ГІДРОГЕОЛОГІЯ, ІНЖЕНЕРНА ТА ЕКОЛОГІЧНА ГЕОЛОГІЯ

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ARTIFICIAL HYDROGEOLOGICAL WINDOWS AS A SOURCE OF BUCHAK-KANIV AQUIFER'S POLLUTION IN THE NORTH-EAST OF UKRAINE

(Представлено членом редакційної колегії д-ром геол. наук, проф. О.Є. Кошляковим)

A new method for determining the location of artificial hydrogeological windows in the roof and base of the aquifer has been proposed. As an example, the Buchak-Kaniv aquifer is given. This aquifer is widespread in the north-eastern part of Ukraine and is the main source of water supply for the region. In our opinion, pollution of the Buchak-Kaniv aquifer can occur primarily through artificial hydrogeological windows in its roof and bottom. In order to determine the location of artificial hydrogeological windows, factor analysis of the chemical composition of groundwater aquifer is used. The analysis was first carried out in places where it is precisely known about anthropogenic contamination of the aquifer with oil products and associated waters through artificial hydrogeological windows (for example, oil or other wells). As a result, a number of influential factors weighing more than 10% were identified. Further, in other areas factor analysis is also carried out using the same set of components of the chemical composition of groundwater. The coincidence of influencing factors indicates the theoretical possibility of an artificial hydrogeological window in a given area.

In addition, various options for the distribution of pollutants over the horizon area are considered.

The identification of these windows is important for identifying sources of aquifer pollution. Especially attractive will be the use of this method in areas where old (working and closed) oil, gas and oil-gas condensate fields are located.

Keywords: Buchak-Kaniv aquifer, artificial hydrogeological windows, aquifer pollution, factor analysis, oil and gas fields.

Introduction. Buchak-Kaniv aquifer is widely developed within the north-eastern part of Ukraine and is its main source of water supply. It is intensively used in the city of Kharkiv, Poltava, Sumy and practically in all rural settlements. This aquifer is also used for water supply of industrial facilities and drilling in the extraction of oil and gas. In Poltava region, water of this aquifer is used for bottling as table water ("Gogolivska", "Veselo-Podilska").

Within the northeast of Ukraine, Buchak-Kaniv aquifer is reliably protected from pollution in natural conditions because the regional aquitard of Kyiv sediments and a thick stratum of marl and chalk deposits inhibit the hydraulic connection of this aquifer with overlying and underlying aquifers and complexes.

As a result of prolonged and intensive operation of the aquifer, the hydrostatic head has now been reduced by 10–20 m, chemical composition is changing, and groundwater often becomes polluted (*Руденко, 1972; Камзист та Шевченко, 2009*).

Many researchers have studied this aquifer in natural and disturbed conditions (*Руденко, 1972; Сухно, 1973; Варрава и др., 1977; Шестопалов и др., 1989, 1991; Чомко, 2000; Камзист та Шевченко, 2009; Левонюк, 2017*). According to their data, the water bearing rocks are gray, greenish-gray fine-, fine- and heterogeneous sands of Buchak and Kaniv suites. Buchak-Kaniv aquifer lies on the marl-Cretaceous sediments of the Upper Cretaceous and Eocene rocks (Luzanovska suite). The roof of the aquifer lies at a depth of 130 to 145 m. The thickness of the aquifer is 17–35 m. Buchak-Kaniv aquifer is covered by dense Kyiv marls and clays, which determines its pressure character. The aquitard reaches 25–100 m. The static level is at a depth of 115–45 m.

Water content of Buchak-Kaniv deposits varies widely. The well flow rates vary from 0.04 to 11.1 dm^3/s at the slopes of 16 and 30 m, respectively.

The waters of this aquifer are fresh. By chemical composition, hydrocarbonate sodium and hydrocarbonate-chloride sodium are isolated with mineralization not exceeding 0.5–1.2 g/dm^3 and chloride-hydrocarbonate sodium and chloride sodium with mineralization from 1 to 3 and from 3 to 5 g/dm^3. The reaction of water in most cases is slightly alkaline (pH=7.2–8.4). Total hardness varies from 1.6 to 10.0 meq/dm^3.

The following micro-components were found in the water: bromine from 0.5 to 1.24 mg/dm^3, iodine to 0.16m/dm^3, fluorine from 0.4 to 6.4 mg/dm^3.

Hydrochemical zonality of this aquifer was studied by K.N. Varava, G.N. Negoda et al. (*Варрава и др., 1977; Левонюк, 2017*). According to their data, in the direction from the northeast (from the feeding area) to the southwest (to the unloading area), water changes according to chemical composition in the following sequence: HCO3 – Ca, SO_4; HCO_3 – Na, Ca; HCO_3–Ca, Na; HCO3–Na; Cl, HCO_3–Na; Cl–Na.

The supply of the aquifer occurs in places where the sediments are deposited on the surface, as well as in places where the waters of the underlying aquifers are discharged.

Many researchers believe that the main formation sources of the aquifer exploitation reserves are natural resources coming from the natural feeding areas of the aquifer and the elastic reserves of groundwater in it. Each of these sources has a different role (*Руденко, 1972; Сухно, 1973; Варрава и др., 1977; Шестопалов и др., 1989, 1991; Левонюк, 2017*).

Recently there have been publications, connected with general issues of Bučak-Kaniv aquifer pollution (*Журавель и др., 1996, 1997; Васильев и др., 1997, Чомко и др., 2004*).

Material and methods. In our opinion, pollution of Buchak-Kaniv aquifer could first and foremost occur through artificial hydrogeological windows in its roof and base (*Чомко и др., 2003, 2017*).

Under artificial hydrogeological windows we understand the shafts of old water intake wells, old and emergency gas and oil wells and emergency wells used to maintain reservoir pressure and burial of associated commercial waters (*Чомко, 2000*). Through the degraded shafts of these wells, Buchak-Kaniv aquifer has a hydraulic link to the overlying Mezhygorsk-Obukhov and Quaternary aquifers contaminated within the oil treatment sites, storage bins and with the underlying Jurassic, Triassic and Carboniferous aquifer complexes containing saline waters and brines. On the territory of the north-eastern part of Ukraine there are several dozen or even hundreds of such emergency and old wells. The location of many of them is unknown. The size of these artificial windows in the roof and base of the aquifer is also unknown.

In classical style, presence of artificial hydro-geological windows at great depths is determined by various pollutants, unusual chemical elements and radicals in the underground waters, by decrease in pressure and their difference in adjacent aquifers (*Мироненко и Румынин, 1982; Шестопалов и др.,2007*).

To determine the location of artificial hydrogeological windows, we suggest using a factor analysis of Buchak-Kaniv aquifer's groundwater chemical composition (*Йереског и др., 1980; Чомко, 2000; Чомко и др., 2002, 2005; Шестопалов и др.,2007*). The research was carried out according to the following scheme.

At the first stage of the factor analysis the results of chemical analyzes of Buchak-Kaniv's aquifer groundwater located in Kachanovske oilfield have been processed. The crater of the emergency wells No. 35 and 65 is located there, and contamination of underground water with mineralized waters is well-known and is confirmed by such data.

In 1962, as a result of the accident at well No. 35 at a depth of 2315 m, a powerful outburst of oil and gas-water mixture occurred. After some time, the well 65 began to flow in. At the site of the well, a crater with a saline reservoir in the central part was formed. The rocks were washed to a depth of more than 40 m. For almost two months carbon brines were supplied to the aquifers and complexes of the upper hydrogeological floor.

As a result of the accident at wells No.35 and No.65, no less than 1500 tons of oil and 200,000 cubic meters of pulp with brines were delivered to the surface. The pulp contained about 20,000 tons of various salts, which came into the river Tashan (the right tributary of the Vorskla River), some of them were detained by dams, and some fell into the aquifers of the upper hydrogeological floor.

Moreover, for a long time the crater was a storage place for man-made drilling waste and a temporary storage of associated commercial waters.

At present, the crater has a diameter of approximately 190 m and average depth to the bottom is about 20 m, it is filled with highly mineralized reservoir waters. Therefore, the crater has become a powerful source of pollution of surface and groundwater, including the waters of Buchak-Kaniv aquifer (*Журавель и др., 1997*).

In 1997, in four wells, operating in Buchak-Kaniv aquifer at Kachanovske oil field, the MPC was exceeded for individual hydrochemical components.

Thus, in Well No.4 (CPSC), maximum Na permissible concentrations were exceeded 2 times, Li 1.1 times, petroleum products 2 times, mineralization 1.2 times. In the well of the GPRS, the maximum permissible concentration for Na was 2.3 times, Li – 1.5 times, mineralization – 1.4 times. In the water intake wells of the villages of Pogarshchyna and Kachanove, the MPC of petroleum products was recorded to be 1.3 and 1.6 times higher (*Журавель и др., 1996; Васильев и др., 1997*).

Results and discussion. The input data table contained the following variables for 8 wells: dry residue, oil products, pH, HCO_3, Cl, F, SO_4, Ca, Mg, Na, K, Cd, Br, Fe, Ba, NO_2 and NO_3. The elements in the matrix of initial coefficients in factor analysis are the coefficients of pair correlation between the initial data. Calculations according to the program of factor analysis were carried out according to the generally accepted method.

Using the principal component method (R-modification factor analysis), it has been determined that there are five factors in the area of Kachanovske oil field, with weights greater than 10%, containing chemical elements whose bond strength is greater than 0.2.

The first factor (weight 21.65%) contains Na (bond strength 0.862). Fe (0.236), F (0.231), and Cd (0.215) have bond strength exceeding 0.2. The remaining elements are less important. The characteristic element of the first factor is Na.

The second factor (weight 19.55%) includes bromine (bond strength 0.933) and Cl (0.289). Fe (-0.278) and Na (0.253) have bond strengths greater than 0.2. The remaining elements are insignificant in the second factor. The main element of this factor is bromine.

The third factor (weight 15.83%) belongs to oil products (bond strength -0.864), F (0.534) and barium (0.314). SO4 (0.280) and Cd (0.201) also have the bond strength exceeding 0.2.The main element of this factor is petroleum products and fluorine.

The first three factors contain the main elements characteristic of groundwater of the lower hydrogeological floor, in particular carbon brines.

The fourth factor (weight 12.04%) and the fifth factor (weight 10.81%) include the remaining elements. HCO3 (0.259), Ca and Mg at 0.206 have the bond strength higher than 0.2 in the fourth, while NO2 (0.237) and Mg (0.225) – in the the fifth factor.

To determine distribution of these factors on the area, the Q-modifications of the factor analysis defined the loads of each factor for all wells. Distribution of these values made it possible to establish the fact that in the vicinity of the crater of emergency wells No.35 and 65, the first three factors intersect. This indicates contamination of Buchak-Kaniv aquifer groundwater by brine carbon.

Under the same scheme, the results of chemical analyzes of groundwater in Buchak-Kaniv aquifer in the area of Glinsky, Andriyashevsky, Perekopov and Anastasevsky oil and gas-condensate fields were also processed. The initial data table contained the same elements for all 16 wells operating in Buchak-Kaniv aquifer.

The first factor (weight 18.74%) contains Na (bond strength 0.664). Cd (0.276) and Fe (0.214) have the bond strength higher than 0.2. The remaining elements are insignificant. A characteristic element of the first factor is also Na.

The second factor (weight 16.57%) includes Cl (bond strength 0.782) and bromine (0.227). Fe (-0.219) and Na (0.212) have the bond strength greater than 0.2 . The remaining elements do not play an important role in the second factor. The main element of this factor is chlorine.

The third factor (weight 12.36%) is barium (bond strength 0.889) oil products (-0.726), F (0, 345) and. SO4 (0.269) and Cd (0.227) also have the bond strength greater than 0.2. The main element of this factor is barium and petroleum products.

The fourth factor is 11.84%, and the fifth factor is 10.05%.

Based on distribution results of the obtained factors on the research area, it was possible to establish that the same three first factors intersected on the territory of Glinske field and in the vicinity of emergency wells crater at Kachanovske field.

Consequently, by analogy with Kachanovske field, at Glinsky deposit, there is at least one artificial hydrogeological window. In our opinion, this could be an emergency or an old liquidated oil well or an emergency well that was used to maintain reservoir pressure, through which Buchak-Kaniv aquifer contaminated with mineralized waters.

N.E. Zhuravel, A.N. Vasiliev, P. V. Klochko, and others have studied the peculiarities of waters with increased density migration in fresh water. In their opinion, contamination of aquifers in oil fields is associated with inter-layer fluid flow over the annular space behind the column and tightness breach in the production columns and injection wells in case of accidents. The negative effects in both cases are similar. The nature of the accidents in the wells is determined by the technical state of the production columns, which in turn depends on the duration of the well operation, efficiency of the anodic and inhibitor protection, timeliness of detection and elimination of the overflow or non-tightness of the column (*Журавель и др., 1997*).

The detection time of production columns non-tightness, even if all the technological requirements are met, can range from several hours to one month. On average, a reservoir is depressurized in 2 wells during a year, the theoretical leakage of reservoir fluids due to one such case is estimated at 5–10 m^3.

Migration of waters with increased density in the fresh water environment is largely determined by the combined action of two mechanisms – density convection and transverse hydro-dispersion (*Мироненко и Румынин, 1982*). Density convection leads to gravitational differentiation of solutions in density. With a planned piston displacement of fresh water by a saline solution, density convection promotes deformation of the displacement front: a more rapid advance of the heavy fluid occurs along the base of the formation and the front assumes an inclined position. In environments with high dispersion characteristics, deformation of the displacement front of the equilibrium fluids will be determined not only by differences in density, but also by mixing processes. Unfortunately, this complex process has not been studied enough.

The processes determined by the combined effect of dispersion and the gravitational differentiation of the equilibrium fluids prove to be especially complex in pulsed intake of solutions with an increased density from point sources into the aquifer.

In these conditions an intrusion of dense, highly mineralized solutions is formed near the source, streamlined by the natural (regional) flow of groundwater. The complexity of water migration forecast in such cases, in addition to the three-dimensionality of the problem, is exacerbated by the need to jointly solve the equations of filtration and mass transfer (*Мироненко и Румынин, 1982*). Therefore, only qualitative regularities of dense waters migration process have been studied on the basis of physical modeling data.

According to physical modeling data, the migration pattern as a whole is of a voluminous nature. What is more, the mass transfer process is strongly influenced, on the one hand, by the gravitational forces arising from differences in the densities of the infiltrating liquid and the carrier flow, and on the other – the effects of dispersion erosion of migrating solutions intrusion and further dispersion of components carried from its lateral surface by the flow of groundwater (Fig. 1 (*Васильев и др., 1997*)).

Gravitation most significantly affects the first stages of the migration process: intrusion of saline waters steeply plunges and quickly reaches the lower boundary of the formation. In this case, only the shape of the aureole changes, but the volume and mineralization of the waters within it practically do not differ from the initial ones. Influence of the natural flow in this case is not much appreciable. At later stages of migration, gravity also contributes to an increase in the rate of mineralized waters aureole advance along the formation base. Further migration leads to an increase in the size of saline waters aureole, and two zones are distinguished in its structure: the inner (core) represented by undiluted brines and the outer zone of the hydrodispersed erosion of the lateral boundaries of the nucleus, within which the content of salt components varies from the initial to the background values. The core of the intrusion is still flowing through fresh reservoir waters, and the velocity of its horizontal displacement is noticeably inferior to the rate of the transit flow. Such a ratio in the rates leads to the fact that the formation water, washing the body of mineralized waters from the sides, demolishes part of the substance that goes to the formation of the scattering zone of the components.

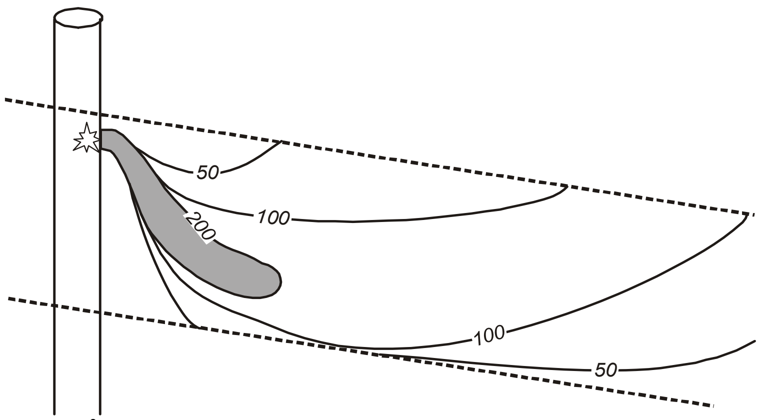

Fig. 1. Isolines of water (g/dm³) mineralization in the aquifer in mass transfer under conditions of density convection

The intensity of transverse scattering during the processes of density convection significantly exceeds the analogous characteristic of the spatial microdispersion of a physically inert tracer. Introduction of heavier liquid and the planned deformation of the flow lines of the filtration stream washing the intrusion lead to the appearance of an orthogonal component (with respect to the main transfer direction) of the filtration rate, which causes additional convective movement of the salts towards the peripheral zones of the halo. In the case of a one-time release, the core of mineralized water gradually decreases in volume and disappears altogether, and the halo of salt components dispersion becomes wider.

Physical- chemical processes in aquifers can cause noticeable changes in the permeability of rocks. In particular, in sandy aquifers that have undergone the intrusion of saline waters, repeated replacement of the latter with fresh water can cause precipitation of compounds from the solution, pitting the pores and reducing permeability several times.

Under these conditions, we can only estimate the area of the contamination aureole. Taking into account the peculiarities of mineralized waters migration in the fresh water flow and sorption phenomena (especially with respect to petroleum products) and other physical and chemical processes, it is possible to estimate where mixing of different density water will bring the concentration of pollutants in the aquifer to MPC level.

To calculate the area of groundwater contamination during interlayer flows and leaks from production columns, we have adopted the average effective porosity (0,2) and power (30 m) of Bučak-Kaniv aquifer, and for formation fluids: leakage volume – 10 m^3, salinity – 200 g/dm^3, the oil content – 25%.

Calculations have showed that mineralized waters can cause local salinization of more than 300 m^2 of aquifer, and volley discharge into an aquifer of the same amount of water-oil mixture can lead to oil contamination of groundwater over a much larger area (up to 13,000 m^2). The front of oil pollution can advance 1.0–1.5 km from the emergency well.

With a prolonged outflow of the water-oil mixture from the emergency production well, contamination of the underground waters of Buchak-Kaniv aquifer may be possible in a much larger area.

Conclusions. The results of factor analysis cannot be considered final as a limited number of data on the chemical composition of groundwater in Buchak-Kaniv aquifer have been studied. To confirm these results, one needs to enter additional data. When confirming the results using the same methodology, it is necessary to carry out research on the entire territory of DDV, especially within the old oil and oil and gas condensate fields. This will reveal unknown artificial hydrogeological windows and it will be possible to take measures to protect Buchak-Kaniv aquifer from pollution.

Список використаних джерел

Варавва, К.Н., Вовк, И.Ф., Негода, Г.Н. (1977). Формирование подземных вод Днепровско-Донецкого бассейна. Київ: Наукова думка.

Васильев, А.Н., Журавель, Н.Е., Клочко, П.В. (1997). Закономерности распределения техногенных загрязнителей в экосистеме кратера аварийной скважины Качановского нефтяного месторождения. *Доповіді НАН України*, 4, 184–188.

Журавель, Н.Е., Васильев, А.Н., Клочко, П.В. и др. (1997). Критическая экосистема кратера аварийной скважины Качановского нефтяного месторождения. Харьков: Прапор.

Журавель, Н.Е., Клочко, П.В., Самонова, Л.С. (1996). Проблемы охраны подземных вод в районе нефтегазовых месторождений на конечной стадии разработки (на примере Качановского месторождения). *Экологические аспекты загрязнения окружающей среды*, 2, 91–92.

Йерескоr, К.Г., Клован, Д.И., Реймент, Р.А. (1980). Геологический факторный анализ. Ленинград: Недра.

Камзіст, Ж.С., Шевченко, О.Л. (2009). Гідрогеологія України. Навчальний посібник. Київ: ІНКОС.

Левонюк, С.М. (2017). Зміни показників захищеності підземних вод бучацько-канівського водоносного комплексу центральної частини ДДАБ. *Матеріали IV наукової конференції "Гідрогеологія: наука, освіта, практика"*. Харків: Стиль-Издат, 54–57.

Мироненко, В.А., Румынин, В.Г. (1982). О расчетных моделях миграции в стратифицированных комплексах водоносных пород. *Записки ЛГИ,* 91, 5–20.

Руденко, Ф. А. (1972). Гідрогеологія Української РСР. Київ: Вища школа.

Сухно, И.Г. (1973). Химический состав каневско-бучакского водоносного горизонта юго-восточной части Днепровского артезианского бассейна. *Материалы Харьковского отделения Географического общества Украины,* 12, 18–25.

Чомко, Д.Ф. (2000). Визначення гідрогеологічних вікон в покрівлі мергельно-крейдяного водоносного горизонту за гідрохімічними критеріями. *Геологічний журнал*, 4, 93–98.

Чомко, Д.Ф., Кошляков, О.Є., Чомко, Ф.В., Удалов, І.В., Чомко, Р.Ф. (2017). Українсько-російсько-англійський словник-довідник гідрогеологічних термінів. Київ: ВПЦ "Київський університет".

Чомко, Д.Ф., Решетов, И.К., Чомко, Ф.В., Чомко, Р.Ф. (2002). Многомерный статистический анализ при исследовании техногенного загрязнения подземных вод. *Геологічний журнал*, 2, 73–80.

Чомко, Д.Ф., Решетов, И.К., Чомко, Ф.В., Чомко, Р.Ф. (2005). Применение факторного анализа при исследовании техногенного загрязнения подземных вод. *Вестник Новочеркасского политехнического института*, 511, 153–164.

Чомко, Ф.В., Чомко, Д.Ф., Чомко, Т.В. (2003). Искуственные гидрогеологические окна – источник загрязнения бучакско-каневского водоносного горизонта на северо-востоке Украины. *Вісник Харківського національного університету,* 610, 18–24.

Чомко, Д.Ф., Решетов, И.К., Чомко, Ф.В., Чомко, Т.В. (2004). Попутно-промысловые воды нефтяных месторождений – источник загрязнения бучакско-каневского водоносного горизонта. *Матеріали науково-практичної конференції "Екологічні проблеми нафтогазового комплексу", Київ,* 53–57.

Шестопалов, В.М., Богульский, А.С., Бублясь, В.Н. (2007). Оценка защищенности и уязвимости подземных вод с учетом зон быстрой миграции. Киев: ИГН НАН Украины.

Шестопалов, В.М., Лялько, В.И., Огняник, Н.С. и др. (1991). Водообмен в гидрогеологических структурах Украины: Водообмен в нарушенных условиях. Київ: Наукова. думка.

Шестопалов, В.М., Сухоребрый, А.А., Гудзенко, В.В. и др. (1989). Водообмен в гидрогеологических структурах Украины: Водообмен в естественных условиях. Київ: Наукова думка.

Reference

Chomko, D.F. (2000). Vyznachennia hidroheolohichnykh vikon v pokrivli merhelno-kreidianoho vodonosnoho horyzontu za hidrokhimichnymy kryteriiamy. *Heolohichnyi zhurnal*, 4, 93-98. [in Ukrainian]

Chomko, D.F., Koshliakov, O.Ye., Chomko, F.V., Udalov, I.V., Chomko, R.F. (2017). Ukrainsko-rosiisko-anhliiskyi slovnyk-dovidnyk hidroheolohichnykh terminiv. Kyiv: VPTs "Kyivskyi universytet". [in Ukrainian]

Chomko, D.F., Reshetov, I.K., Chomko, F.V., Chomko, R.F. (2002). Mnogomernyj statisticheskij analiz pri issledovanii tekhnogennogo zagryazneniya podzemnykh vod. *Heolohichnyi zhurnal*, 2, 73-80. [in Russian]

Chomko, D.F., Reshetov, I.K., Chomko, F.V., Chomko, R.F. (2005). Primenenie faktornogo analiza pri issledovanii tekhnogennogo zagryazneniya podzemnykh vod. *Vestnik Novocherkasskogo politekhnicheskogo instituta*, 511, 153-164. [in Russian]

Chomko, D.F., Reshetov, I.K., Chomko, F.V., Chomko, T.V. (2004). Poputno-promyslovye vody neftyanykh mestorozhdenij – istochnik zagryazneniya buchaksko-kanevskogo vodonosnogo gorizonta. *Materialy naukovo-praktychnoi konferentsii "Ekolohichni problemy naftohazovoho kompleksu", Kyiv,* 53-57. [in Russian]

Chomko, F.V., Chomko, D.F., Chomko, T.V. (2003). Iskustvennye gidrogeologicheskie okna – istochnik zagryazneniya buchaksko-kanevskogo vodonosnogo gorizonta na severo-vostoke Ukrainy. *Visnyk Kharkivskoho natsionalnoho universytetu*, 610, 18-24. [in Russian]

Jereskog, K.G., Klovan, D.I., Rejment, R.A. (1980). Geologicheskij faktornyj analiz. Leningrad: Nedra. [in Russian]

Kamzist, Zh.S., Shevchenko, O.L. (2009). Hidroheolohiia Ukrainy: navchalnyi posibnyk. Kyiv : INKOS. [in Ukrainian]

Levoniuk, S.M. (2017). Zminy pokaznykiv zakhyshchenosti pidzemnykh vod buchatsko-kanivskoho vodonosnoho kompleksu tsentralnoi chastyny DDAB. *Materialy IV naukovoi konferentsii Hidroheolohiia: nauka, osvita, praktyka,* Kharkiv: Styl-Yzdat, 54-57. [in Ukrainian]

Mironenko, V.A., Rumynin, V.G. (1982). O raschetnykh modelyakh migraczii v stratificzirovannykh kompleksakh vodonosnykh porod. *Zapiski LGI*, 91, 5-20. [in Russian]

Rudenko, F.A. (1972). Hidroheolohiia Ukrainskoi RSR. Kyiv: Vyshcha shkola. [in Ukrainian]

Shestopalov, V.M., Bogulskij, A.S., Bublyas', V.N. (2007). Oczenka zashhishhennosti i uyazvimosti podzemnykh vod s uchetom zon bystroj migraczii. Kyiv: IGN NAN Ukrainy. [in Russian]

Shestopalov, V.M., Lyalko, V.I., Ognyanik, N.S. et al. (1991). Vodoobmen v gidrogeologicheskikh strukturakh Ukrainy: Vodoobmen v narushennykh usloviyakh. Kyiv: Naukova. dumka. [in Russian]

Shestopalov, V.M., Sukhorebryj, A.A., Gudzenko, V.V. et al. (1989). Vodoobmen v gidrogeologicheskikh strukturakh Ukrainy: Vodoobmen v estestvennykh usloviyakh. Kyiv: Naukova dumka. [in Russian]

Sukhno, I.G. (1973). Khimicheskij sostav kanevsko-buchakskogo vodonosnogo gorizonta yugo-vostochnoj chasti Dneprovskogo artezianskogo bassejna. *Materialy Kharkovskogo otdeleniya Geograficheskogo obshhestva Ukrainy,* 12, 18-25. [in Russian]

Varavva, K.N., Vovk, I.F., Negoda, G.N. (1977). Formirovanie podzemnykh vod Dneprovsko-Doneczkogo bassejna. Kyiv: Naukova dumka. [in Russian]

Vasylev, A.N., Zhuravel, N.E., Klochko, P.V. (1997). Zakonomernosti raspredeleniya zagryaznitelej v ekosisteme kratera avarijnoj skvazhiny Kachanovskogo neftyanogo mestorozhdeniya. *Dopovidi NAN Ukrainy,* 4, 184-188. [in Russian]

Zhuravel, N.E., Klochko, P.V., Samonova, L.S. (1996). Problemy okhrany podzemnykh vod v rajone neftegazovykh mestorozhdenij na konechnoj stadii razrabotki (na primere Kachanovskogo mestorozhdeniya). *Ekologicheskie aspekty zagryazneniya okruzhayushhej sredy,* 2, 91-92. [in Russian]

Zhuravel, N.E., Vasylev, A.N., Klochko, P.V. et al. (1997). Krytycheskaia ekosystema kratera avaryjnoj skvazhsny Kachanovskoho neftyanogo mestorozhdeniya. Kharkov: Prapor. [in Russian]

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ШТУЧНІ ГІДРОГЕОЛОГІЧНІ ВІКНА ЯК ДЖЕРЕЛА ЗАБРУДНЕННЯ БУЧАЦЬКО-КАНІВСЬКОГО ВОДОНОСНОГО ГОРИЗОНТУ НА ПІВНІЧНОМУ СХОДІ УКРАЇНИ

Запропоновано новий метод визначення місця розташування штучних гідрогеологічних вікон у покрівлі та підошві водоносного горизонту. Як приклад розглянуто бучацько-канівський водоносний горизонт. Цей водоносний горизонт поширений у північно-східній частині України і є основним джерелом водопостачання для даного регіону. На наш погляд, забруднення бучацько-канівського водоносного горизонту може відбуватися насамперед через штучні гідрогеологічні вікна в його покрівлі та підошві. Для визначення місця розташування штучних гідрогеологічних вікон використано факторний аналіз хімічного складу піземних вод водоносного горизонту. Факторний аналіз спочатку був проведений у місцях, де точно відомо про техногенне забруднення водоносного горизонту нафтопродуктами та супутними водами через штучні гідрогеологічні вікна (наприклад, нафтові або інші свердловини). У результаті було виявлено ряд впливових факторів з вагою більше 10 %. У подальшому в інших районах також проводився факторний аналіз з використанням такого ж набору компонентів хімічного складу піземних вод. Збіг впливових факторів говорить про теоретичну можливість існування у данному районі штучного гідрогеологічного вікна.

Крім того, розглянуто різні варіанти поширення забрудників по площі горизонту.

Виявлення цих вікон важливе для визначення джерел забруднення водоносних горизонтів. Особливо привабливим буде використання цього методу в районах розташування старих (працюючих і закритих) родовищ нафтових, газових та нафтогазоконденсатних родовищ.

Ключові слова: бучацько-канівський водоносний горизонт, штучні гідрогеологічні вікна, забруднення водоносних горизонтів, факторний аналіз, нафтові і газові родовища.

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ИСКУССТВЕННЫЕ ГИДРОГЕОЛОГИЧЕСКИЕ ОКНА КАК ИСТОЧНИКИ ЗАГРЯЗНЕНИЯ БУЧАКСКО-КАНЕВСКОГО ВОДОНОСНОГО ГОРИЗОНТА НА СЕВЕРО-ВОСТОКЕ УКРАИНЫ

Предложен новый метод определения местоположения искусственных гидрогеологических окон в кровле и подошве водоносного горизонта. Как пример рассмотрен бучакско-каневский водоносный горизонт. Этот водоносный горизонт распространен в северо-восточной части Украины и является основным источником водоснабжения для данного региона. На наш взгляд, загрязнение бучакско-каневского водоносного горизонта может происходить, прежде всего, через искусственные гидрогеологические окна в его кровле и подошве. Для определения местоположения искусственных гидрогеологических окон использован факторный анализ химического состава подземных вод водоносного горизонта. Анализ сначала был проведен в местах, где точно известно о техногенном загрязнении данного водоносного горизонта нефтепродуктами и попутно-пластовыми водами через искусственные гидрогеологические окна (например, нефтяные или другие скважины). В результате был выделен ряд влиятельных факторов с удельным весом более 10 %. В дальнейшем в других районах также проводился факторный анализ с использованием такого же набора компонентов химического состава подземных вод. Совпадение влиятельных факторов говорит о теоретической возможности существования в данном районе искусственного гидрогеологического окна.

Кроме того, рассмотрены различные варианты распространения загрязнителей по площади горизонта.

Выявление этих окон важно для определения источников загрязнения водоносных горизонтов. Особенно привлекательным будет использование этого метода в районах расположения старых (работающих и закрытых) месторождений нефтяных, газовых и нефтегазоконденсатных месторождений.

Ключевые слова: бучакско-каневский водоносный горизонт, искусственные гидрогеологические окна, загрязнение водоносных горизонтов, факторный анализ, нефтяные и газовые месторождения.