Original Scientific Paper
Journal of Applied Engineering Science

doi:10.5937/jaes17-22883
Paper number: 17(2019)3, 625, 425 - 430

PROBLEMS OF RATIONAL USE AND PROTECTION OF GROUNDWATER WITHIN THE RUSSIAN FEDERATION

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The performed studies have evaluated groundwater resources across continents and hold their comparison with the resources of surface water. Temporary condition of water resources in the world, the prospects for their security of countries are a matter concern. The world situation with water resource is clearly not satisfactory and remains disturbingin general. In many regions there is co-quantitative depletion of water resources, their deficit becomes increasingly stressful. Water availability has decreased approximately in 2 times (from 13 to 7.6 thousand m³/year per person) since 1970. It is given the modern availability of fresh water in Europe. Russia occupies a leading position according to the total volume of freshwater. In Russia as a whole the security of inferred groundwater resources is 6 m³ per day per person. However, it is experienced a significant water shortage in a number of constituent entities of the Russian Federation due to uneven distribution of groundwater resources. Up to 70% of the total volume of extracted groundwater is used for drinking and general-purpose needs. Water supply of more than 50 % of the territory and population of the Russian Federation is based only on groundwater. There are territories with local water scarcity.

Environmental threat is the deterioration and contamination of groundwater under the influence of anthropogenic load. It is recorded about 6 thousand sites of technogenic pollution of groundwater in the country. Also there are about 500 water intakes with constant or episodic pollution of groundwater. Mainly, pollution is evident in urban and industrial agglomerations making it impossible to supply consumers with water of required quality.

In accordance with the basic principles of state policy in the field of use and protection of water objects, we have identified the activities that ensure rational use, restoration and protection of groundwater resources.

Key words: water resources, freshwater; groundwater, pollution and depletion of groundwater

INTRODUCTION

Freshwater is a vital recourse for human life . Experts predict the supply of fresh drinking water is not unlimited. It is estimated that the supply of water for a resident of the Earth from 1970 to 2003-2005 has decreased by approximately 2 times (from 13 to 7.6 thousand m³/year). This is mainly due to the population growth (by 3 billion people) as well as the depletion of freshwater resources in some regions and countries [5]. According to some scenario of progressive socio-economic and demographic growth it is predicted a water crisis in the world [4]. By 2025 more than half of the countries either will experience severe water scarcity or feel its lack, and by the middle of the XXI century three-quarters of the population will not have enough fresh water. It is estimated that around 2030, 47% of the world's population will exist under the threat of water scarcity. In 2000the shortage of fresh water, including agricultural and industrial needs was at 230 billion m³/year, by 2025 this deficit will increase to 1.3-2.0 trillion. m³/year. To a certain extent, poor countries and rich developed economies are equal before the water shortage. These problems are most acute in such countries as Germany, Spain, Netherlands, France, Japan, China, India, Nigeria, Egypt, Kuwait, Saudi Arabia, UAE, etc.

At the same time, by 2050 the population of developing countries will significantly increase where water is already scarce. If the population of the Earth by the mid of the twenty-first century matches the forecast (up to 9 billion people) and the total water resources do not change significantly, it will lead to a further reduction in the potential water availability per capita to 5.5–5.0 thousand m3/year. Most likely, Africa, South Asia, the Middle East and Northern China feel the lack of freshwater first. According to forecasts by 2020,from 75 to 250 million people would be in this situation due to climate change in Africa and the acute shortage of water in arid and semi-arid regions causes a rapid migration of the population. This is expected to affect from 24 to 700 million people.

Developed countries have felt water shortage in recent years. Not so long ago a severe drought in the US led to water shortage across large areas of the Southwest and in the cities in northern Georgia State.

The problem of freshwater resources availability, its quality and patterns of resource use has acquired a particular social significance and an extremely sharp political character in different regions of the world in recent years. A number of studies conducted in the area of mutual influence of water factor and international policy have shown that the possibility of using fresh water in sufficient quantity and of required quality is already the subject of disputes in the international arena. In the

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future we can expect political instability, armed conflicts and a further increasing number of problems in the development of world economies.

We should make more efforts to preserve freshwater sources, as well as, to search for possible less expensive ways to solve the problem of freshwater shortage in many coun-tries at present as well as in the future.

STRUCTURE OF WORLD FRESHWATER RESOURCES

It is important to imagine the overall picture of freshwater availability in the world. Current estimates of renewable resources of fresh surface and groundwater and potential water availability of different parts of the world give an idea of the distribution of water resources and the specific water availability of regions (table 1).

The average long-term value of river flow of the world is 42785 km^3/year at the beginning of the 21st century and the value of natural (renewable) groundwater resources is 11,720 km^3/year or 27% of the total river flow. Natural resources are a part of general groundwater resources which is characterized by the value of groundwater supply in natural conditions due to infiltration of atmospheric precipitation, absorption of river runoff and overflow from other aquifers, which is determined in total by the amount of flow or by the thickness of the layer of water entering the level groundwater. Due to the constant renewal of natural resources, it is precisely that part of the total groundwater resources that can provide an unlimited lifespan.

Total value of natural resources of groundwater, i.e. the supply of groundwater within the entire land area (excluding Antarctica and Greenland) is about 12,000 km^3/year. On continents they grow from 312 for Australia and Oceania to 3656 km^3/year in South America. On a global scale natural resources of groundwater are averaged 25-30% of the total water resources (total river flow). The minimum ratio of resources of groundwater and surface water is characterized arid Australia, relatively low – Asia and maximum - Europe.

WATER SUPPLY OF RUSSIA

The Russian Federation belongs to the number of states that are the most provided with water resources. The average annual renewable water resources of Russia make up 10% of global river flow (second place in the world after Brazil) and are estimated at 4.3 thousand km^3/year.

According to the total volume of freshwater resources Russia occupies a leading position among European countries of (table 2).

In general the country's water supply is more than 30 thousand m^3/year per person. Russia, together with Scandinavia, South America and Canada, will remain the regions with the most abundant fresh water of more than 20,000 m^3/year per capita (the critical level of freshwater availability is 1,700 cubic m^3/year per person) according to the UN, by 2025.

Water resources of the Russian Federation are characterized by significant uneven distribution across the country. The developed areas of the European part of the country, where more than 70% of the population and production capacity are concentrated, account for no more than 10% of water resources. In low-water years water scarcity is observed in areas of intensive economic activity in the basins of the rivers Don, Ural, Kuban, Irtysh, and also on the western coast of the Caspian Sea, in the Belgorod and Kursk regions, the Stavropol Territory and in some parts of the Volgograd and Orenburg regions.

The Russian Federation has a water management complex that is one of the largest in the world and includes more than 30,000 reservoirs and ponds with a total volume of over 800 km^3 and a useful volume of 342 km^3. The network of inter-basin and intra-basin redis

Table 1: Current water supply of parts of the world [5]

Part of the world	Population, million people	Resources, km^3/year		Water supply, thousand m^3/year	
		Surface water (riverflow)	Ground water resources	Surface water for 1 person	Ground water resources for 1 person
Europe	687.5	2900	1055	4.2	1.5
Asia	3698.5	13510	3435	3.7	0.9
Africa	790	4050	1130	5.1	1.4
North America	479.4	7890	2132	16.5	4.4
South America	345.7	12030	3656	34.8	10.6
Australia and Oceania	27.7	2405	312	86.8	11.3
All land terri-tory*,	6028.8	42785	11720	7.1	1.9
including Russia	144.4	4053	915	28.1	6.3

Table 2: Total volume of freshwater resources in a number of European countries

Country	Total resources, km^3 / year
Russia	7770.6
Norway	390.8
Turkey	234.3
France	189.1
Germany	188.0
Sweden	179.0
Hungary	120.0
Spain	111.1
Finland	110.0
Netherlands	89.7
Portugal	73.6
Greece	72.0
Poland	63.1
Switzerland	53.3
Romania	42.3
Belgium	20.7
Denmark	16.3
Bulgaria	15.8

tribution channels, water-management systems of water transportation with a total length of more than 3 thousand km, allows the transfer of flow in the volume up to 17 km^3/year.

The total volume of abstraction (withdrawal) of water resources from natural water bodies has reached 80 km^3/year in certain years; it amounted to 70.8 km^3 in 2014. From the data of the Statistical Bureau of the European Communities, which characterize water use in selected European countries, it follows that in absolute terms the amount of water abstraction in Russia considerably exceeds the intake of water in European countries.

Up to 60 km^3 of water is annually used in the economy. Over 90% of the total volume of water use falls on such sectors of the economy as thermal and nuclear energy (37%), agro-industrial complex (24%), housing and utuilities services (18%), mining and manufacturing (12%) .

The functioning water management complex effectively provides the current water resource requirements of the Russian Federationin general. At the same time the country economy will require an increase in the guaranteed volume of water resources of appropriate quality, designed to meet drinking and domestic needs, as well as for use in industry, agriculture, energy and recreational purposes in the future.

The volume of water losses during transportation is up to 8 km^3/year in the Russian Federation. Over 4.8 km^3 of water a year is lost in irrigated agriculture due to low technical level and significant deterioration of melioration systems and hydraulic structures, about 3 km^3 /year, or more than 20% of the total volume of water supplied to the water network is lost in centralized water supply systems due to their unsatisfactory technical condition.

THE USE AND CONDITION OF GROUNDWATER IN RUSSIA

Groundwater deposits of Russia contain over 10% of the world explored reserves, their static reserve is 28,000 km^3 and the average multi-year renewal volume is 869 km^3. The resource potential of groundwater is almost 400 km^3 per year.

The total amount of groundwater resources suitable for use (drinking and domestic, industrial and technical water supply, irrigation and pasture irrigation) is about 34 km^3/year. In Russia as a whole, the availability of predicted groundwater resources is 6 m^3 per day per person. At the same time, some territorial entities of the RFare experiencing a significant water deficit, which is caused by the uneven distribution of groundwater resources. Murmansk, Kurgan, Omsk, Novgorod, Yaroslavl regions, certain areas of the Arkhangelsk, Rostov, Tyumen regions, the Republic of Kalmykia and the Stavropol Territory are not sufficiently provided with underground waters, the quality of which corresponds to hygienic standards.

The fresh groundwater abstraction is 8.0 (2010), – 7.82 (2012), 7.65 (2013), 8.7 (2014) and 8.9 (2015) km^3/year [3].

The use of groundwater is multifunctional. There are the following types of groundwater: drinking, technical, heat and power, etc. The use of underground water facilities for drinking and domestic needs accounts for 69%, i.e., more than half of the total volume of produced water. It is fresh groundwater that is often the only source of providing the population with high quality drinking water, protected from pollution. Water supply for more than 50% of the territories and population of the Russian Federation is based on groundwater.

Among urban settlements, the number of those supplied with groundwater is more; thus, about 69% (2028) of cities and settlements use mostly underground water (more than 90%), another 12% (354) of them have mixed sources of water supply, and only 19% (576) are supplied mainly with surface waters.

The cities where surface waters are practically the only source of household and drinking water supply are Moscow, St. Petersburg, Nizhny Novgorod, Ekaterinburg, Omsk, Volgo-grad, Chelyabinsk, Rostov and others. Since surface water, in contrast to groundwater, is essentially not protected against possible contamination, the population of these cities is under constant threat of getting out of drinking water intakes. The cities with underground sources of water supply, but exploiting the first aquifer from the surface, connected with surface waters and insufficiently protected from pollution (Krasnoyarsk, Voronezh, Vladi-kavkaz, Ulan-Ude, etc.) are also in this group.

Local shortages of water resources (primarily to ensure the needs of drinking and domestic water supply)occur in the Republic of Kalmykia, Belgorod and Kursk regions, the Stavropol Territory, certain areas of the Southern Urals and southern Siberia. In the Kursk region the source of coverage of water demand is surface water and groundwater, and the total abstraction of water from natural sources in 2014 was 240.08 million m^3, including from groundwater - 96.72 million m^3. As of 01.01.2015, on the territory of the Kursk region 142 fresh groundwater deposits are registered [6].

Intensive use of groundwater leads to a decrease in its level and the formation of large depressive funnels, both in the exploited aquifer and in hydraulically related adjacent aquifers in the operation of water intakes for water supply. The area of depressive funnels can reach hundreds and thousands of square kilometers in areas of intensive water abstraction, while a decrease in the level of groundwater is up to 100 m and more. Local craters of depression are formed practically around all regional centers, industrial regions, and large deposits of minerals. For example, such a funnel exists in the Moscow region. Regional craters of depression are recorded in the Tula, Leningrad, Novosibirsk, Tomsk, Tyumen regions, the Republic of Mordovia, the Altai Territory. The regional crater of depression has been formed in the area of the Kursk magnetic anomaly and covers the territory of the Belgorod, Kursk, Orel and Bryansk regions. The depression of surface level in the funnel center is 80-90 km.

On the territory of the Russian Federation, about 6,000 sites of technogenic pollution of groundwater have been recorded, mainly in the Privolzhsky, Siberian and Central Federal Districts. Most groundwater contamination sites with the 1st class of pollutant hazard ("extremely dangerous") are detected in the areas of large industrial enterprises.

Under the influence of anthropogenic load, there is deterioration in the quality and pollution of groundwater. The quality of groundwater meets modern regulatory requirements for drinking water not in all fields. Thus, signs of incomplete compliance of groundwater with drinking purposes are noted in 62% of the developed and in 51% of undeveloped fields, and in 50% of water intakes located in areas with unappreciated stocks. In this case, in 85% of water withdrawal this discrepancy is related to the natural conditions of forming the quality of groundwater and 24% - with technogenic pollution. In connection with this, special water treatment is carried out for 10% of water intakes. The number of identified foci of groundwater pollution is constantly growing. On average, about 335 new foci of pollution are detected each year. The greatest number of groundwater contamination sites has been detected in the Privolzhsky (37%), Siberian (25%); Southern (11%) and Central (10%) federal districts. The structure of pollution, that is, the ratio of identified foci with different chemical composition of pollutants and different sources of pollution, remains practically stable over the past few years. Pollutants are nitrogen compounds (nitrates, nitrites, ammonia, and ammonium compounds), petroleum products, sulphates and chlorides, heavy metals (copper, zinc, lead, cadmium, cobalt, nickel, mercury or antimony).

The pollution of deeper aquifers used for centralized water supply depends on the degree of their protection. Of the total number of explored deposits, 15% are classified as secure, 42% - protected, 43% - unprotected.

On the territory of Russia, about 500 water intakes with permanent or incidental contamination of groundwater have been identified, 25% of which - with a capacity of more than 1000 m^3/day. In most group water intakes, groundwater pollution is observed only in individual wells and is of an insignificant (1-10 MPC) intensity.

Sources of pollution are waste and sewage storage tanks, large landfills of solid household waste, construction sites, oilfields and oil depots [8-9], industrial sites, etc. In the territory of the Kursk, Bryansk, southern parts of the Kaluga and Tula regions, the consequences of the Chernobyl accident in the form of radioactive fallout on the surface have appeared, they gradually seep into ground and underground waters. Problems of radiation safety have been identified in the Tver, Ivanovo, Moscow, Smolensk, Ryazan, Belgorod and Voronezh regions. The greatest environmental hazard is the contamination of groundwater at the water intake of drinking water supply (including the Kursk region).These are mainly water intakes, consisting of single wells with a capacity of less than 1000 m^3/day. Water intakes of the city of Lipetsk are problematic in this respect; nitrate pollution has been discovered in their underground waters. At the water intakes of the Kursk urban agglomeration, groundwater partly does not correspond to the sanitary norms for the content of manganese, iron, phenol, oil products. At some water intakes, there is a discrepancy between water quality and radiation safety requirements. In the Smolensk region, at water intakes of large cities, there is a tendency towards the increase of mineralization, total hardness, iron, manganese, strontium content.

In the Perm region, strontium contamination has been detected in the section of the Suhorechensky water intake. An unsuitable situation with the quality of groundwater is formed at the water intakes of the Omsk, Novosibirsk and Tomsk regions. Thus, environmental problems can adversely affect the socio-economic development of a large area.

According to experts, the volume of contaminated groundwater is twice the volume of explored waters, suitable for use. A significant part of the fields is operated without official approval of their reserves [2].

Leading Western countries have begun work on the rehabilitation (remediation) of contaminated surface waters since the 1980s. In Russia such work has not been conducted yet.

However, one should note such a positive fact that the decrease in groundwater production in the Russian Federation, which began in the 1990s, has led to a slowdown in the levels of groundwater levels, their stabilization and even recovery. Rehabilitation of groundwater conditions has also covered areas where mines are conserved or liquidated.

BASIC MEASURES TO PROTECT GROUNDWATER IN RUSSIA

The increase in the anthropogenic pressure on groundwater in the process of their use, as well as the irretrievable loss of useful properties of groundwater, preventing their further use, lead to the followings:

- application and development of engineering methods for the protection of groundwater;
- maintaining permanent environmental monitoring;
- application of the best, least water-intensive technologies in production processes, liquidation of irrational water consumption and numerous losses of water at all stages of its use;
- establishment of water use limits and determination of forecast indicators (volumes of water consumption and water disposal) for enterprises with a focus on both technical and economic parameters of production capacities and actual production volume, and on specific environmental indicators (for example, the water capacity of the gross regional product, the water disposal factor);
- strengthening of state regulation measures of relations in the field of use and protection of groundwater.

We should highlight the last item. The variety of natural properties of groundwater determines the multi-purpose nature of their use which determines the existence of a multitude of subjects having the right to use underground waters, whose interests may not coincide, and sometimes contradict each other. A large number of federal agencies take part in regulating the issues of water resources research, protection and use in the Russian Federation, among which a head which coordinates all issues for groundwater has not been identified. Due to various departmental affiliations, the existing management system does not solve all the tasks facing it. The purpose of the management should be to prevent further pollution and stabilize the consumption and quality of groundwater.

In accordance with the basic principles of state policy in the field of use and protection of water bodies defined by the "Water Strategy of the Russian Federation for the period to 2020", the improvement of public administration is to implement the principles of integrated water resources management in the Russian Federation. Development of public administration system should be built on the basis of implementation of basin management principle in the field of water relations (basin councils) and securing authority for local authorities to protect water objects that are in federal ownership and located on the territories of municipalities (It should be noted that basin planning of water management for Russia is not new and is connected with administration. The latter implies interaction with water users within large river basins, organization, planning and control over the implementation of all economic measures for the restoration and protection of water resources (including underground ones), the creation of associated financial flows, and reporting to the federal regulatory authorities. However, this system operates only for surface water bodies due to established traditions.).

An effective management system, which has already been implemented in more than 50 countries, has been developed in France. It is based on several new principles:

1. the unity of underground and surface waters;
2. basin: the management is conducted not by territory, but by a water basin;
3. two-level: consists of the basin committee (the water parliament), which has the legislative right, and the water agency - the executive body;
4. economic: the polluter pays;
5. decentralization of management;
6. sharing responsibility: any owner is responsible for the state of water.

The most important factor that influences the possibility of organizing an effective water resources management system is the formation of a budget for the "water sector", which is being built on tax collections and targeted payments.

These payments should be accumulated, for example, in a specially created extra-budgetary fund. Such a fund will allow the implementation of environmental measures in the use of surface and underground resources (providing the population with clean drinking water, clearing channels, strengthening banks, creating dams and dumping, ensuring the safety of hydraulic structures).

CONCLUSION

In our country drinking water supply is based on the use of surface and groundwater. It has their own specific features of resources, composition, regime and properties in connection with the geological, geographic and hydro-geological conditions of various regions of the vast country. Surface drinking water, having the greatest resources, naturally changes its chemical and micro-biological composition, physical properties during the seasons of the year. It is most exposed to the possibility of industrial, agricultural and domestic pollution. The modern quality of surface water significantly limits its use for domestic and drinking purposes. In this regard, the importance of groundwater as a more secure and widespread resource is increasing.

Excessive use of water in industry and irrigation is un reasonable. Fresh groundwater of high quality should be used carefully and preserved for future generations. It is necessary to develop and clearly fulfill all requirements for the protection of drinking groundwater within specific fields. In view of this, the economic, ecological and social character of water relations requires direct state regulation. It seems that the measures of rational use and conservation of groundwater resources will be effective and real, if they are based on the subordination of the interests of individual water users to the national interests of the country.

Ensuring the rational use of water resources is one of the key environmental problems of the national security of the country. The successful solution of this problem will contribute to the social and economic development of the Russian Federation.

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Paper submitted: 12.07.2019.
Paper accepted: 09.09.2019.