Regional Features of Sustainable Use of Fresh Groundwater in Europe (on the Specific Example of Belarus)

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Abstract

Freshwater resources are one of the major constituents in successful development of economy of any part of the world. As a rule, surface waters provide for agriculture and industry. But since groundwaters server as a major source of drinking water, their quality and availability is of vital importance.

This article presents an analytical overview of distribution of fresh groundwater resources in Belarus, the dynamics of their usage and the influence of human activity on groundwater resources.

Spatial differentiation of freshwater resources within the borders of Belarus is reviewed. The dynamics of fresh groundwater abstraction and consumption during a prolonged period of time (24 years) is analyzed.

Also, described and classified are the main natural and anthropogenic factors influencing the quality and availability of fresh groundwater. Their mapping is done.

As a result, it was found out that the country possesses rather considerable resources of fresh groundwater sufficient for present and perspective water demands. However, the quality of groundwater does not always meet the norm.

Key words: natural fresh groundwater resources, water quality, drinking water, fresh water consumption, groundwater contamination

INTRODUCTION

The area under study – Belarus is situated in eastern Europe. The west of the country is characterized by the climate transitioning between maritime and continental. The climate in the central and eastern parts is continental. The territory of Belarus is situated in the sufficient precipitation area. The average annual precipitation is 700 mm, ranging from 600–650 mm in the southeast to 650–700 mm in the highest areas in the center of the country. The average annual evaporation varies from 550–575 mm in the south to 475 mm in the north of the country (Climate, 1996). Due to its climatic, geologic and geomorphological features, the territory of Belarus has favorable conditions for formation of freshwater resources, their wide distribution and reproduction.

OBJECTIVES

• To carry out a regional evaluation of provision of the territory of Belarus with freshwater resources and examine their differentiation.

• To analyze groundwater usage in national economy.

• To find and classify natural and anthropogenic factors influencing sustainable use of fresh groundwater and carry out its mapping.

The following methods were used to implement these objectives: comparative-geographic, cartographic and method of statistical analyses.

RESULTS AND DISCUSSION

Freshwater resources include surface and ground waters. Surface waters and groundwater aquifers have a hydraulic connection. This has to be taken into consideration when solving problems of sustainable use of fresh groundwater.

Freshwater resources of Belarus are generated in the boundaries of five main catchment areas. These are the Dnieper, the Pripyat, the Western Dvina, the Neman and the Western Bug. All the main rivers of these catchment areas are transboundary. The largest Belarus rivers rise in Russia or Ukraine, flow through Belarus territory and bear their water towards Ukraine and Latvia. The total annual average river runoff is evaluated at 57.9 km^3/year; 59% of it is related to internal water resources and 41% is received from neighboring territories. Its largest amount belongs to the Dnieper catchment area (11.3 km^3/year) and the smallest to the Western Bug catchment area (1.4 km^3/year).

The water-bearing strata containing fresh water used for water supply belong to Quaternary, Paleogene and Neogene, Cretaceous, upper Jurassic, upper Devonian and upper Proterozoic sediments. As a rule, exploited aquifers are shallow (50–200 m). They contain hydrocarbonate calcium as well as magnesium and calcium water with mineralization level between 20 mg/dm^3 up to 1.000 gm/dm^3 (Jasoveyev, M.G. *et. al*., 2005).

To supply urban Belarus with water, over 260 fresh groundwater fields were explored. Their recoverable storage is about 6.600.000 m^3/day. The majority of fresh groundwater fields (over 60%) are small fields with recoverable groundwater storage of 1.000–30.000 m^3/day. The natural fresh groundwater resources are evaluated at 15.9 km^3/year, while the prognosis water resources at 18.1 km^3/year. However, these resources are not evenly distributed among catchment areas. The total abstraction at 1.800.000 m^3/day for public water supply accounts for only 27.3% of recoverable groundwater storage (The state, 2001). The prognosis groundwater resources can be considered sufficient for actual and perspective water demands.

In Europe, about 18% of the total water abstraction comes from groundwater, its proportion varying from country to country. In Belarus, the water abstraction from natural sources had a 39% decrease during the 1985–2008. For the same period of time the portion of surface water in total water abstraction decreased from 60 to 44%, while groundwater abstraction has increased from 40 to 56%. Water consumption has a similar tendency to decrease, but it has different features depending on the consumption sector. In 2008, water consumption was estimated at 1410 mln. m^3, or 86% of total water abstraction. On average, the total water consumption is distributed as follows: 40.6% of it is used for household and drinking purposes, 30% for industry, 21.3% for fish farming and 8% for irrigation, watering and agricultural needs. Compared to 1985, the total water consumption decreased by 46.5%. From 1985 to 2008, there was a steady tendency to decease of water consumption in industry, agriculture and fish farming sectors. For household and drinking purposes only groundwaters are used. The average water usage for drinking purposes per capita is about 200–220 l/day. It is higher than in many European countries (120–150 l/day/per capita). In this sector, the water consumption increased by 41% from 1985 to 2002, but after that decreased by 28% during the 2002–2008 (Environment, 1999, Environment, 1997–2009). There appears to be several reasons that account for serious decrease of water consumption. Some of them are decline in industrial and agricultural activity in the first half of the 1990s, decrease in population, water savings due to recirculation and successive water supply, introduction of domestic water metering.

The quality and availability of fresh groundwater is affected by several factors, which can be classified as natural and anthropogenic (Fig. 1). Natural factors include natural increased/decreased concentration of chemical elements, salt-water intrusion, floods and swamping. A specific feature of groundwater in Belarus is naturally high concentrations of iron (>0.3 mg/dm^3), manganese (>0.1 mg/dm^3) and deficit of fluorine (<0.7 mg/dm^3). There is salt-water intrusion in some sectors of underground saline water discharge, belonging to tectonic fractures and salt tectonics at the Pripyat

trough. This causes mineralization rate to increase to 4.000–6.000 mg/dm^3 and the chemical compound of groundwater to acquire a chlorine sodium component. Floods occur either in spring or after abundant rains. As a result, industrial waste, sewage and radionuclides enter the floodwater, causing contamination of soil, open water systems and groundwater (Jasoveyev, M.G. *et. al*., 2005).

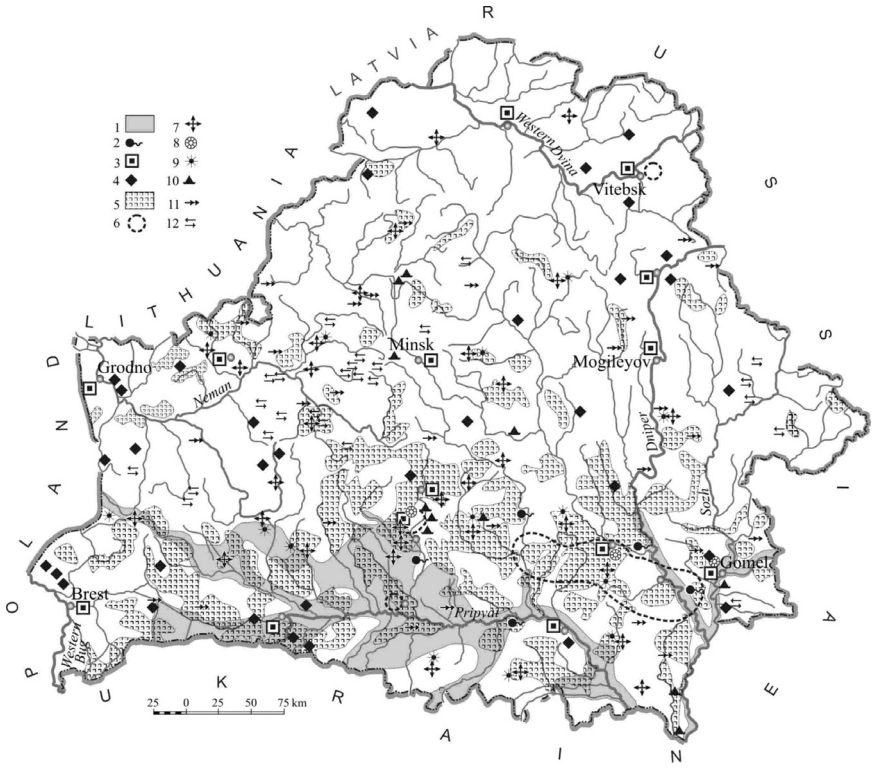

Figure 1 – Factors and processes effecting on quality and availability of fresh groundwater

Natural factors: 1 – Flood and waterlogging at hazardous spring flood, 2 – Salt water intrusion; Anthropogenic factors: 3 – Industry and household objects of intensive pollution, 4 – Large-scale agriculture objects, 5 – Areas of intensive land reclamation, 6 – Areas of mineral deposits prospect and exploration (oil, potash salt, building materials, dolomites), 7 – Deflation (on land reclamation, industry dumps, borrow pits), 8 – Karst (in industry dumps), 9 – Disintegration of organic (on land reclamation), 10 – Wetlands bordering on reservoirs, 11 – Suffusion (in separate borrow pits), 12 – Sheet erosion (on cultivated lands)

Anthropogenic stress has the deepest influence on the groundwater (3–6 m deep) and inter-stratum water-bearing complexes of Quaternary sediments. It leads to freshwater pollution by nitrates, chlorine, sulfates, pesticides, mineral oil products, heavy metals, etc., to developing processes of deflation, sheet erosion, suffusion, elevation of ground water level, wetlands, disintegration of organic substance, depletion of water and salt underground water intrusion.

CONCLUSIONS

Natural conditions of the territory of Belarus are favorable for formation of freshwater resources. Fresh surface and ground waters are unevenly distributed throughout the country, but they are sufficient for actual and perspective demands. The analysis of the dynamics of water abstraction in Belarus helped determine characteristic stages of water abstraction. There are several factors causing freshwater abstraction and consumption changes. To determine the role of each factor, one needs carry out additional analyses and specify the role of separate branches of national economy in the structure of freshwater consumption.

The quality of drinking water, as a rule, meets the standards. The only exception is when there is a naturally high concentration of some chemical elements in water. Anthropogenic stress causes a more serious problem to the regime of fresh groundwater.

There are practical and economic measures that could help achieve sustainable fresh groundwater usage. Some of them are improving ecological conditions in the protection zones of groundwater intake; limiting or restricting agricultural land use within the borders of cones of depression and riparian water protection zones; using superficial artesian waters for technical purposes in the areas of groundwater pollution and wetlands; monitoring regularly surface and ground waters within the borders of large-scale industry and agriculture, as well as solid municipal waste heaps.

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