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Environmental Protection of International River Basins

PILOT PROJECT
Detailed assessment sources of pollution of potable GW sources supplying the "Novinki" region in the territory of Minsk

INCEPTION REPORT

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INTRODUCTION

In present time intension of impact on nature habitat increases continuously, therefore irrational use and quality deterioration of ground water could lead to irreversible consequences.

Municipal drinking water supply of Minsk agglomeration is based on ground water basically. Only some regions in the western part of Minsk use drinking water from Vileyka-Minsk water system, that was introduced in 1976. Part of surface water coming from Vileyka-Minsk water system doesn't exceed one third of water consumption. In the nearest future drinking water supply in Minsk is planned to be fully from groundwater.

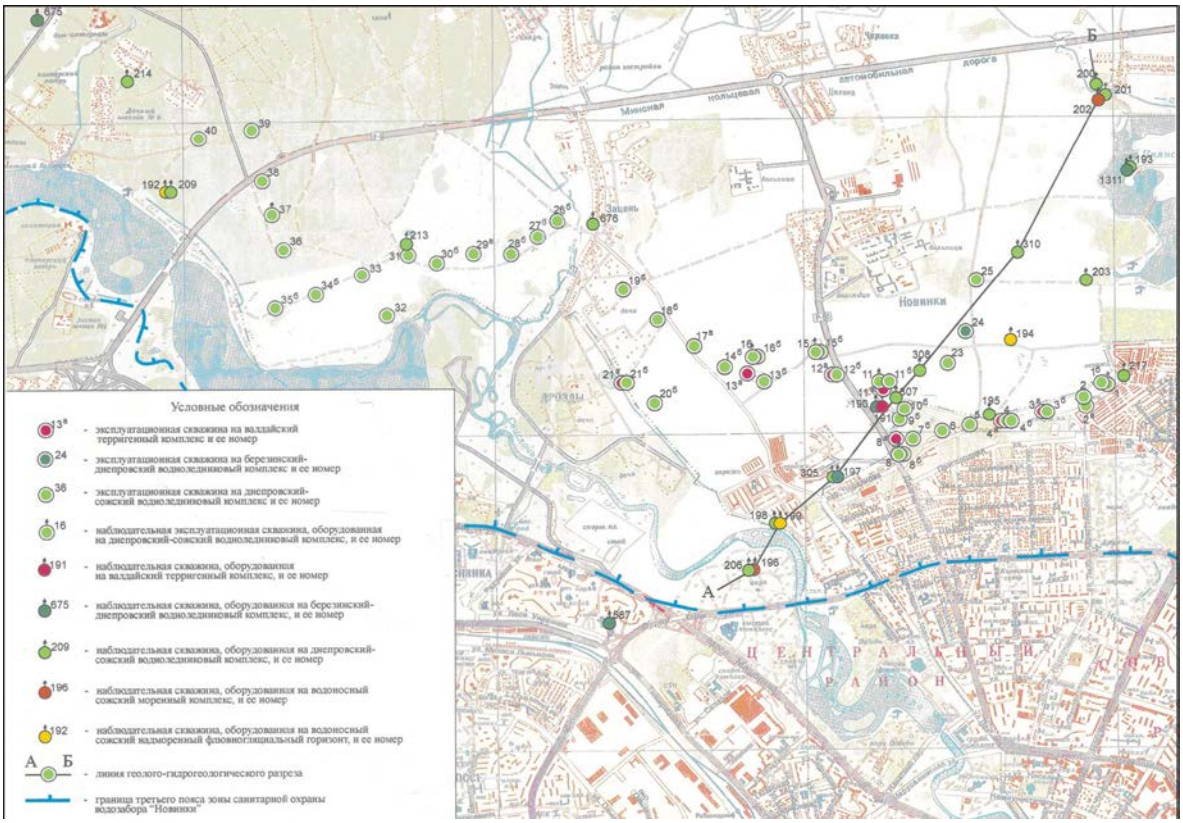
The territory of Mink agglomeration is characterized by significant amount of fresh groundwater resources. The thickness of fresh water is 300 m in average. The main working aquifers are Dneper-Sozh fluvioglacial aquifer of Quaternary deposits and Valdai terrigene aquifer of the upper Proterozoic deposits. The depth of occurring of Dneper-Sozh fluvioglacial aquifer is 40-60 m, and Valdai terrigene aquifer occurred at depth of 190-320 m. Some Minsk intakes explore Narovsk terrigenous-carbonate aquifer of the middle Devonian deposits together with Valdai terrigene aquifer. In present unconfined aquifer that occurred first from surface isn't almost working, but had been worked by shaft wells before Minsk intakes were introduced. This aquifer was partly drained under intakes work influence.

Ground water abstraction for drinking and industrial water supply of the city purpose is carried out on 15 water intakes, each of them has more than 10 wells with 50-300 m depth. The older intakes ("Novinki", "Petrovschina", " Zelenovka", "Drazhnya") were built in 1930^{s} и 1950^{s}. In present they are in Minsk agglomeration completely or almost completely. The rest of intakes ("Borovlyany", "Ostrovy", "Volma", "Vitskovschina", "North and South Vodopoi", "Felitsianovo", "Green Bor") are in the more favorable environmental conditions, in distance of 8-25 km from city [6]. Total capacity of intakes is 374 000 m^3/day. More than 95 % of abstracted ground water volume in Minsk is for the account of Dneper-Sozh fluvioglacial aquifer work.

In present steady state (or close to steady) of filtration is observed for all working water intakes. It means that achieved level of water abstraction is compensated by restoration completely and doesn't limit in time. In spite of existing favorable prognosis concerning hydrodynamic situation, question of future quality for these intakes is open yet. It is due to rapid growth city infrastructure, agricultural and industrial development, intensive water abstraction.

The most critical situation for future ground water quality in Minsk agglomeration is "Novinki". "Novinki" intake is situated in nothern-west part of

Minsk and was built in 1932. Ground water abstraction in this period was carried out only from Dneper-Sozh fluvioglacial aquifer. In 1958 Valdai terrigene aquifer work started. In present time 39-41 wells work constantly (picture 1).



Picture 1 – Scheme of working and observational wells places of "Novinki" intake

The most of them explores Dneper-Sozh fluvioglacial aquifer, one – Berezina-Dneper intertill fluvioglacial aquifer, two - Valdai terrigene aquifer. "Novinki" intake is one of the more efficient within the Minsk agglomeration. Total average daily extraction from working wells reaches 50 600 m^3/day.

Wells are situated in a jogged line with 15 km of distance, that stretched from NW to SE along Drozdy reservoir and valley of the Svisloch river. Distances between wells change from 250,0 to 450,0 m and are 350,0 m in average. Depth of wells varies from 33.0 to 306.0 m. Data of regular survey on ground water quality shows clear tendency to anthropogenic pollution (first of all nitrates) increasing in working Dneper-Sozh fluvioglacial aquifer. Nitrates in ground water were almost absent at the beginning of intake working (in 1930^s). In 1970^s, nitrates in a number of wells had been 20-27 mg/l, and rose to 50-65 mg/l in the middle of 1990^s.

Hydro-geochemical testing of wells in 2009 showed 62,3–81,8 mg/l of nitrates for maximum content, and exceeding of MAC was fixed for 9 wells. Nitrates content in 18 wells was less than MAC, but more than level of natural geochemical background [7].

Additional field survey for more unfavorable wells of this intake was carried out in May of 2014 in the frame of WFD meeting the requirement. It was set that nitrates content in working well № 15 achieved to 83,5 mg/l which exceeds MAC almost 2 times. Changing of ground water quality is due to the ground water contamination sources are on the territory of the intake. These contamination sources are anthropogenic (municipal, agricultural, waste storage of poultry farm). Early this territory was place of waste from Krupskaya poultry farm storage and utilization.

Since one of the main purposes of WFD is development of measures for ground water protection, the measures based on mathematic modeling method will be received for human impact decreasing and ground water quality improving in frame present work.

Aim of present work

Aim of present work is ground water quality assessment and prognosis for “Novinki” intake and development of measures for ground water protection and quality elements conservation in level of municipal drinking water standards.

For achieving of aim it will carried out **follow tasks**:

1) geology-hydrogeology data collection, summarizing and study having for “Novinki” intake;

2) assessment of ground water vulnerability of investigation territory;

3) ground water contamination sources study and mapping using GIS;

4) mathematic modeling of ground water geofiltration and geomigration in “Novinki” intake territory using GMS tools;

4) guidance development for ground water protection against pollution.

Carrying out of these tasks is expected to do in few phases.

First phase of investigation consist of:

1. Collecting, summarizing and analyzing the landforms, hydrography, geology and geology-hydrogeology data for site research. It will collect and analyze the facts, including sections of bore wells and geology-hydrogeology dissection of layer data, water cut extent, ground water level data for working and supply aquifers including shallow ground water. It will study the lithological composition and assess the aeration zone depth, also study the covering degree of working Dneper-Sozh fluvioglacial aquifer (presence or absence of moraine deposits of Sozh age, depth and lithological composition).

2. Creating the data base based on facts systematization, that will be used for mapping consisting of facts map with all boring wells, geology map of Quaternary deposits, hydrogeology map and geology-hydrogeology section. Geology map of Quaternary deposits will contain all genetic type of deposits underlying first from

land surface with ages. Hydrogeology map will show identified hydrogeology layers (aquifer, low-yield aquifer, impermeable) within whole water-saturated strata, also the water level surface position of working aquifer. The scale of map is 1:10 000.

3. Collecting and analyses the data for existing working and observation wells: their precise position, working state, water intake quantity, level regime characterization and data of chemical composition and quality of ground water, as working aquifer, as supply aquifer and complex. It will presented graphic matter with changing dynamic of extraction, level regime and chemical composition, aggregated tables. For this purpose we are going to use data of informational resources “State water cadaster – data base Ground water of the Republic of Belarus” (certificate № 0870800076 from 07.03.2008).

4. Studying the ground water quality and chemical composition for whole period of pilot project duration. For this purpose it will be accompanied by additional sampling from 5 working wells (4 times for year), that are the most polluted. Also it will be determinate contamination compound that may be present in ground water of “Novinki” intake. There are NH_4+, PO_4, Fe, SO_4^{2+}, Cl^-, NO_2^-, NO_3^-, F^-, B, Ba, solids content. Additional it will be determinate such parameter as permanganate oxidation (mgO_2/l). In our point of view, this research will permit to fix (define) that season of year in which nitrates concentration (the most widespread pollution ground water contamination of “Novinki” intake) achieve the maximum, which allows to make the appropriate conclusion. Analysis for ground water chemical compound and quality definition will be carried out at accredited laboratory (branch “Central laboratory” of Research and Practical Centre of Geology).

5. Assessing the ground water vulnerability of site research starting from surface pollution. According to V.M.Goldberg ground water vulnerability is covering degree of aquifer by deposition (mainly permeable), what impedes the contamination penetration from the top of the ground into ground water [3].

Realization of above works is immediate stage which need to next natural hydrogeological conditions schematization and is necessary part for follow mathematic model development and geofiltration and geomigration tasks solution.

At second phase of investigation it is going:

1. to study the ground water contamination sources within the “Novinki” intake: their placement, size, capacity, contamination characterization, recycling mode. For this it will be need to study all maps included data of ground water contamination sources places. It will be taken into account the actual and historical (1960-1990s) maps, since some of contamination sources (e.g. filtration fields, old waste storage etc.) might be built by garages, housing estate, but can influence to ground water chemical compound and quality.

2. Realize the reconnaissance survey of identified pollution sources (in the site), and ecological state of zones of sanitary protection of intake “Novinki”.

3. Summarize all obtained information and draw the map of identified pollution sources in scale of 1:10 000 using Mapinfo.

At third phase of investigation it is going to realize the mathematic modeling of ground water geofiltration and geamogration process within “Novinki” intake.

The goal of **geofiltration modeling** is:

- to identify the ground water balance changing within the site research;

- to predict the ground water level decreasing in the intake regarding for local depression cone interaction;

- to assess the ground water formation sources and the extraction consequences on subsoil water and river runoff [1, 2, 4, 5].

Hydrogeochemical modeling goal is to assess potential changing of ground water chemical compound due to contamination penetration from the top of ground.

To design the mathematic model based on previous investigations needs to:

- realize the schematization of geology-hydrogeology conditions of site research. The schematization is reduction the initial data to particular schema, that reflects the ground water occurrence, feeding, movement and discharge features within site research, with information about depth of occurrence, aquifer and separating layers thickness, horizontal and vertical conductivity, porosity, water loss, head dimensions etc. Dissection of deposits into aquifer and permeable layers will realize according to the data, that characterizes permeability and filtration features of deposits according to the vertical and horizontal extension [4, 5];

- solve the epignosis tasks in nonstationary equation in order to correct and adapt the model to natural and impeded conditions of site research;

- solve prognosis geofiltration and geomigration tasks with assessment of extraction impact on ground water level decreasing and river runoff, draw the prognosis maps of the main aquifers.

To develop and design the mathematic model it will be used actual soft of Aquaveo company, that provides modeling of ground water movement and contamination migration process (Groundwater Modeling System «GMS v.7.0.2»).

GMS v.7.0.2 is dynamic developing system that can be named GIS for ground water modeling. In addition to import and export of tables into (from) GIS-codes (AutoCAD, ArcGis and MapInfo), it has own GIS-module. It means data preparation process can be carried out in GMS, also in extern codes. Model and calculation modules are 3D. It is important that model takes into account the landforms, thickness of all aquifers and separating layers in details, which allows to approximate to research geology-hydrogeology conditions of site. As a result, in

addition to model we have GIS-system, i.e. 3D view of geology-hydrogeology compound of all site research, that we can be used to understand the geology-hydrogeology composition of research site and make a decision in hydrogeological survey at any place of site.

At fourth phase of investigation it will develop the guidance for ground water quality improving aimed to resources and ground water conservation for "Novinki" intake and based on above mentioned works.

It is supposed to consider some method aimed to:

- ground water contamination sources elimination in "Novinki" intake,
- extraction decreasing from polluted working wells,
- exploitation removal of polluted wells and wells boring on the more favorable site of intake.

It is planning to offer the guidance for improving the regular net of wells in the territory of "Novinki" intake for following regular ground water monitoring.

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