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Transboundary aquifers

title: **Transboundary aquifers in Russia**

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In recent years the problem of transboundary waters using has become rather actual in many countries. It concerns not only the interstate boundaries where the use of marginal or transboundary rivers (rivers crossing boundaries) in many cases is regulated by special international agreements. The agreements between Russia and China about the Amur River waters usage, the agreement between the Governments of Russia and Estonia about collaboration in the field of transboundary waters protection and regional use and other international agreements can be mentioned as the examples of it. "Convention on transboundary water streams and international lakes protection and use" accepted in Helsinki in 1992 is of great importance either. In the Convention the attention is paid to the necessity of unified principles development devoted to the interstate transboundary water objects protection and use including surface and ground waters on the basis of special agreements between countries.

The problem of transboundary water use regulation is rather acute also inside some countries (e.g. USA, Australia, Russia, India and others), where particular administrative regions (states, regions, federal divisions) have a constitutional independence and solve many problems of natural resources use independently, coordinating basic legislative acts only with neighboring countries or federal organs. Thus, for example, in Australia each state has special commissions on water resources, which give permissions for water use (including drilling of artesian water wells) and arrangement of research and designing works, definition of allowable water extraction limits for different state demands, and implement control over water quality and contamination levels by different components.

It should be noted that the problems of transboundary rivers use and protection can be solved easier than the problems of transboundary aquifers use. It is connected with the fact that the major countries have good observation networks controlling discharge and quality of river waters. Moreover, some countries have special hydrometric stations on their boundaries which are constantly measuring discharge and composition of river waters in an automatic mode. In such cases the quantity and quality of water to be kept for a neighboring country (or state) are regulated and controlled in accordance with existing special agreements. Many countries have a good experience in solving of this problem.

The matter is more difficult with the use of transboundary groundwater aquifers. As it is known, the groundwater resources unlike river waters cannot be measured directly; they can be only calculated. The methods of regional assessment both of replenished and non-replenished groundwater resources considerably differ from each other in many countries. At present, the experience of resources and quality estimation of transboundary aquifers, including firstly prospects and allowable limits estimation of their possible exploitation, is extremely limited, though such transboundary aquifers exist almost in all the countries (except island ones).

After Soviet Union disintegration the problem of transboundary aquifers studying has become rather acute for Russia as it has land boundaries with 13 sovereign countries (Zektser, 2007).

Without pointing out at the legal and juridical problems of transboundary groundwater use having the important individual value, we will consider only the primary goals of regional researches of transboundary aquifers.

Determination of prospects for groundwater use and withdrawal management is always connected with the problems of exploitation restrictions in accordance with different criteria. The

latter may be both of inside and outside types (Mironova et al., 2006). The inside criteria include, above all, limitations of hydrogeological and hydrodynamical operation conditions, such as groundwater recharge rate in an annual and multi-year cross-section, tolerance dynamic level lowering throughout estimated period, risk of non-standard groundwater drawing up to a water intake from adjacent aquifers, variability of hydrogeological parameters of an exploited aquifer in plane and cross-section, and others. The outside criteria that can restrict the groundwater use are related to possible impacts of a planned water extraction upon different environmental components including river runoff, which is especially must be taken into account for aquifers of infiltration type in river valleys; suppression or death of vegetation due to excessive lowering of shallow groundwater level in the upper unconfined aquifer; activation of karst and suffusion processes; earth surface subsidence, etc. (Zektser, 2000; Yazvin, 1998).

The following basic problems of transboundary aquifers studying and use often tightly connected with each other can be distinguished:

- Quantitative assessment of natural and exploitable groundwater resources of boundary and transboundary aquifers. The method of such regional estimation is developed well enough. It is based chiefly on hydrodynamic calculations, including regional models of groundwater discharges and possible productivity of aquifers and large groundwater well fields;
- Determination of chemical, biological and radionuclide compositions of groundwater and an allowable level of its changes;
- Estimation of fresh groundwater vulnerability in transboundary aquifers to anthropogenic contamination penetrating from the earth's surface;
- Scientific and methodical substantiation of inter-country agreements on allowable limits of groundwater use from transboundary aquifers, including, firstly geoenvironmental aspects, allowable levels of groundwater extraction, a risk of aquifer contamination and depletion;
- Development of joint interstate monitoring of transboundary aquifers groundwater use and its protection.

On the border territory of Russia with the neighboring countries 13 regions (within on-land boundaries) are distinguished, where transboundary groundwater systems are spread. Some regions are subdivided into sub-regions, according to hydrogeological conditions. Brief description of these regions and sub-regions is given below.

Geofiltrational models of Russian and Estonian, and Russian and Ukrainian border regions have been developed in recent years in Russia to determine the prospects of transboundary aquifers use. Modelling results are shortly stated below.

RUSSIAN AND ESTONIAN BORDER

Russian and Estonian hydrogeologists teamwork resulted in integrated Russian-Estonian geofiltrational model of lomonosovskiy-voronkovskiy aquifer. The model was based on the analysis of available hydro-geological information on the Estonian Republic territories, the Leningrad and Pskov regions of Russia. Water containing formations of this aquifer are presented by quartz sandstones with interbedded clays with total thickness of 30 meters. The thick stratum of loptovskiy clays serves as their upper aquiclude and clays of upper Proterozoic appear as

their bottom. This aquifer is subartesian with pressure value of near 100 m; water levels in wells are established at depths of 15–45 m. The aquifer is maintained in border regions of Russia and Estonia. Three possible variants of hydrodynamic situation development in Russian and Estonian border area have been considered in the regional model: They are the following: 1) the new water intake in Ivangorod with productivity of 3000 m3 per day is added to the already operating water intakes with existing productivity; 2) water withdrawal from all water intakes on the Russian territory, including the new one in Ivangorod, has increased twice, and Estonian water intakes yields remain constant; 3) Estonian water intakes yields are decreasing twice. As a result it has been determined that the groundwater overflow through Russian–Estonian border under the influence of water withdrawal is much lower than their natural discharge through it. Even double decrease in water withdrawal from this aquifer on the Estonian territory does not change the current hydrodynamic conditions. Only the high increase in water intake on Russian territories can change the hydrodynamic situation, up to the complete inversion of the natural flow.

Researches of Russian and Estonian transboundary aquifers, as outlined above, were the first and almost the only joint work of experts from neighboring countries on transboundary groundwater studying. These researches can be an example of the international cooperation on this challenge (Mironova et al., 2006).

RUSSIAN AND UKRAINIAN BORDER

The integrated base of cartographic and factual data for the general mathematical model of transboundary aquifers of Dneprovo-Donetsk artesian basin is created. The model covers the territory of 248×276 km, a grid step is 1 km. Northern part of model includes the Belgorod region of Russia, southern part comprises the Kharkov region of Ukraine. 4 aquifers and three relatively impermeable layers are considered vertically. The basic regional water intake is coincided with the second one which consists of maastriht-turonskiy and alb-senomanskiy aquifers.

On model living conditions the specifications of regional hydrodynamic flow existence for undisturbed filtration regime have been reproduced and hydro- and pezoizogips maps for 4 aquifers and a water exchange map between them have been constructed. Also the data on balance components have been obtained. Besides, graphic representation of groundwater flows for simulated aquifers concerning state borer is received.

To reproduce the disturbed filtration conditions all existing water intakes of the Belgorod region for the periods of 1970, 1980 and 1990 have been set with prolongation of ten-percentage increase in water withdrawal till 2009.

Maps of levels decrease in exploited aquifers and also tables of certain hydrodynamic balance components on calculated time steps are received.

On the basis of the analysis of structure of groundwater resistance indicators and their quality for transboundary aquifers of the Dnepr and Don river basins it is determined that the Dneprovsko-Donetskiy basin is characterized by an high resistance indicator, and the Donetsk basin has extremely low groundwater resistance indicator to anthropogenic impact (Belousova, 2005; Goldberg, 1987).

In conclusion, we should say that the constantly operating models are a reliable tool for forecasting of the practical groundwater use prospects, which meet the requirements of environmental protection limitations and prevention or minimization of damage to neighboring countries.

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