AIR LOAD OF THERMAL WATER

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Abstract

Due to its special geological attributes, Hungary is extraordinarily rich in medicinal thermal water and mineral water. However, extraction and utilisation of thermal waters means a load for environmental air because of high methane and/or hydrogen-sulphide content, among other factors. We would like to describe the air load of these two components, which was based on data provided by thermal spas and our own measurements, utilising passive monitoring procedure. We determined that the Zsóry-bath in Mezőkövesd and in the surrounding area – depending on the weather conditions – detectable rotten egg scent means a hydrogen-sulphide concentration that is below the hygienic threshold limit. High methane content does not only mean an issue but also a possibility for thermal baths which fact is not taken advantage of in many cases.

Keywords

air load, air pollution, thermal bath, methane, hydrogen-sulphide

Introduction

We utilise our thermal water wells of enormous volume and extremely versatile compound mostly in the following areas: balneology, drinking-water supply, agriculture. Beside the properties we have to emphasise what effects of extraction of thermal water resources and qualitative parameters of those have on the quality of environmental air. In the recent years different by-gases of thermal wells, especially methane and hydrogen-sulphide, have gained a more and more crucial role.

Since methane is a greenhouse-effect generating gas, and simultaneously has reasonably high energy content, therefore letting it exhaust into the atmosphere does not cause local and global pollution only but also it is considered as wasting the resources. As a result of this the relatively constant methane-content of thermal wells determines the correct method of usage and handling of these facilities, which means both environmental and economical advantage.

The importance of characteristic, rotten egg scented hydrogen-sulphide is due to its contradiction attributes, as it is a toxic and flammable gas considering the chemical properties; it can be detected even in low concentration, in higher concentration or in case of longer exposure the ability of smell is dulled persistently; at 0.07% respiratory organs might as well be paralysed. On the other hand its balneology-attributes are excellent, because wells containing hydrogen-sulphide – in other words: sulphuric wells – are able to compensate for the sulphur-deficiency of human system, in a form of a bath. Therefore it has a vital role in curing vascular- rheumatic- and certain skin-syndromes as well. Concerning the quality of the environmental air it is one of the most important sulphur-compounds.

Thermal wells might be discovered on nearly 70% of Hungary's area, because Hungary, given its location inside the Pannon-Basin has favourable geothermal features. The geothermal gradient – ie. temperature increase pro each unit of depth increase – which is nearly 5°C/100 m in Hungary, is approximately times 1.5 of the worldwide average value (2-3.3 °C/100 m), furthermore Earth crust in the Carpathian-Basin is only 24-27 km thick, whereas the average thickness is 30-35 km all around the Earth. Additionally, some thick layers of formations with good thermal insulation capabilities can be found; these layers have water draining abilities, this way water contained and flowing inside them becomes the transfer medium of Earth's heat. (Gáspár, 2009)

Some hydrocarbon-research drillings' negative results played a vital role during the development of discovering the country's thermal well resources; as a result of this seeking for hot wells has been operational in Hungary for more than 140 years now. The first sets of drilling were executed by the excellent mining engineer, Vilmos Zsigmondy in 1866 in Harkány and on the Margaret-Island, as a result of the drillings, wells with 61.2°C and 43.8°C temperature were discovered, from depths of 37 m and 118 m. From the next decade on they kept on drilling successfully in the Városliget, Hajdúszoboszló, Debrecen, Szeged, Szolnok and in various places of the country. (Hárs, 2006)

Based on the data of a register – titled „Hungary's thermal water resources" – which was composed with the support of National Technical Development Committee and published by VITUKI Rt. Hydrology Institute in 1993, there are 1152 thermal wells recorded in Hungary. Based on these data nearly 50 % of these wells bring methane-containing by-gases of different compound and output rate to the surface. Methane (CH_4) is an organic compound which can be found in the greatest volume in the atmosphere amongst all other organic compounds. Atmospheric methane is an important greenhouse-gas on the one hand; on the other hand it actively participates in controlling the chemical processes of the stratosphere and troposphere. (Bozó et al., 2006)

As per edict Nr. 12/1997. (VIII.29.) KHVM classification of thermal water based on gas content calculated at 1013 millibar pressure and at 20°C is shown in Table 1.

Table 1. Classification of thermal water based on gas content

Classification of thermal water based on gas content	Gas content
„A"	<0.8 l/m^3
„B"	0.8-10 l/m^3
„C"	>10 l/m^3

Methane furthermore (CH_4) forms a flammable and hazardous explosive mixture when exposed to air between 5-15%, therefore the edict determines that for the good of gas-release technical safety measures in the area of waterworks shall be taken which would exclude the risk of explosion in the waterworks and the supplied locations as well. In case of gas-content classification „A" no gas-release shall be accomplished, classification „B" : gas-release methods and safety measures shall be implied, classification „C": a gas-release instrument compliant to MSZ-10-226 national standard shall be utilised.

Based on the above, it is without any doubt that methane content originating from thermal water is going to play a more and more crucial role both from environmental and economical perspective.

Concentration of hydrogen-sulphide in the atmosphere is exceptional due to complex reasons. Hydrogen-sulphide (H_2S) is an achromatic, characteristically rotten egg scented gas, the density of which is higher than that of air. Hazard originates from the fact that heating of H_2S might cause rapid combustion or explosion. After burning it disintegrates, generating poisonous SO_2 additionally it rapidly reacts with strong oxidants, causing fire- and explosion hazard. (Géczi and Béres, 2011) Its benefit is mainly realised in the balneology, absorbed through the skin reduces blood pressure due to its vasodilating-effect, improves blood supply of the veins and sulphur-content of vein cells therefore reducing the risk of arteriosclerosis. An additional beneficial feature is inflammation-reduction, it improves metabolism, and contributes to curing certain skin-syndromes as well.

As per edict Nr. 4/2011. (I. 14.) VM hydrogen-sulphide is considered as a category II., increasedly hazardous polluting substance based on its affects on health and environment. This edict determines the design value for activities which are bound to undergo environmental effect-analysis in order to evaluate air-pollution levels of the areas in question, additionally design values required and recommended for completing the spreading models and effect-analyses.

The hereby presented data and facts obviously verify the importance of tracing the gases originating from thermal water from atmospheric, environmental, health- and economical perspectives as well.

Material and methods

As determined in the classification of thermal water based on gas content – Table 1. in the previously mentioned edict Nr. 12/1997. (VIII.29.) KHVM, thermal baths are obliged to have the methane content of their water resources controlled every five-, three-, or two years. Ten Hungarian baths provided the already existing measuring reports on our request furthermore they allowed us to visit the wells and observing the gas-release methods. Three units of Budapest Gyógyfürdői és Hévizei Zrt. participated in the data supply procedure: Széchenyi Gyógyfürdő, Rudas Gyógyfürdő és Uszoda and Lukács Gyógyfürdő és Uszoda. From the trans-danubian region Bükfürdő Gyógy- és Élménycentrum and Nagyatádi Termál- és Gyógyfürdő were at service, from the Eastern part of the country Cserkeszőlő Gyógy- és Strandfürdő, Túrkeve Termál- és Élményfürdő, Mezőkövesd Zsóry Gyógy- és Strandfürdő, Berekfürdő Termál- és Strandfürdő and Füzesgyarmati Kastélypark Fürdő participated.

Hydrogen-sulphide concentration of environmental air was determined by our own measurements. Mezőkövesdi Zsóry Gyógy- és Strandfürdő which possesses thermal water resource with high hydrogen-sulphide content, was willingly at service and provided continuous admittance for completing our measurements. Determining of hydrogen-sulphide concentration was executed by allocating and thereafter laboratory evaluation of passive monitoring probes. KVI-PLUSZ Environmental Measurement Ltd. was giving us a helping hand with usage of the measuring instruments and completing the analyses. During the measurements we examined territorial distribution of the load and setup of concentration under different weather conditions. Measurements also included examination of air quality of indoor spaces.

Figure 1. Radiello passive monitor probe and its allocation

Passive monitor probes have gained a more and more crucial role in field of air quality measurements since they are simple and relatively cheap tools. Resulting from this fact we utilised the Radiello manufactured passive measuring instrument that consists of a holder, a pipe and a cartridge impregnated with adsorbent. For determining the hydrogen-sulphide we used RAD 170 type cartridge and RAD 120-1 type blue diffusion jacket. As for the working method, hydrogen-sulphide gets bound on a special, zinc-acetate impregnated, cylindrical micro-fibre structured polyester surface where it transforms into zinc-sulphate during a chemical reaction. After water extraction, in the presence of complex-former compound this phenomenon can be examined by means of spectrophotometric method in the visible range. Hydrogen-sulphide gets bound on the surface of the cartridge matching proportionally with the concentration of the pollution. (Figure 1.)

In connection with Zsóry Gyógy- és Strandfürdő the hydrogen-sulphide monitors were placed for 7-9 days 4 occasions in March, May, July and September 2013. We used 3-3 sensors in all occasions: one in the area of the spa (outdoor) close to the pools (A), another one in the office of the technical manager (B), which is very close to the indoor thermal pools and the third one in the backyard of a terraced house which is located 3 km away from the spa (C). (Figure 2.)

For describing the country-wide situation we have fulfilled the July measurements with further sites. Apart from the existing three measuring points we placed instruments directly in the pool chamber of the spa and very close to the thermal water well where the gas-release takes place. Simultaneously with this we executed further measurements in the Pápa Várkert Gyógy- és Termálfürdő area and engine room, in Győr, the Rába Quelle Gyógy-, Termál- és Élményfürdő, in the area of Veresegyházi Termálfürdő, and in the pool chamber of Velence Resort Spa.

Figure 2. Location of passive monitors
A- bath area outdoor; B – bath area indoor; C – Mezőkövesd family house 3 km away from the bath

Results and conclusion

The specific accumulated methane content of thermal water from baths participating in the data supply procedure is displayed in Chart 2. All the gas-content examinations were executed by laboratories approved by the National Accreditation Board – we have to add concerning the presented results. Based on the gas content values the applicable methods are: free exhaust into the atmosphere, gas-release, respectively operating a gas engine. According to Table 1. we can establish that operating a gas-release instrument by national standard MSZ 15285:1998 (formerly MSZ-10-226) is required with more than half of the 16 wells. Experience shows that already above 200 l/m^3 gas engines can economically be utilised for generating electric power. (According to other sources balanced and continuous water flow rate plus minimum 10m^3/h methane gas extraction – which is independent from flow rate – is a basic requirement.) For this we only found examples at Túrkeve Termál és Élményfürdő, at Füzesgyarmati Kastélypark Fürdő and Berekfürdő Termál és Strandfürdő during our research. At Nagyatádi Termál és Gyógyfürdő feasibility studies and calculations have already been made, as soon as they can manage, they are going to purchase a gas engine which is capable of generating electric power.

Table 1. Classification of thermal water based on gas content

Name of the bath	Examined well	Relative accumulated methane content	Grade (Table 1)
Cserkeszölő Gyógy- és Strandfürdő	I.	8,03 l/m^3	B
	II.	9,40 l/m^3	B
Túrkeve Termál- és Élményfürdő	K-26	205,12 l/m^3	C
Bükfürdő Gyógy- és Élménycentrum	I.	164 l/ m^3	C
	III.	103 l/m^3	C
	IV.	15,18 l/m^3	C
	VIII.	33,46 l/m^3	C
Nagyatádi Termál- és Gyógyfürdő	B-65	258 l/m^3	C
Zsóry Gyógy- és Strandfürdő	Nr. 3.	0,02 l/m^3	A
Berekfürdő Termál- és Strandfürdő	Nr. 3.thermal well K-173	507,32 l/m^3	C
	Nr. 4. thermal well B-192	879,54 l/m^3	C
Füzesgyarmati Kastélypark Fürdő	B-34	342,8 l/m^3	C
Rudas Gyógyfürdő és Uszoda	Attila Nr. 2. well B-4	0,05 l/m^3	A
	Hungária Nr. II. well B-6	0,00 l/m^3	A
Lukács Gyógyfürdő és Uszoda	Roman well	0,00 l/m^3	A
Széchenyi Gyógyfürdő és Uszoda	Nr. II. well B-13	0,88 l/m^3	B

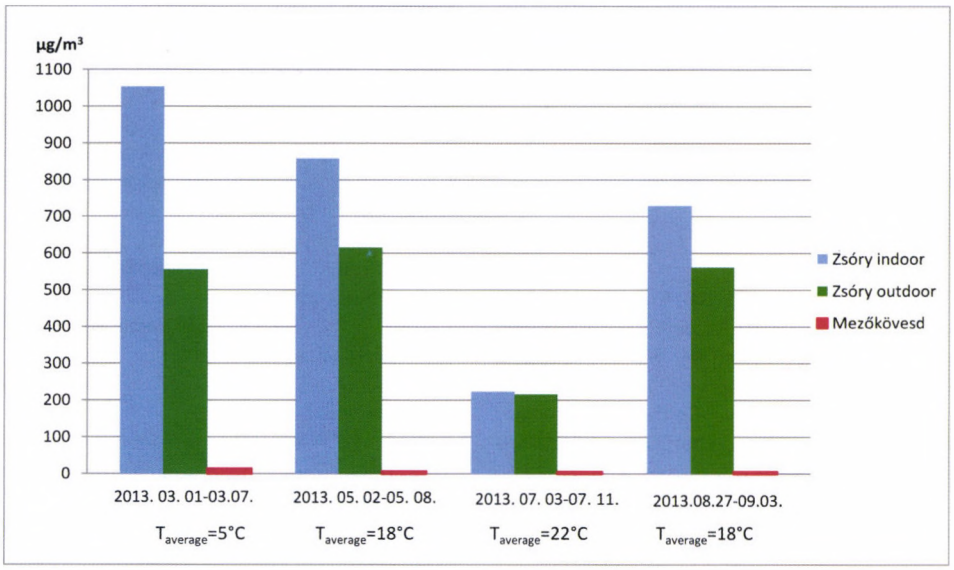

Figure 3. Forming of hydrogen-sulphide concentration in 2013 in Mezőkövesd and Zsóry Gyógyfürdő

We can observe the hydrogen-sulphide concentration determined by means of passive monitors allocated in Mezőkövesd and at Zsóry Gyógyfürdő in the diagram of Fig. 3. During the measurements average temperature in March was 5°C, in May and August 18°C, in July 22°C. The scent of hydrogen-sulphide resembling to rotten egg can be clearly detected in all cases at Zsóry bath, however it never reached the average concentration (AC) referring to workplace atmospheres as described in edict Nr. 25/2000. (IX.30.) EüM-SzCsM AC_{value}=7000 µg/m³ and peak concentration (PC) which is PC_{value}=14000 µg/m³. It can be determined based on our measurements which were carried out in Mezőkövesd that hydrogen-sulphide concentration did not ever exceed the design value of 8 µg/m³ which is described in Appendix Nr. 2. of VM edict Nr. 4/2011.(I.14.). Here we would like to add that in the area of the town we could not detect in any of the 4 occasions the characteristic scents and based on a survey executed in the town we have been told by the inhabitants that rotten egg scent can rarely be detected, with severe north-western winds only.

Based on the diagram it is clearly visible that we can face higher hydrogen-sulphide concentration at lower ambient temperatures, the explanation of which is that vertical air movement originating from density-differences is lower at lower ambient temperature.

The results of wider range hydrogen-sulphide measurements executed in July 2013 are presented in Figure 4. Our goal was that we can get a clear scope on the air's hydrogen sulphide content even with thermal baths which have different properties from "sulphuric" thermal water. In Győr we could examine the hydrogen-sulphide concentration getting into the atmosphere from „iodine"-, in Pápa from the very high (4410 mg/l) dissolved mineral substance containing- and in Veresegyháza, the practically with Széchenyi Gyógyfürdő identical compound thermal water. In Velence we measured indoor area detectable hydrogen-sulphide content of thermal water which is rich in minerals and in Pápa we did the same in the engine room. We compared these results with values measured in the indoor and outdoor of Zsóry Gyógyfürdő. It reveals from the figure that the ratio of the examined component in the „non-sulphuric" waters is smaller by several magnitudes.

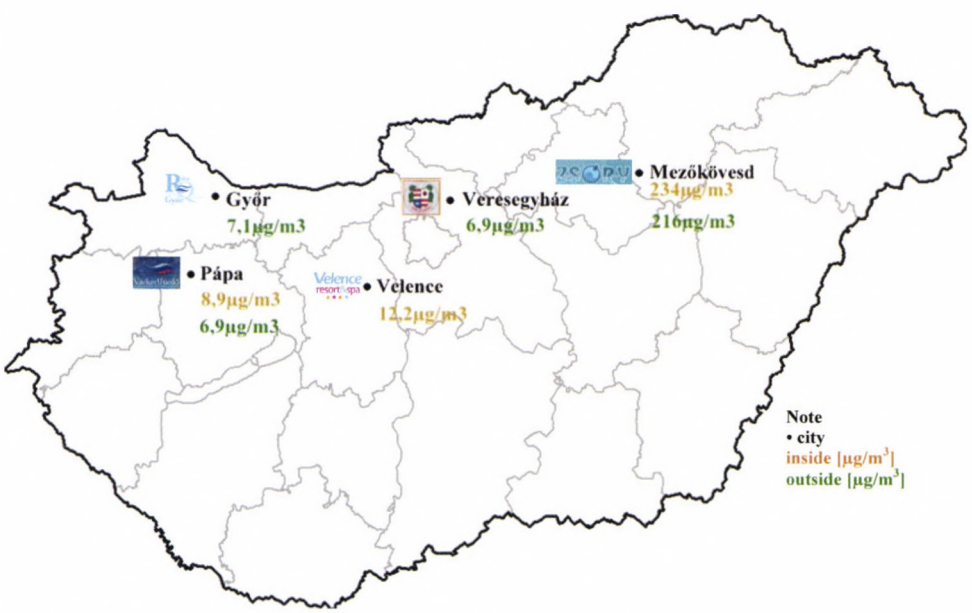

Figure 3. Forming of hydrogen-sulphide concentration in 2013 in Mezőkövesd and Zsóry Gyógyfürdő

We have set it as a goal, however it has not been realised yet due to financial reasons, that we also place passive measuring instruments in the area of Harkányi Gyógy- és Strandfürdő as well. The measurements which are planned to take place there might provide further interesting results because of the also "sulphuric" water. We trust that we are going to have the opportunity to execute the measurements later on.

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