Ecological safety of water resources in Khujand (Tajikistan) area, in the development context of agricultural activities

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Abstract. The research deals with investigation of relation between agricultural activity and ground water, surface water composition and quantity. The area of investigation is under huge increases in water consumption and active development of agricultural and economic activities. On the one hand, the agricultural complex uses groundwater and thereby reducing the level of groundwater, on the other hand, the irrigation system causes the development of a desalination zone to the depths of groundwater. Anyway, the influence into the groundwater is obvious. In the article has analyzed the relationship of surface and groundwater, hydraulically connected. It was studied the expansion of irrigation area contributes to the irrigation water flow strengthening into the rivers, also to the groundwater flow.

1 Introduction

Considering the ecological state of water resources there, it should be noted that groundwater and surface water are hydraulically connected in the investigated area (Khujand, Tadjikistan). At the same time, water supply is carried out at the expense of groundwater hydraulically connected to the water of the rivers, respectively, the quality of exploited aquifers is closely related to the quality of surface water.

Expansion of irrigation area contributes to the irrigation water flow strengthening into the Syr-Darya River, which also increases the infiltration recharge of groundwater due to irrigation drains of increased mineralization, ultimately causes deterioration in the quality of groundwater. There are existing water intakes within the investigation area, data on which were used in our research. Consequently, the depth of the studied thickness is limited by the depth of the operated well.

It is water pollution that is determined here by developed agriculture and irrigation regime. The interception of the river-flow (for irrigation purposes) caused drainage, where the mineralization of groundwater increased under conditions of hydraulic connection.

2 Materials and methods

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The investigation is based on data of hydrogeological wells for the period from 1976 to 2019. For confidentiality purposes, the article does not provide primary data of the water quantity and quality, but only the interpretation and research results.

Among the research methods we distinguish: hydrogeochemical methods [1], experimental filtration work (EFW), interpretation of time and area tracking of EFW, analytical modeling of experimental testing the aquifers and borehole water intakes (ANSDIMAT/AMWELLS) [2, 3]. Based on the actual material, an analytical model was created. For the right bank, the "strip formation" (figure 1) scheme was chosen, and for the left bank, the "semi-confined formation" (figure 2) scheme was selected. The river is the boundary of the provided recharge for the banks. In some wells, the calculated and actual drawdowns differ - this is due to the fact that deep wells are located in a less permeable part of the aquifer with well depths where the values are underestimated (filtration coefficient, fluid recovery) [4]. For a more accurate solution, one should resort to numerical simulation, where it will be possible to take into account the decrease in the filtration coefficient with depth and the configuration of the filtration flow boundaries.

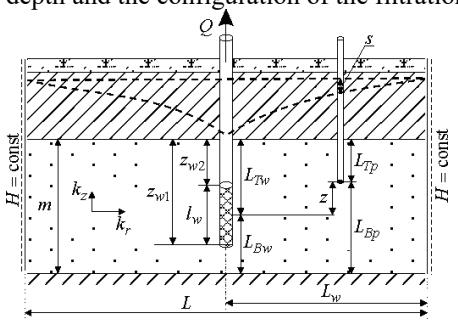

Fig.1. "Strip formation" scheme.

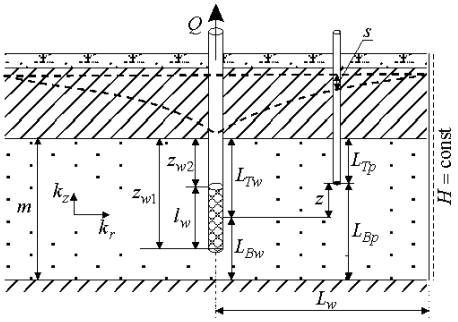

Fig. 2. "Semi-confined formation" scheme.

3 Results

It should be noted, to be based on the conducted research, the following results were achieved:

1. Pollution and the growth of mineralization of natural waters are explained by the developed agriculture and irrigation regime here.

2. Chemical appearance of rivers has deteriorated significantly over the past decades. So, fixed: increased mineralization, exceeding the maximum permissible concentrations for a number of components (sulfates, magnesium, hexavalent chromium, copper, zinc compounds). Thanks to the detailed description of the Syr-Darya River, there is no doubt that

it is not recommended to use the water for centralized water supply. Only special treatment allows using the water for household needs, but this is unprofitable.

3. Groundwater closely relation with surface water, which explains the high mineralization and the concentration of sulfates above the maximum allowable concentrations. Aquifers are not protected from surface pollution. Because of this, pollution coming from the surface will quickly reach the groundwater level. Given the poor protection, unsatisfactory quality of these aquifers, their exploitation for water supply to the city of Khujand is inappropriate.

4. Having assessed the chemical composition of groundwater in the area, it should be noted that some part of the hydrogeologal complex are suitable for domestic and drinking water supply.

5. In order to avoid the inflow of more saline or polluted water, it is necessary to adhere to the specified mode of production wells and equip the wells to the aquifer complex with the position of filters [5].

Thus, a detailed characterization of the water-bearing strata was carried out, part of which is suitable for the exploitation of the city of Khujand.

4 Discussion

Actually, we had to investigate a huge amount of data, but data detail is uneven, mostly this is due to the data lack of individual dates than to their accuracy.

In hydrogeological terms, the study area is characterized by the presence of a rich groundwater flow confined to the alluvial deposits, to the alluvial-proluvial deposits, and to the Neogene-Quaternary deposits. Thus, the following aquifers are distinguished within the investigated area from Quaternary to Neogene.

In the formation of the alluvial aquifer, the main role is played by the surface water: rivers and the water flow of the foothill plume. The groundwater flow is directed parallel to the general riverbed, while river water is absorbed in the expanding valley areas, and springs emerge in narrowing of the channel areas. As mentioned before, the hydraulic connection between groundwater and surfacewater is quite close. The chemical composition is sulfate-hydrocarbonate, in places hydrocarbonate-chloride-sulfate and closely related to changing of river chemical composition.

The main sources of groundwater recharge in the alluvial-proluvial deposit are surface runoff and, in part, irrigation water [6]. A sharp increase in the water abundance of groundwater horizons and the degree of sediment permeability is explained by their close relationship with rivers. According to the chemical composition, groundwater is sulfate-bicarbonate and sulfate-chloride calcium-magnesium.

Groundwater confined to the alluvial-proluvial deposits is exposed at different intervals. The horizon is quite watery. The composition of the water is bicarbonate-calcium or sulfate-calcium. Groundwater level is closely related to the river, as confirmed by well data. The main source of nutrition of the aquifer complex are rivers, and precipitation is of subordinate importance.

Sporadic water confined to Neogene-Quaternary deposits (N_{II}-Q_{II}) and the chemical composition is sulphate-calcium, sulphate-sodium and sulphate-magnesium. The formation of groundwater also occurs due to surface runoff.

According to the detailed description of the Syr-Darya River, there is no doubt that it is not recommended to use these water for centralized water supply. Only a special multi-level purification allows the use of this water for household needs.

The depth of the desalination zone reaches the depths of the Quaternary sediments. The formation of the desalination zone is associated with the action of the main channels for irrigation, i.e. fresh groundwater is in the zone of influence of the irrigation system.

The remaining aquifers of the territory have a number of indicators that do not meet or are critically close to the norms [7]. At depths of more than 180 meters, mineralization increases, and the content of sulfates increases. Obviously, such concentrations of sulfates, at depths of more than 180 m, are associated with the presence of gypsum rocks. It is likely that gypsum crystallization occurred under conditions of hydrocarbonate waters and CO_2 deficiency, and subsequently the composition of groundwater has been transformed into sulfate-sodium. The role of bacteria contributing to the acceleration of the oxidation of sulfide minerals and the appearance of sulfate ions in water is not excluded. Talking about 2000th there was mineralization increase in due to calcium and magnesium sulfates. The content of nitrates in the water has enriched, apparently due to the pollution of aquifers.

The presence of water pollution and the mineralization growth are explained by the developed agriculture and irrigation regime here. At the same time, the interception of the river-flow (for irrigation purposes) brought in the 70th and earlier, the formation of a quite deep drainage zone and water mineralization has increases [6].

5 Conclusion

Recently, there has been a negative change in the chemical composition of the surface water, and groundwater. Mostly, it has to do with pollution. However, one should not forget that the variegated chemical composition of the upper part of the section can be associated with continental salt accumulation, the composition of groundwater changes from hydrocarbonate to sulfate. And a further increase in mineralization and groundwater level can cause additional soil salinization.

Therefore, the forecast of changes in the chemical composition, groundwater level is very relevant. According to our research, in the period from 1976 to 2017, the deterioration was marked in quality of the rivers, which is due to extensive irrigation. The data of the existing wells reflected, for a number of indicators, the non-compliance with the requirements for centralized drinking water supply systems. Also, the existing wells are located within the city boundary, that is why the additional threat of bacterial and organic pollution coming from sewer systems, garbage collectors were fixed. The sharpest deterioration of water quality began in 2004-2005.

Thus, to this day, there is an obvious need to assess the quality of water in the Khujand region (Tadjikistan), including for water supply. Forecasting changes in the chemical composition of surface and groundwater is essential [8,9].

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