On Formation of Underground Water in Karst Region of "Neka R." (Province of Mazandaran, Iran).

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Abstract

The under study "Neka R." is an example of karst region where underground water is mainly formed at the expense of infiltration, influent and condensation processes. These processes are first of all promoted by physical and geographical conditions of the region. Infiltration feeding takes place from the surfaces of development of karst formations. In summer time this takes place predominantly after intense precipitation exceeding 10mm/day. Precipitation with fewer amounts almost completely is intercepted by trees and vegetation and evaporates. In wintertime infiltration feeding takes place mainly at the expense of melting of the lower part of snow cover and during rains. The size of infiltration feeding of the given area can be determined as the amount of effective precipitation, i.e. as the difference of average amount of precipitation and evaporation. We have carried out such calculations by higher zones of the region under study (for example with the rated altitude every 200m) based upon the values of average precipitation (mm), average evaporation (mm) and surface (km^2) *of the given region.*

Influent feeding in the given area takes place at the expense of surface flow absorption, formed in the area of karst development and non-karstic rocks. Flow absorption takes place in erosion and hydrographic network of the territory. In low water amount of influent waters is not big - generally flows of permanent streams of karst massifs do not exceed 5-6 l/s. In high water they sharply increase, reaching several tens of cubic meters per second. During spring snow melt maximum flows of influent streams are lower; instead the flow is more stable. The value of feeding of karst underground water with influent water fluctuates sharply during different seasons, which is determined by climatic conditions, as well as karst-hydrogeological features of the region.

In a relatively warm period a significant role in the formation of underground water is anticipated by moisture condensation in fissured-karst carbonate collectors. A series of ways is known for assessment of condensation moisture amount, which in such regions generally does not exceed first percents; condensation flow module, as shown by calculations, is up to $3\text{-}4 l/s \cdot km^2$*. In some cases on annual basis condensation does not plan a significant role in water balance of karst massifs, amounting on average no more than 5%-7% of the total flow.*

Water balance preparation is of a special interest for practical use of karst water in the region under study. This is one of the reliable ways of calculation during evaluation of underground flow of the territory. At the same time two main difficulties arise during those calculations: correct determination of the area of balance site and obtaining of data on all elements of water balance, included in the design formula. The first difficulty requires implementation of a special geological-karstologic survey. Depending on local conditions, border of the design area can be erosion cuts, various lithologic and tectonic contacts and topographic divide lines.

Using the water balance equation, the total amount of underground water could be evaluated.

The total flow can be divided into components only in the case if there are data of actual observations of sources (springs) and water streams. The main difficulties we face are related also to insufficient or lacking data on underground karst spring flows, lacking observations of surface stream flows. All *these significantly complicate separate determination of surface, underground and deep flows. And at last, determination of spatial distribution of underground water, including their concentrated movement ways, is very important. Solution of this task requires application of complex methods of investigation: first of all complexation of hydrological-hydrogeological methods with the results of aerial photointerpretation and field geophysical and biolocation methods.*

Key words: *1- Karst 2- Hydrogeology 3- Neka R. 4-Biolocation*

Subject definition

To obtain the values of atmospheric precipitation (X, mm) we have used the data from meteorological stations located nearby. The X=f (H) diagrams have been compiled (where H- is the altitude of the site). With their help the average values for corresponding altitude zones have been obtained (with altitude interval of 100-200 m). The design values of falling precipitation have been determined as weight average. As weighting coefficient the areas of the singled out altitude zones have been assumed (they have been determined by large-scale topographic maps).

Actual data on evaporation from soils and transpiration through vegetation for karst sites of the region are practically missing. Therefore, for calculation of evaporation we considered it more advisable to use empiric formulas and diagrams based on the existence of relatively close relations with different meteo-elements. A special analysis of articles published in publications of different countries showed that there are several tens of formulas and diagrams relating evaporation with precipitation, evaporability, with absolute and relative humidity, air temperature, saturation deficit, etc.

Naturally, while selecting calculation methods, we based upon availability of meteorological data. In general, the values X and Y obtained by independent methods allowed determining the value of the total flow from the given karst massif:

$$Y_{tot} = Y_{surf.} + Y_{undergr.} + Y_{deep.} = X - Z \qquad (2)$$

Dividing the obtained total flow into components is possible only in the case, if the data of actual observations of the sources (springs) and surface streams are available. The observation method and corresponding calculations are common. The main difficulties we are facing here are missing data on underground flows, karst sources, there are no long-term observations of major surface river runoffs, formed at the expense of flows from karst and non-karst massifs. All of the above mentioned makes it impossible separate determination of surface, underground and deep flows for individual karts massifs at this stage. Therefore, the design values obtained by us are to be considered as estimative and requiring results of more detailed and purposeful investigations, Table (1) and Table (2).

Obtaining of new data for justified water balance calculations required implementation of complex works for organization of long-term permanent observations. These works shall include hydrological, hydro-geological and hydro-geophysical investigations with establishment of regime observation network with hydrometric equipment on springs and rivers. Only such kind of works will allow quantitative determination and characterization of underground and deep components of water balance of the territory under study and provision of recommendations for the efficient ways of practical use of underground waters for water supply purposes.

Table (1): The components of Neka No.1 hydro geological zone balance equation

NO	Balance equation components		Annual amount M.C.M
1	The area of Upper Cretaceous calcareous formation	200 Km^2	-
2	Annual rainfall average	780 (mm)	156
3	Actual evapotranspiration	415 (mm)	83
4	Flow coefficient	% 17	-
5	Runoff	132.6 (mm)	26.5
6	Amount of rainfall penetration (%)	% 29.8	-
7	Rainfall penetration (Q_{in})	232.4 (mm)	46.48
8	Springs discharge (Q_S)	404.3 (L/S)	12.75
9	Wells discharge (Q_W)	262 (L/S)	1.36
10	Entering amount of on-ground water to the zone (Q_{Rin})	399 (L/S)	12.6
11	Outgoing amount of on-ground water from zone (Q_{Rout})	358.7 (L/S)	12.15
12	Outgoing underground water plus storage (Q_G)	1040 (L/S)	32.8

Table (2): The components of Neka No.2 hydro geological zone balance equation

No	Balance equation components		Annual amount M.C.M
1	The area of Upper Cretaceous calcareous formation	190 Km^3	-
2	Annual rainfall average	992 (mm)	188.48
3	Actual evapotranspiration	470 (mm)	89.3
4	Flow coefficient	% 27	-
5	Runoff	268 (mm)	50.92
6	Amount of rainfall penetration (%)	% 25.6	-
7	Rainfall penetration (Q_{in})	254(mm)	48.26
8	Springs discharge (Q_S)	268 (mm)	8.45
9	Wells discharge (Q_W)	-	-
10	Entering amount of on-ground water to the zone (Q_{Rin})	-	-
11	Outgoing amount of on-ground water from zone (Q_{Rout})	127 (L/S)	4
12	Outgoing underground water plus storage (Q_G)	1136 (L/S)	35.81

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