RESOURCES OF UTILIZATION OF GROUNDWATER FOR HEAT PUMP IN KOŠICE - SLOVAKIA

MOŽNOSTI VYUŽITIA PODZEMNÝCH VÔD PRE TEPELNÉ ČERPADLÁ V KOŠICIACH NA SLOVENSKU

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Abstract

At present, there is an increasing interest denoted to utilisation of alternative energy sources. It is expressed especially in the municipal and/or industrial sphere, where energetic sources based on fossil fuels, are step by step eliminated by their different alternatives. A common groundwater, which is utilised in heat pumps for heating of objects, is one of the low-temperature energy sources. Košice is the second largest town in Slovakia and there is a large number of buildings with different pretensions to energy in them. From the hydrogeological point of view, the town of Košice is situated very properly and it seems that there is a sufficient amount of high-quality groundwater present, suitable for the above mentioned purposes. The submitted paper gives an overview of its utilisation.

Key words: groundwater, heat pumps, conurbation of Košice

1 INTRODUCTION

Achieving an energetic and economic efficiency is quite real and prospective by means of heat pumps utilising a low-temperature energy source. One of such sources seems to be even the common groundwater with temperature which is generally not lower than 7 °C and not higher than 15 °C. From the energetic point of view, the common groundwater is a very advantageous heat source without substantial temperature fluctuations. The main disadvantage of this system is the relatively high investment costs of acquiring the heat energy water source in question.

The city of Košice, though extending over an area comprising different lithogenetical rock types of various hydrogeological values, is suitably situated due to the possibilities of exploitation of the alternative heat source type in question. The submitted paper evaluates, with view to the individual city districts, the possibility of acquiring groundwater from the individual hydrogeological complexes involved in its territory.

2 CHARAKTERISTIC OF NATURAL CONDITIONS

The city of Košice is situated in several geomorphological units. Its substantial part spreads in the southern part of Košice basin and only smaller parts are located in Čierna hora and Volovské vrchy. The climatic conditions are predetermined by the geomorphology, according to which there can be defined a warm area and a temperate area with cold winter and the annual mean temperature of about 9 °C and the annual mean rainfalls of 600 to 700 mm. Hydrologically, it belongs to the Hornád basin. This river flows through the city and collects water from some smaller streams in its territory (the Čermeľský, Račí, Myslavský streams). Based on the regional geological division of the Západné Karpaty [Western Carpathians], the assessed area belongs to the south-western part of the East Slovakian neogene basin, which is a part of the vast Transcarpathian intermontane basin (Vass et al., 1988).

With respect to its lithology, the surface of most part of the area consists of molasse neogene deposits with a discontinuous cover of quaternary deposits. The older, pre-neogene rock complexes belong to several tectonic units, constituting the basement of quaternary and neogene deposits. They only rise to the surface at the edges of the north-western part of the city in the ranges of Čierna hora and Volovské vrchy.

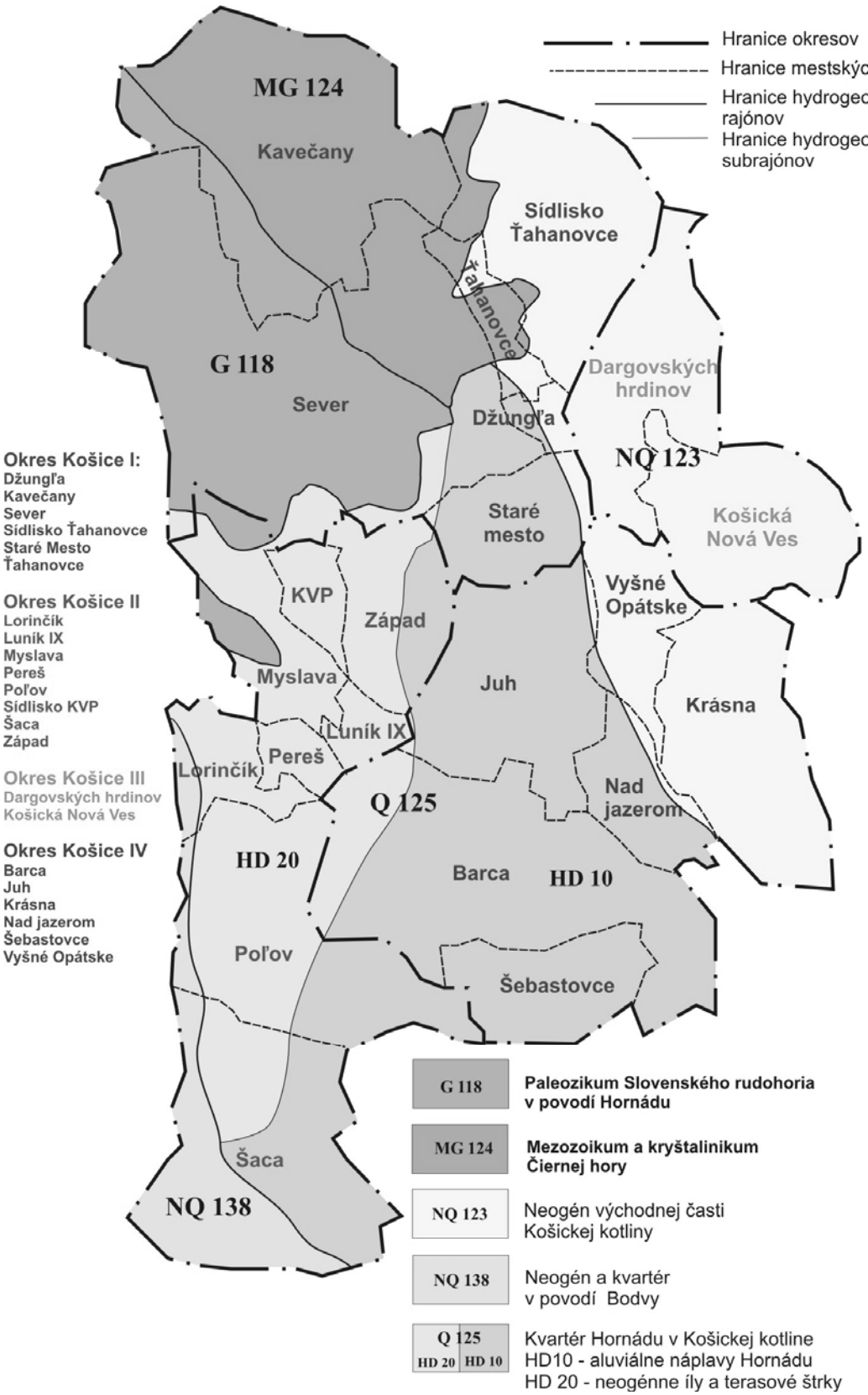

Fig. 1: Hydrogeological units interfering parts of the city of Košice

Hranice okresov	District lines
Hranice mestských častí	City district lines
Hranice hydrogeologických rajónov	Hydrogeological zone lines
Hranice hydrogeologických subrajónov	Hydrogeological subzone lines
Okres	District
Paleozoikum Slovenského rudohoria v povodí Hornádu	Palaeozoic of the Slovenské rudohorie in the Hornád basin
Mezozoikum a kryštalinikum Čiernej hory	Mezozoic and crystalline complex of Čierna hora
Neogén východnej časti Košickej kotliny	Neogene of the eastern part of Košice basin
Neogén a kvartér v povodí Bodvy	Neogene and quaternary in the Hornád basin
Kvartér Hornádu v Košickej kotline	The Hornád quaternary in Košice basin
HD 10 – aluviálne náplavy Hornádu HD 20 – neogénne íly a terasové štrky	HD 10 – alluviums of the Hornád HD 20 – neogene clays and bench gravels

3 POSSIBILITIES OF GROUNDWATER UTILIZATION IN THE CONURBATION OF KOŠICE FOR THE OPERATION OF HEAT PUMPS

The given assessment must be based on regional needs for the possible utilization of groundwater for heat pump operation. In these terms the most suitable factors seam to be firstly the territorial and administrative division of Košice and secondly its regional and local hydrogeological division.

With regard to the territorial and administrative division of Košice, the currently valid scheme of 1996 was used, delimiting 4 districts and 22 city districts (Fig. 1).

Specific assessment of groundwater resources utilization for the given purposes is then confined to the area restricted by the district boundaries. In each of the 22 city districts, conditions of occurrence, circuit and accumulation of common groundwater are evaluated in terms of the hydrogeological regionalisation of Slovakia (Šuba et al., 1984). The visual assessment is based on the modified map of utilizable groundwater resources (Fig. 1), elaborated by means of the data by Šuba et al. (1990) and the map of the main hydrogeological regions of Slovakia (Malík & Švasta, 2002).

To identify the individual hydrogeological sites location in more detail, a set of maps was compiled, enabling identification of the existing investigation sites – hydrogeological boreholes situated in the territory of the city of Košice, executed within earlier investigation work. These documents are archived by two institutions: http://geolisis.gssr.sk/geofond/ ; http://www.geoarchiv.tuke.sk/. Fig. 2 shows a fragment of such a map.

The text part of the subject paper further presents possibilities of groundwater utilization for the given purposes in more detail. Particularly, it gives characteristics of hydrogeological elements, such as the type and thickness of the aquifer, the basic geohydraulic parameter – filtration coefficient and the mean yield related to a hydrogeological borehole situated in the given environment.

It should also be observed here that, with respect to the subject assessment utilization, its concept was organized as follows:

- the individual regions are primarily described according to the districts, in sequence from I to IV
- in each city district of the district, the individual groundwater resources located in its territory are then characterized (Tab. 1)
- precise locations of hydrogeological boreholes is then graphically represented in the maps of the documentation buildings, scale 1:10 000 (Fig. 2).

The city of Košice comprises several hydrogeological regions of different hydrogeological values. Their space arrangement in the individual city districts is indicated in Fig. 1.

Tab. 1: Example of a characteristics´ table file of an object utilizable for heat pump

Borehole designation and location		Archive sources		Technical and geological data	
Original borehole designation	HP-1	Author	Tometz, L.	Borehole depth [m]	12.0
City district	Košice – south	Year of execution	1984	Standing groundwater level [m p.t.]	4.5
Street	Požiarnická	Investor	MsNV Košice	Water lithology from-to [m p.t.]	gravel 4.4 -11.0
Map sheet 1:10 000	37-24-19	Geofond archive number	59499	Yield Q [$l.s^{-1}$]	21.00
Note	Fire brigade, primary school	ÚGV FBERG archive number	2016	Water temperature T_{vo} [^oC]	13.0

HG region G118 – Palaeozoic of the Slovenské rudohorie in the Hornád basin interferes in the north-western part of the town. It is roughly delimited by the Čermeľské valley, Kavečianská road, Watson street, Popradská street and Horný Bankov. It occupies the city districts of Sever and Myslava. It is composed of Palaeozoic rocks – phyllits, porphyroids, diabases and sandstone, alternating monotonously. Their hydraulic capacity of accumulating groundwater is very low and they are of no significant hydrogeological value. Only the numerous, low-yield springs exploited for the centralised city water supply are important hydrogeologically. There are no recorded hydrogeological boreholes in this area.

HG region MG 124 – Mesozoic and crystalline complex of Čierna hora lines the north-western fringe of the city. The boundary is formed by Kostolianska and Kavečanská streets, as well as the Hornád valley at Ťahanovce. The substantial part of its city territory is made up by the Kavečany district and Podhradová (North) housing estate with the surrounding individual housing development. A small part of the region interferes in the Ťahanovce municipality and housing estate. In these conditions, groundwater can be obtained from the Muschelkalk dolomites forming the north-eastern edge of Čierna hora. By means of the ČH-5 borehole, 114 m deep, situated in the rock complex mentioned, groundwater was detected in Suchá dolina with a possibility of long-term withdrawal of Qv = 3.4 $l.s^{-1}$ and temperature of 12 °C. The crystalline complex and Palaeozoic rocks, forming the central part of the subject area, are of inferior hydrogeological significance.

HG region NQ 123 – Neogene in part of Košice basin interferes in part V of the city area. It is delimited by the rivers Hornád in the west and Torysa in the east. The northern and southern boundaries reach outside the city territory. Substantial parts of this region are occupied by the Ťahanovce and Dargovských hrdinov (Furča) housing estates, as well as by Košická Nová Ves, Krásna and Vyšné Opátske. It consists of neogene deposits in the form of impermeable clays with sand and gravel locations of limited intergrain permeability. Sporadically, it is possible to obtain groundwater in the quantity of Qv = 5 to 10 $l.s^{-1}$ from these layers by means of a single borehole, 80 to 150 deep, or, occasionally, in the tectonically disturbed zones, up to 20 $l.s^{-1}$. This fact, however, has been proved outside the city territory.

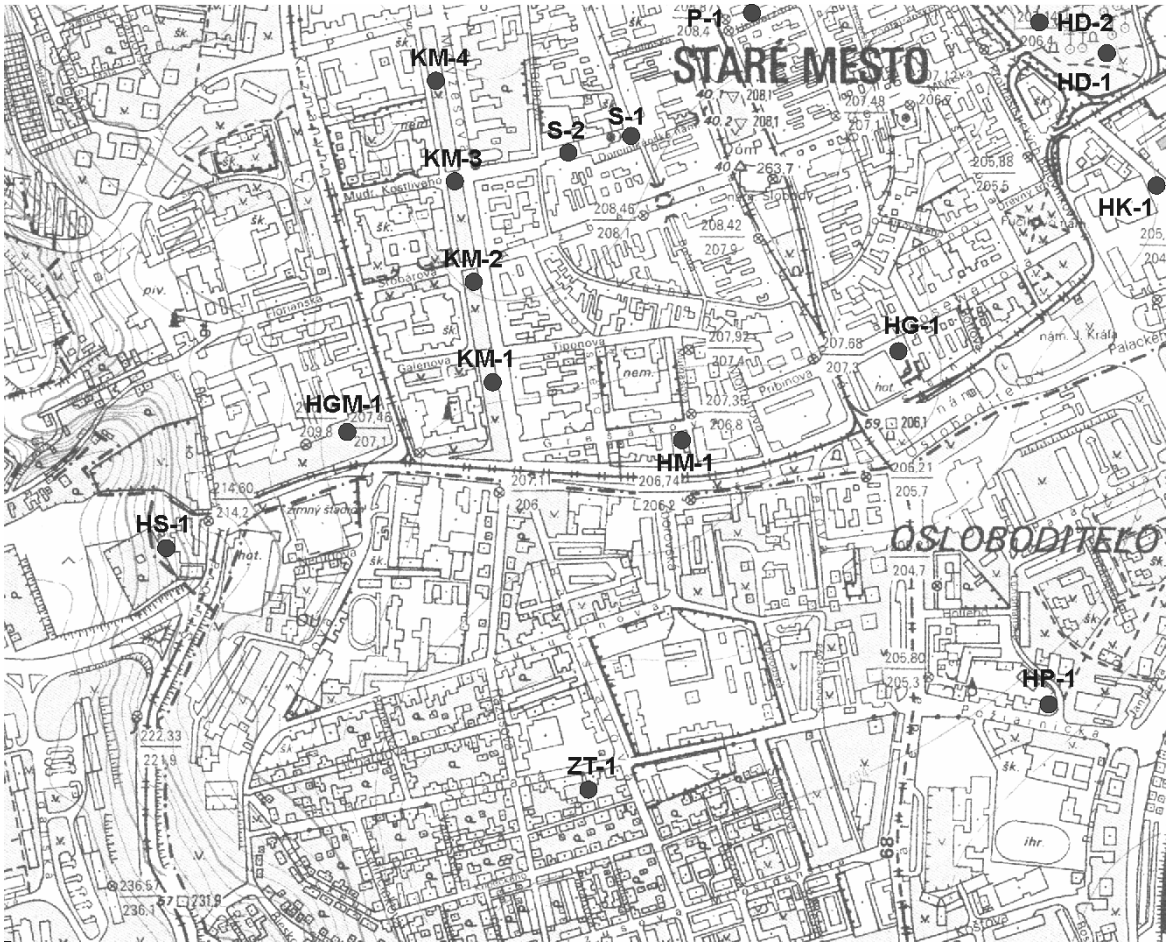

Fig. 2: Hydrogeological objects (boreholes and wells) in the centre of the City

HG region NQ 138 – Neogene and quaternary in the Bodva basin situated in the south-western part of Košice II district. It comprises two important subregions. The first one is in the form of fluvial deposits od Ida and Bodva, with the thickness of 15 to 20 m and permeability of ($k = 5.10^{-4}$ to 2.10^{-3} $m.s^{-1}$). It only interferes in the edge of the area assessed (Lorinčík, Poľov and Šaca city districts). The second subregion contains important quaternary gravel accumulations situated in its south-western part at Šaca and US Steele, where the yield of 5 to 7 $l.s^{-1}$ can be obtained with a single borehole, 10 to 15 m deep.

HG region Q 125 – Quaternary of the Hornád in Košice basin occupies the central part of the city of Košice. It may roughly be demarcated by a line running along Kostolianska road, Watson street, Československej armády street, Moyzesova street, Rázusova street and Rastislavova street up to Barca. The western edge of this region is roughly lined by the Hornád river. The southern boundary of the region spreads outside the city territory; the northern boundary is delimited by Ťahanovská street. It occupies the central city part (Old Town), and the city districts of Juh, Barca, Šebastovce, Nad jazerom and Šaca. Marginally, it interferes in Západ district. Substantial part of the region is composed of quaternary fluvial sandy gravels (HD 10 subregion) with a high permeability of ($k = 1.10^{-4}$ to 1.10^{-3} $m.s^{-1}$). The deposit thickness ranges from 3 to 12 m. Conditions for good groundwater flow and accumulation arose in the coarser parts situated in the southern city part. It is possible to collect the amount of 9 to 15 $l.s^{-1}$ by means of a single borehole here. The yield of boreholes situated in the Hornád bench gravel (HD 20 subregion) is substantially lower. This subregion must also involve the territory delimited by Popradská street and the whole KVP housing estate, where neogene deposits are found with prevailing clays in which, usually in the depth of more than 25 to 30 m, there are gravel locations enabling to obtain 0.5 to 3.0 $l.s^{-1}$ of groundwater with a single borehole. At the depth of 50 to 150 m under the quaternary filling, neogene gravels are sporadically found in the form of artesian layers with the yield of approx. 10 $l.s^{-1}$ per one borehole.

The following text describes the individual city districts with view to the possibility of groundwater utilization for heat pumps.

Thence it follows that the hydrogeological value of the most part of the city of Košice territory is very important with view to the groundwater utilization for heat pumps. This is not only due to the quantity presented,

but also the groundwater quality. Its temperature generally ranges from 10 to 12 °C, but temperatures around 14 °C are not unusual. The original investigation results show that the water to great extent conforms to the conditions for its utilization as drinking water, with the exception of bacteriological and microbiological rates. This points to its trouble-free utilization for heat pumps as well.

The first experiences with heating of buildings on the basis of the subject alternative energy source – groundwater - have also been recorded in the city. Besides private dwelling houses, there is also, for example, a kindergarten site in operation in the Obrancov Mieru Park (Sever city district). The proposed project of air-conditioning in the administrative building at No.3, Murgašova street, seems to be important. In that case, there were utilized both the very favourable hydrogeological conditions of fluvial gravel - sand deposits of the Hornád in the Old City centre and the fact that there has already been a groundwater resource in the building cellar – a well (Photo 1), 7.5 m deep, with a yield more than 10.0 $l.s^{-1}$. Investigation (Tometz, 2006) verified the possibility of not only drawing the required amount of groundwater from this well, but also its reabsorption in the rock environment after utilization for the heat pump. The basins (Photo 2) located in the same cellar were unconventionally used for that purpose; however, at a distance eliminating the possibility of affecting the water drawn from the well.

Conclusions of this subject investigation imply that, with respect to the incompleteness of the well which did not pass through the whole water thickness and thus a limiting reduction (6.0 m from the well opening), the maximum amount utilizable is 9.0 $l.s^{-1}$. On the other hand, the limiting factor is the amount of utilized water absorbed at the maximum value of 7.0 $l.s^{-1}$, which, however, covers and even exceeds the subject site energy requirements.

4 CONCLUSION

The subject paper aimed at suggesting possibilities of groundwater utilization in the city territory of Košice as a modern alternative low-temperature energy source. In general, it is a fact that the groundwater resources are not dislocated evenly over the city territory, as a result of different conditions of accumulation and flow of groundwater attached to different lithogenetical rock types. It can, however, be claimed that the potential given in the city territory is very significant. It is mainly situated in the central part of the city (administrative buildings, schools, hotels, etc.), but also in the suburban – industrial and dwelling parts (Juh, Barca, Nad jazerom). In these conditions, the existing resources can often be utilized, the number of which exceed a hundred sites in Košice. For that reason it is not possible to agree to some opinions (e.g., Havelský, 2002) on the infeasibility of groundwater utilization for the given purposes owing to high investment demands. This fact may then be projected to the whole area of Slovakia universally, with due regard to the fact that the dislocation of suitable groundwater resources and storage is not uniform there.

Photo 1: Internals of the pumping well situated in the cellar of Murgašova Street

Photo 2: Disposal basin for water consumed by heat pump

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RESUMÉ

Dosiahnutie energetickej aj ekonomickej efektívnosti je veľmi reálne a perspektívne za pomoci tepelných čerpadiel, ktoré využívajú nízkoteplotný zdroj energie. Jedným z takýchto zdrojov sa javí aj obyčajná podzemná voda s teplotou spravidla nie nižšou ako 7°C a nie vyššou ako 15°C. Pre otvorené systémy je ale potrebná vzhľadom na vodohospodárske predpisy reinjektáž použitého prietoku do ďalšieho podzemného vrtu. Hlavnou nevýhodou takéhoto systému sú investične pomerne vysoké náklady pre získanie predmetného vodného zdroja tepelnej energie.

Mesto Košice, aj keď sa rozprestiera na území so zastúpením rôznych litologicko-genetických typov hornín, ktoré majú rôznu hydrogeologickú hodnotu, je z hľadiska možnosti využitia predmetného typu alternatívneho zdroja energie vhodne situované. Predkladaný príspevok hodnotí vo vzťahu k jednotlivým častiam mesta, možnosť získania podzemnej vody z jednotlivých hydrogeologických celkov, zasahujúcich do jeho teritória.

Pri danom hodnotení je treba vychádzať z regionálnych potrieb možného využitia podzemných vôd pre prevádzku tepelných čerpadiel. Z uvedeného hľadiska sa ako najvhodnejšie javí na prvom mieste územné a správne rozdelenie Košíc a na druhom mieste jeho regionálne a lokálne hydrogeologické rozčlenenie.

Pre územné a správne rozdelenie Košíc bola využitá v súčasnosti platná schéma, ktorá vymedzuje 4 okresy a 22 mestských častí.

Konkrétne hodnotenie využiteľnosti zásob podzemných vôd pre dané účely je potom viazané na územie vymedzené hranicami okresu. V každom z 22 mestských častí sú zhodnotené v zmysle hydrogeologickej rajonizácie Slovenska podmienky výskytu, obehu a akumulácie obyčajných podzemných vôd.

Hydrogeologická hodnota značnej časti územia mesta Košice, je z hľadiska využitia podzemnej vody pre tepelné čerpadlá veľmi významná. Nie je to len z hľadiska kvantity ale aj kvality podzemnej vody. Jej teplota sa spravidla pohybuje v rozmedzí 10 až 12°C, no výnimkou niesu ani teploty okolo 14°C. Jej kvalita je veľmi priaznivá aj z fyzikálno-chemického hľadiska, menej však z biologického hľadiska.

To poukazuje na jej bezproblémové využitie aj pre tepelné čerpadlá.

V rámci mesta boli zaznamenané aj prvé skúsenosti s realizáciou vykurovania budov na báze predmetného zdroja alternatívnej energie – podzemnej vody. Okrem súkromných obytných domov je napr. prevádzke objekt materskej škôlky v Parku Obrancov mieru (mestská časť Sever). Významným sa javí pripravovaný projekt klimatizácie administratívnej budovy na Murgašovej ul., č. 3. V danom prípade boli využité veľmi priaznivé hydrogeologické podmienky fluviálnych štrkovo-piesčitých náplavov Hornádu v centre Starého Mesta. Prieskumnými prácami tu bola overená možnosť nielen čerpať požadované množstvo podzemnej vody z tejto studne, ale po jej zužitkovaní tepelným čerpadlom ju aj späť vsakovať do horninového prostredia. Za týmto účelom boli netradične využité nádrže, nachádzajúce sa v tom istom suteréne, no v dostatočnej vzdialenosti, ktorá vylúčila možnosť ovplyvnenia čerpanej vody zo studne.

Záverom možno však konštatovať, že daný potenciál na území mesta je veľmi významný. Zvlášť je sústredený do historickej časti mesta, ale aj do jej priemyselnej časti. V takýchto podmienkach možno často využiť jestvujúce zdroje, ktorých počet v Košiciach prevyšuje sto objektov.