SUSTAINABLE DEVELOPMENT AND WATER MANAGEMENT

(*Gondárné Sőregi Katalin*[1], *Gondár Károly*[1], *Könczöl Nándorné*[1], *Kun Éva*[1], *Székvölgyi Katalin*[1], *Zachar Judit*[1])
[1]*SMARAGD-GSH Kft.*

1. SUSTAINABLE DEVELOPMENT

According to the Water Frame Directive Hungary has to bring its groundwater bodies that can be found in its area into good status till 2015. This procedure means not only appropriate quality, but also appropriate management of the groundwaters.

In order to achieve this purpose, the preliminary identification of the water bodies and the estimation of the resources in Hungary already has been done.

It is well known that extreme exploitation of groundwater can lead to decrease of resources and drying up of springs (Transdanubian-mountains in Hungary). Keeping the water bodies in good status means also providing ecological water demands.

In addition the medicinal tourism is one of the prominent economical sectors in Hungary and has high priority also in the National Development Plan. Medicinal tourism utilizes thermal groundwater resources in increasing degree.

In order to converge these contradictory interests thoughtful water resource management and suitable laws should be needed. The question is whether there are enough available data and suitable methods to perform exact calculations of water resources; whether the Water Frame Directive is able to guide suitable water resource management; as well as Hungarian laws are suitable to protect the groundwater resources.

The pilot area is the Southwestern Bükk region where the groundwater is stored in Triassic limestone. The Bükk Mountain is a geologically continuous system, besides, considering its structural and economical capabilities the model area can be separated, and thus individual calculations can be carried out.

Regarding the above mentioned conditions we attempt to answer these questions based on a research carried out on the pilot area and the experiences of an administrative licensing action on the same area.

To the question, if sufficient data are available, the answer is no. In order to gain hydrological data we started a research project in collaboration with the University of Miskolc and the North Hungarian Environment and Water Directorate: „Realization of a monitoring system supplying water management decisions for the Bükk Region to keep the sustainable development". Establishment of a suitable database and carrying out of simultaneous streamflow measurement series covering the whole Bükk Mountain are included in the tasks. Present estimation of water resources is based on these new data.

2. PRESENTATION OF THE METHODS

The scheme of the karst water flow is depicted in Fig. 1. The interior of the mountains is uncovered, open karst. As a consequence of the anticlinal structure of the mountain, the Triassic limestone can be found in deeper and deeper towards the edges of the mountain. The Jurassic clayshale, limestone, diabase appears gradually in the cover, then Oligocene clay and Miocene sand, tuff can be traced in the basin areas. The conductivity of these cover formations are low. The Jurassic layer cannot be considered to be completely impermeable because of the interbedding limestone layers and the fractured diabase formations, the Oligo-Miocene sediments can be practically regarded to be impermeable.

Due to the geological succession the infiltration peak can be found in the interior of the mountain, on the Nagy-Fennsík situated at 900m average altitude.

The infiltration is 400 mm/year in average and 351 mm/year in dry period calculated by Böcker-method [1]. In the other parts of the mountain the infiltration was calculated according to the decreasing precipitation with the altitude and petrological conditions. Total amount of recharge ($Q_{be/in}$) was calculated by a GIS method, using the software ArcView 9.1. In case of average condition the recharge is 24 418 600 m^3/year. In case of drought it is 16 328 100 m^3/year.

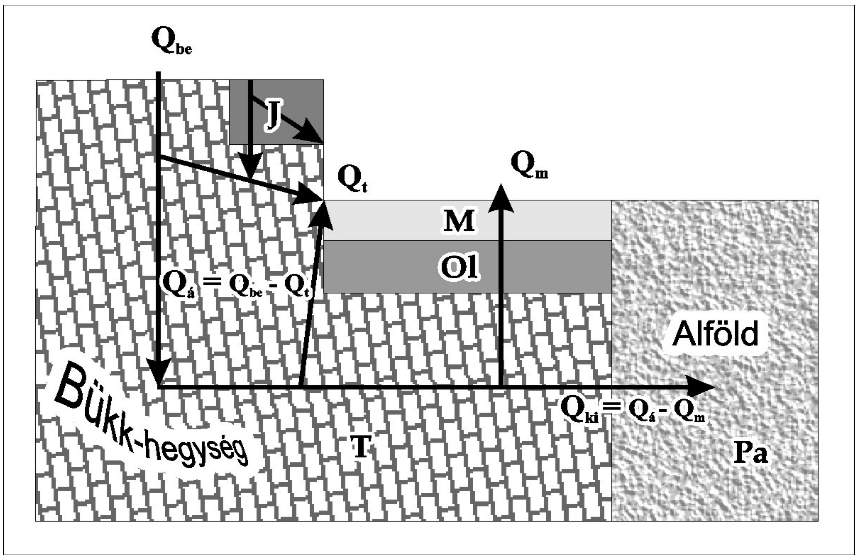

Fig. 1 Conceptual scheme of groundwater flow in the pilot area

There are different flow systems. The local flow system terminates as temporary karst-springs (Imó-kő, Fekete-len, Vörös-kő and Szikla-spring), which are located at the edge of the uncovered karst in the interior of the mountain. Their average yield is approximately 948 400 m^3 (Q_{t1}) in an active period [2]. At the end of intermedier flow system the karst-water gets to the surface in form of springs having permanent but variable yield (Mónosbél, Bélapátfalva, Apátsági-spring, Noszvaj – Forró-kút, Eger). The flow is very slow in the *confined* aquifer below the Jurassic formations. The radiometric age of karst springs (the temperature is 27 °C) flowing up in Eger at the edge of the mountain is 4700 years [3] using $\delta^{13}C$ correction. Almost all of these permanent springs are used by waterworks to supply drinking water or utilized as medicinal water in Eger. The yield of the springs (Q_{t2}) emerging from the end-point of the intermedier flow paths is 4 763 300 m^3/year in average and 3 569 300 m^3/year in dry period.

The non-perfect impermeablity of Jurassic formations is proved by the 1) existence of numerous permanent springs having low yield (10-40 l/min) that gush in the interior of the mountain and 2) the downward increasing yield of the streamlets. It acts as an independent, fractured aquifer above the confined karst *aquifer.* A small amount of stored water is filtrating to the karst water system from the Jurassic cover beds by diffusion and through active sinkholes in the valleys of the creeks. The yield of these streamlets was calculated based on simultaneous stream flow measurements carried out during the present project. Their average total yield (Q_{t3}) is 10 109 405 m^3/year. The minimum yield is 6 065 643 m^3/year [4]. The total amount of naturally discharged water is:

$$Q_{t\ average} = Q_{t1} + Q_{t2} + Q_{t3} = 15\ 821\ 100\ m^3/year$$
$$Q_{t\ minimum} = Q_{t1} + Q_{t2} + Q_{t3} = 9\ 635\ 000\ m^3/year$$

The total amount of the water, however, does not come to the surface, but flows towards the Alföld ($Q_{á}$) in a regional flow system of the karst aquifer. The age and temperature of the karst-water increases along a particular flow path in the *confined* system. The temperature and age of the karst-water in Egerszalók is 70 °C and 13 200 ± 400 yrs [5].

The confined karst aquifer is exploited by thermal wells in Egerszalók, Bogács, Mezőkövesd and Andornaktálya. Each of these wells provides hot water for spas (Q_m). The remaining groundwater moves slowly towards the Alföld and is transmitted to the porous aquifer of the basin ($Q_{ki/out}$) or turns back towards the Bükk. The exact mechanism of this process is not known.

The long term source of water demand appearing in this region can be calculated as the difference between the water yield given by the natural water circulation ($Q_{á}$) and the production of supply wells that have been already existed in the past (Q_m). Essentially these are the available potential dynamic water resources (Q_p). Increasing of the production, however, reduces the water amount (Q_{ki}) emerging from the karst-water reservoir in all case. In case of equilibrium, recharge and discharge should be equal (Fig. 2).

Hydrogeologists use this generally accepted method of calculation of water resources in Hungary. Though it is contradictory with the concept 'resources stored in water body' defined by the Water Frame Directive that is rather similar to the concept of static water resources. The WFD distinguishes cold and hot karst water resources, but in our opinion these two water resources cannot be managed separately; separation of water bodies exclusively according to their temperatures is not relevant. Its consequence is that water body definition of the WFD is not suitable to be the base of water resource management of karst areas where both discharge and recharge are relatively fast. Obviously calculations of water resources based on recharge indicate many errors, besides better follow the dynamics of the real system.

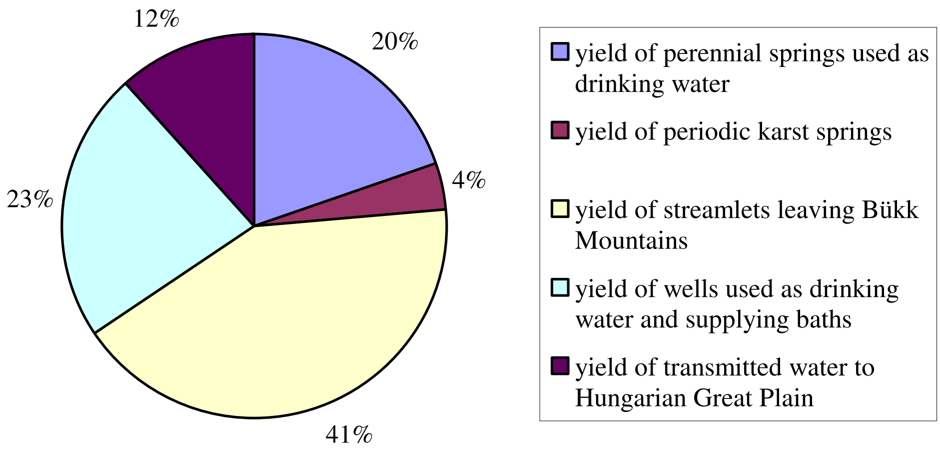

Fig. 2 Water budget of the SW-Bükk in average period

3. LEGAL BACKGROUND

Neglecting the errors of calculation and postulating the accuracy of measurements and suitability of the applied methods, we must investigate whether the legal background is adequate for the proper water management. Is it suitable to sustain the operation of the system?

The Paragraph (1) of Article 15 of Act LVII of 1995 on water management (and the Act LXXI of 2001 modifying the previous one) declares that „Groundwaters may only be utilized to an extent, taking into account the provisions of this Act, that the balance between water withdrawal and recharge shall be maintained without any adverse effect to groundwater quality."

It can be seen that in the period of extremely low recharge, free water resources are not available in the area (Fig. 3), so each arising new water demand should be refused. At the same time the following question is arisen: after how long period should a water body be re-supplied? Namely the abstraction of supply wells can cause pressure decreasing in the confined area but after shutting down wells pressure will increases during shorter or longer period depending on the local hydrogeological circumstances. Whether can we state that we don't cause irreversible environmental damage until the ecological water demand is guaranteed, namely the natural springs flow with expected yield?

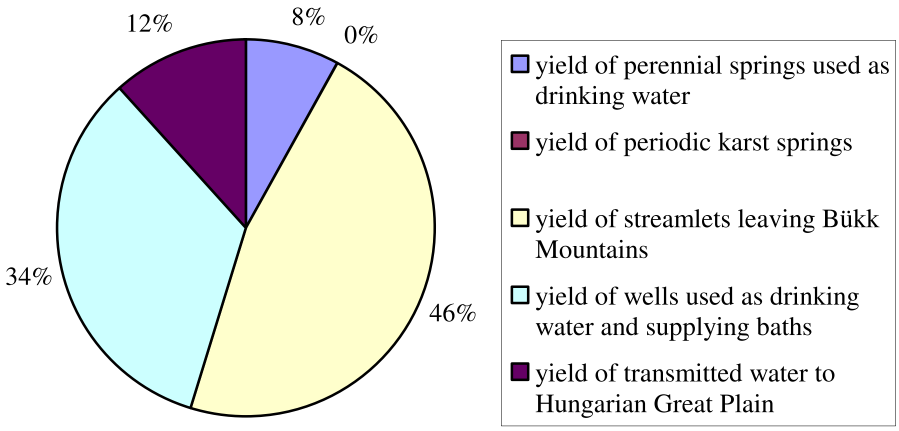

Fig. 3 Water budget of the SW-Bükk in low recharge period

The Annex 1 of the Governmental Decree No. 123/1997 (VII. 18.) on the protection of the actual and perspective water sources and the engineering facilities of drinking water supply can give an answer: The average total capacity of a drinking water source is the maximum exploitable quantity, which is determined based on the up-to-date knowledge and conditions and its environmental effect is acceptable. Namely also the economical interest can be validated in the exploitable water resources, if each stakeholder accepts the effect on the nature or on the wells that have already operated in the past.

Different acts declare the degree of the effect in different ways. Mostly the Act No. 219/2004. endeavours to define it numerically. The Governmental Decree No. 219/2004. (VII. 21.) on the protection of groundwaters, Article 9 par. (1) a) declares that „In order to ensure the good quantitative status of groundwater the activity shall be carried out so as not to cause the exceeding of the abstraction limit value (M_i). Abstraction limit value (M_i) means the total annual volume of water (in m^3/year) that may be withdrawn from a distinct part of body of groundwater with the highest permitted range of declination." The problem is that although the act draws it up, the abstraction limit value, M_i is not determined yet in the practice.

Many have the opinion that the question of both sufficient-or-non-sufficient and effect-or-non-effect is to be left to the experts' judgement for which the wide frames of the laws, quoted above, give possibility.

In our opinion, since there is a quite strong lobby for the authorities, the frames must be set more explicitly. The base of the traceable and righteous water management would be the determination of regional quotas in any case. The economical specialities are also to be considered at determination of the quota. Concerning the limit value, M_i, a professional consensus and such experts should be needed who have experiences due to daily practice.

It can occur in the administrative practice that for an operation permit of a well, a test operation is dictated during which, in principle; the effect of withdrawal can be measured. We cannot keep this practice to be followed in any case. Generally the time of the test operation and quantity of abstracted water is less to cause such effect like a long operation. Otherwise this procedure, considering the expenses of the drillings, is not fair by the investor, and it is an experience from Hungary that the strong investment interest can carry the release of operation permit into execution.

Finally, it would be required of the operators to provide up-to-date service data supply (produced and overflow water amounts, pressure data), because otherwise the operation of the system can never be traceable.

[1] BÖCKERT, T: **Beszivárgás meghatározása karsztvidéken a negyedévi határcsapadékok módszerével (Determination of recharge on karst area based on quaternaly limit of precipitation).** VITUKI Beszámoló, 1974. p. 207-215.

[2] TÓTH, G.: **A Magas-Bükk déli peremén fakadó időszakos karsztforások karszthidrográfiai jellemzése (Karsthydrological characterisation of periodic springs discharge at the edge of High-Bükk).** Hidrológiai Közlöny, 1984. XIV, Vol. 3., p. 169.

[3] SMARAGD-GSH Kft.: **Heves megyei Vízmű Rt. Eger, Petőfi téri vízbázisának diagnosztikai vizsgálat. I. ütem jelentés (Diagnostic investigation of the Eger Petőfi tér groundwater supply. I.st phase report).** Északmagyarországi Környezetvédelmi és Vízügyi Igazgatóság adattár, 2003.

[4] SMARAGD-GSH Kft., Miskolc University and North Hungarian Environment and Water Directoriate: **Vízgazdálkodási döntéseket támogató monitoring rendszer magvalósítása a Bükk-vidéken a fenntartható fejlődés érdekében – Vízhozam körbemérések (Development of a monitoring system supplying water management decisions for the Bükk Region to keep the sustainable development).** 2006.

[5] DEÁK, J.: **Dating the Karst Thermal Waters in The Eger Area.** 10th International Speleological Congress Proceedings, Hungary, 1989. p. 570-572.