of the 1980s. The mineralization of waters in the Bol'shoi Egorlyk River gradually increased to 2.0–2.5 g/l in 1985–1990 and was as high as 2.0–3.0 g/l in subsequent years (Fig. 1). Mineralization in the Veselovskoe and western Proletarskoe reservoirs increased up to 3 g/l. By spring and summer of 1990, the salinity in Lake Manych-Gudilo was 20–25 g/l (sometimes, 30–35 g/l). The salt reserve has increased three times since 1951 [7], provoking the mass death of all fish species.

In the 1970s–early 1980s, the ionic composition of waters in these reservoirs was gradually transformed in the W–E direction from the sodium sulfate to sodium chloride–sulfate and sodium chloride classes of the magnesian type III [3, 4, 6].

Adequate data on the mineralization and ionic composition of waters in the reservoirs under consideration are unavailable. Despite the widespread opinion that the mineralization of reservoirs and flows in the Manych River basin is progressively increasing, field observation data in favor of this assumption are almost entirely absent. The inference of a progressive increase of mineralization in the Ust'-Manych, Veselovskoe, and western Proletarskoe reservoirs is inconsistent with the dynamics of the water and salt discharges of the Bol'shoi Egorlyk River, which adequately reflects changes in the mineralization of reservoirs located west of the Barannikovskaya Dam. This is demonstrated by the figure, which is based on our observations and on materials of the Hydrometeorlogical Survey and Bataisk hydrogeological–reclamation team. According to data from the latter source, the annual mineralization of waters in the Bol'shoi Egorlyk River, Veselovskoe, and western Proletarskoe reservoirs in 1999–2000 was as high as 2.0–2.2, 1.7–2.0, and 1.9–2.0 g/l, respectively. Moreover, water volume in the river tended to



Mineralization (*1*) and annual discharge dynamics (*2*) of Bol'shoi Egorlyk River waters.

Southern Scientific Center, Russian Academy of Sciences, Rostov-on-Don, Russia; e-mail: gargopa@mmbi.krinc.ru

Concentration of dissolved ions (g/l) in Manych reservoirs (July 5–16, 2004)

Concentration levels	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$	SO_4^{2-}	HCO_3^-	Cl^-	Sum of ions, g/l
Eastern part of the Proletarskoe Reservoir							
Average	0.614	1.769	8.562	9.067	0.213	11.569	31.794
min	0.143	0.097	1.299	1.729	0.13	0.350	5.195
max	0.846	2.353	14.061	13.112	0.259	18.250	48.713
Western part of the Proletarskoe Reservoir							
Average	0.13	0.112	0.406	0.872	0.228	0.356	2.103
min	0.115	0.105	0.321	0.816	0.192	0.241	1.816
max	0.164	0.127	0.480	0.913	0.271	0.400	2.467
Veselovskoe and Ust'-Manych reservoirs							
Average	0.130	0.146	0.375	0.977	0.214	0.343	2.185
min	0.120	0.124	0.206	0.663	0.198	0.271	1.750
max	0.145	0.167	0.544	1.297	0.234	0.381	2.712

decrease until 1987, while its mineralization increased. Later, these trends were reversed.

Taking all these facts into consideration, the Azov Branch of the Murmansk Marine Biological Institute, Kola Scientific Center, Russian Academy of Sciences and the Southern Scientific Center, Russian Academy of Sciences carried out hydrochemical studies of reservoirs and water flows in the Manych River basin during spring, summer, and autumn of 2001 and 2004.

In spring of 2001 (April 29–May 5), the salinity of waters in shallow and poorly flowing parts of Lake Manych-Gudilo amounted to 24–25 g/l. In terminal April–early May of 2004, the concentration of Cl ion in these waters was 13–16 g/l and was as high as 42–46 g/l in some basins (Gruzskie lakes). In the Veselovskoe Reservoir, the content of this ion was as low as 0.27–0.57 g/l.

In July of 2004, mineralization in Lake Manych-Gudilo averaged 32–37 g/l; i.e., it increased by approximately 10–13 g/l (1.5 times) as compared with the terminal 1980s and by 17–22 g/l (or 2.5–3.0 times) relative to the 1950s and 1960s (table). At the same time, the Ca^{2+} concentration remained almost at the level of the terminal 1980s, although it appeared to be 1.5–2.0 times higher than in the preceding period (1950s–1960s). The concentration of the majority of other ions increased 2–4 times as compared with the mentioned years and terminal 1980s. The sole exception is the HCO_3^- ion, the content of which slightly decreased, although it remained higher than in 1953, 1956, 1960, and 1963. This confirms the inference [4, 7] according to which a transformation of the ionic composition of mixed river and collector-drainage waters results in a decrease of the average HCO_3^- content, although the total mineralization of lake water decreases (table).

Because of the different rates and trends of changes in the concentration of dissolved ions, the ratio between some of them was slightly changed. Previously, the ratio between Mg^{2+} and Ca^{2+} concentrations changed insignificantly, from 1.8 to 2.1 [7]. In July, this parameter increased up to 2.9 (table).

According to observations in July of 2004 and classification [1], waters of the Lake Manych-Gudilo and eastern Proletarskoe Reservoir belong to the sodium chloride class of types III and II, respectively.

In the western Proletarskoe area located between dams and the Ust'-Manych and Veselovskoe reservoirs, water mineralization ranges from 1.7 to 2.7 g/l (average 2.1–2.2 g/l). Waters of this area belong mostly to the sodium sulfate class (table).

In line with classification [1], waters of the western Proletarskoe, Veselovskoe, and Ust'-Manych reservoirs belong to the sodium sulfate class of type II.

Observations in August and October provided data similar to those obtained in June.

The works carried out by researchers from the Azov Branch of the Murmansk Marine Biological Institute and the Southern Scientific Center revealed a freshening trend in the Ust'-Manych, Veselovskoe, and western Proletarskoe reservoirs, with mineralization decreasing by approximately 1 g/l as compared with the terminal 1980s–early 1990s, as well as the progressing mineralization of Lake Manych-Gudilo by an additional 10–13 g/l (or 1.5 times) relative to the terminal 1980s. These studies also established some changes in ion ratios and water types, particularly in the eastern part of the Proletarskoe Reservoir. Despite some decrease in mineralization in reservoirs located west of the Novo-Manych Dam, caused in large part by the climate-induced growth of the Kuban River drainage and the reduction of irrigation areas, as well as by the lower inflow of waters from Lake Manych-Gudilo, its level

exceeded the optimal one that was reached by the beginning of the 1970s. After the mid-1980s, Lake Manych-Gudilo was characterized in the first several years by a slight freshening trend, which gave way to a relative stabilization and then, beginning in the terminal 1990s, to a growth in mineralization.

The high mineralization level of Manych reservoirs and its increase (mainly in Lake Manych-Gudilo) were caused by both natural and anthropogenic factors. The main causes are the following:

(1) shortage of river discharge (Don River, in particular) and poor flowage;

(2) lithology of rocks of the drainage area, coasts, and bottom of basins; development of salt marshes and saline soils; and

(3) recurrent collector-drainage waters from irrigation systems and confined groundwaters with mineralization of approximately 2.5–4.0 g/l.

The main branches of economic activity, which are sensitive to salinity variations, are agriculture and fishery. Water in the Proletarskoe Reservoir is unsuitable for irrigation, while water from the Veselovskoe and Ust'-Manych reservoirs can be used only in some seasons. In the Veselovskoe and western Proletarskoe reservoirs, mineralization is at the maximum permissible level for fishes, and it is beyond this limit in the greater part of Lake Manych-Gudilo.

The following top-priority measures aimed at an optimization of the salinity regime and the improvement of the ecologic–economic situation in the reservoirs under consideration should be undertaken:

(1) the water and salt exchange between the western and eastern parts of the Proletarskoe Reservoir through the Novo-Manych Dam should be restricted to the water flow from the former basin to the latter;

(2) waters of the Bol'shoi Egorlyk River mixed with the collector-drainage and Kuban River waters should be drained into the western part of the Proletarskoe Reservoir when their mineralization is relatively low (1.0–1.5 g/l or lower) and into its eastern part in the case of higher mineralization;

(3) the drainage of the Kuban River into the Bol'shoi Egorlyk and Kalaus rivers should be maintained at the level characteristic of the last 10–15 years, while that of the Don River should be increased up to 0.7–0.8 km^3/yr; and

(4) the supply of collector-drainage waters—one of the main mineralization sources for reservoirs and flows of the Manych River basin—should be decreased to the level that was characteristic of the terminal 1970s–early 1980s period by reducing irrigation areas, introducing water-saving technologies, and replacing present-day crops by less water-consuming cultures.

REFERENCES

1. O.A. Alekin, *Fundamentals of Hydrochemistry* (Gidrometeoizdat, Leningrad, 1970) [in Russian].
2. *Hydrometeorological Regime of Lakes and Reservoirs in the USSR: The Tsimlyansk and Manych Reservoirs* (Gidrometeoizdat, Leningrad, 1977) [in Russian].
3. G. V. Kravtsova, Trudy Zoologicheskogo Inst. **196**, 64 (1989).
4. M. I. Kriventsov, *Hydrochemistry of Western Manych Reservoirs* (Gidrometeoizdat, Leningrad, 1974) [in Russian].
5. P. M. Lur'e, V. D. Panov, and A. M. Salomatin, *The Manych River: Hydrography and Drainage* (Gidrometeoizdat, St. Petersburg, 2001) [in Russian].
6. T. B. Forsh, in *Lakes of the Semiarid Zone of the USSR* (Leningrad, 1970), pp. 36–48 [in Russian].
7. A. P. Frolov, Vodn. Resursy **27**, 322 (2000) [Water Resources **27**, 288 (2000)].