Magdalena SENZE and Monika KOWALSKA-GÓRALSKA

PRESENCE OF METALS IN WATERS FROM SACRED SPRINGS IN EUROPE

Abstract: Laboratory tests were carried out of water sampled from springs located at various towns throughout Europe: in Poland (Gierzwald and Ludzmierz), France (Lourdes, La Salette), Portugal (Fatima) and Greece (Ephesus). The following were determined for the samples: electrolytic conductivity, and copper, zinc, cadmium, lead and nickel concentrations. The waters in question had the reaction ranging from 7.64 pH to 8.15 pH. Electrolytic conductivity oscillated between 201.00 μS · cm⁻¹ and 702.00 μS · cm⁻¹. Metal contents were as follows: copper – 0.0001–0.0052 mg Cu · dm⁻³, zinc – 0.0015–0.2153 mg Zn · dm⁻³, cadmium – 0.0005–0.0012 mg Cd · dm⁻³, lead – 0.0000–0.0101 mg Pb · dm⁻³ and nickel – 0.0000–0.0017 mg Ni · dm⁻³. The tests showed that the waters in question, which are believed by pilgrims to possess medicinal and healing properties, met the criteria established for water intended for human consumption.

Keywords: water, metals, sacred springs

Waters from sacred springs around the world are regarded as special, due to their reputed medicinal, healing and converting properties. Usually they are sampled by pilgrims to be drunk as potable water. They are also used by the sick to wash ailing parts of the body. Frequently the sick can also have a bath in sacred waters.

Europe has numerous places which, due to religious worship (the presence of relics, miraculous healing), are regarded by pilgrims as particularly important and worth visiting. Such sanctuaries are often located at small towns or villages, on slopes of hills, far from big cities. Apart from their considerable religious importance, they often have water springs, referred to as sacred. Some of such small settlements have grown increasingly popular with pilgrims and developed into quite sizeable towns. Consequently, the locations from which water is sampled had to be adapted to enable a larger number of people to draw – and often more – water in a shorter time. Because such water is regarded by pilgrims as possessing healing properties, it is usually drunk.

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Most probably a majority of the people using the water do not even think about its composition or any pollutants that may be present in it.

The tests were run in the years 2005–2008 on samples collected in south-eastern, central and western Europe: Gierzwald and Ludzmierz in Poland, Lourdes and La Salette in France, Fatima in Portugal and Ephesus in Turkey.

The aim of the research was to determine the pollution with heavy metals of waters sampled from the sacred springs in question.

**Material and methods**

The samples were collected into polyethylene bottles directly from the pipes from which water was taken by pilgrims. Immediately after they were collected measurements were taken of their reaction and electrolytic conductivity. Next they were mineralized in concentrated nitric acid. Metal (copper, zinc, lead, cadmium and nickel) concentrations were determined using atomic absorption spectrophotometry by means of a Varian Spectr AA-110/220 unit.

**Results and discussion**

The analysed waters were alkaline or slightly alkaline. The reaction values oscillated between 7.64 pH (Fatima) and 8.15 pH (Gierzwald) (Table 1). For none of the waters, apart from that from Gierzwald, for which the maximum was recorded, did the reaction exceed 8.00 pH. Under the Ordinance of 29 March 2007 of the Minister of Health, the reaction of water intended for human consumption should fall within the range 6.5–9.5 pH. This means that the waters in question satisfy the relevant requirements. According to the classification of surface waters intended for human consumption, the waters met the standards prescribed for category A1 on a three-level scale [1]. As per the guidelines regarding the presentation of the condition of groundwater, the waters met the cleanliness criteria for class 1 [2]. These alkaline waters could be help for example with hyperacidity (acid-alkaline balance).

<table>
<thead>
<tr>
<th>Site</th>
<th>Reaction (pH)</th>
<th>Electrolytic conductivity [μS · cm⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gierzwald (Poland)</td>
<td>8.15</td>
<td>486.00</td>
</tr>
<tr>
<td>Ludzmierz (Poland)</td>
<td>7.72</td>
<td>365.00</td>
</tr>
<tr>
<td>Fatima (Portugal)</td>
<td>7.64</td>
<td>201.00</td>
</tr>
<tr>
<td>Ephesus (Greece)</td>
<td>7.73</td>
<td>702.00</td>
</tr>
<tr>
<td>Lourdes (France)</td>
<td>7.89</td>
<td>350.00</td>
</tr>
<tr>
<td>La Salette (France)</td>
<td>7.85</td>
<td>339.00</td>
</tr>
</tbody>
</table>

The results of the measurements of electrolytic conductivity were used to formulate conclusions about environmental pollution with mineral compounds. The lowest figure,
at 201.00 μS · cm⁻¹, was obtained for the water collected at Fatima in Portugal (Table 1). The maximum was found at Ephesus (702.00 μS · cm⁻¹). The determined conductivity values fall, similarly to the reaction, within the limits set for water intended for human consumption (with the border value amounting to 2500 μS · cm⁻¹) [3]. In line with the guidelines for surface waters intended for human consumption, the waters from the sacred springs were identified as belonging to category A1 [1]. According to the groundwater classification, the waters in question met the requirements set for the best quality water class, except for the samples collected at Ephesus (702.00 μS · cm⁻¹ – class II). The difference, however, is not significant, as the threshold value for class I amounts to 700 μS · cm⁻¹ [2].

The analysis of heavy metal concentrations covered copper, zinc, cadmium, lead and nickel. The highest copper concentration was found in the Fatima spring (0.0052 mgCu · dm⁻³) (Fig. 1). The values obtained for Ephesus were not much lower (0.0048 mgCu · dm⁻³). The lowest copper concentration was in the samples from Ludzmierz in Poland (0.0001 mgCu · dm⁻³). The cut-off value for water intended for human consumption is 2.00 mgCu · dm⁻³, and so all of the samples met the criteria set in the Ordinance referred to above [3]. In terms of copper concentration in surface waters intended for human consumption the waters in question fell within the first, A1 category [1]. According to the groundwater classification system, copper concentrations satisfied the requirements set for class 1 water, the maximum threshold for which amounts to 0.0100 mgCu · dm⁻³ [2].

Zinc content ranged from 0.0015 mgZn · dm⁻³ to 0.2153 mgZn · dm⁻³ (Fig. 2). The highest concentration was found in the case of water from Ephesus (Greece). Also the samples from Fatima had a high concentration of zinc, at 0.1115 mgZn · dm⁻³. The lowest concentration was at Ludzmierz. The concentrations determined for Gierzwald and La Salette were similar, at 0.0300 mgZn · dm⁻³ and 0.0271 mgZn · dm⁻³, respectively. The Ordinance of the Minister of Health referred to above does not
regulate zinc content in potable water [3]. As per the groundwater classification system, the waters sampled in Poland (Gierzwald and Ludzmierz) and France (Lourdes and La Salette) belong to class 1, whereas those from Fatima and Ephesus – to class 2 [2]. According to the classification of surface waters intended for human consumption, all of the waters studied as part of the research met the requirements for the cleanest water category – A1 [1].

Cadmium concentrations proved the lowest at Ludzmierz (0.0005 mgCd · dm$^{-3}$) and the highest at Lourdes (0.0012 mgCd · dm$^{-3}$) (Fig. 3). The Gierzwald and Fatima samples had 0.0008 mgCd · dm$^{-3}$, and those from La Salette and Ephesus – 0.0009 mgCd · dm$^{-3}$. All of the samples fell within the range of values specified in the Ordinance of the Minister of Health referred to above, which sets the maximum
permissible concentration at 0.0050 mgCd·dm⁻³ [3]. According to the surface water classification, the determined cadmium levels met the requirements for category A1 [1]. Under the groundwater classification system, the waters covered by the research belong to class 1, except for the water from Lourdes, which is class 2, with the maximum concentration threshold at 0.0010 mgCd·dm⁻³ [2].

As far as lead is concerned, its maximum concentration was found at La Salette (0.0101 mgPb·dm⁻³) (Fig. 1). A lot of lead was also found in the water from Lourdes (0.0098 mgPb·dm⁻³). No lead was found in the water samples from Ludzmierz. All the recorded values fall within the limits prescribed by the Ministry of Health [3]. Based on the recommendations of the Minister of the Environment regarding groundwater, all of the waters in question belong to the highest water cleanliness class [2]. The same applies to the classification of surface waters intended for human consumption (category A1) [1].

No nickel was found at Ludzmierz. The highest nickel concentration was at Fatima (0.0017 mgNi·dm⁻³) (Fig. 3). The samples from Gierzwałd and Lourdes had the same concentration of the metal: 0.0005 mgNi·dm⁻³. The maximum permissible nickel concentration in water intended for human consumption amounts to 0.0200, and so all of the samples qualify as fit for consumption [3]. Nickel concentrations in the waters in question were low and so all of the waters belong to groundwater cleanliness class 1 and to category A1 for surface waters [1, 2].

Recapitulation

The tests showed that the waters in question, which are believed by pilgrims to possess medicinal and healing properties, met the criteria established for water intended for human consumption in terms of their the pH value, conductivity and heavy metal concentrations.

References

miedzi, cynku, kadmu, ołowiu i niklu. Badane wody odznaczały się odczynem w zakresie od 7,64 pH do 8,15 pH. Konduktywność wahała się od 201,00 do 702,00 μS · cm⁻¹. Zakresy zawartości metali wynosiły dla miedzi (0,0001–0,0052 mgCu · dm⁻³), dla cynku (0,0015–0,2153 mgZn · dm⁻³), dla kadmu (0,0005–0,0012 mgCd · dm⁻³), dla ołowiu (0,0000–0,0101 mgPb · dm⁻³) oraz dla niklu (0,0000–0,0017 mgNi · dm⁻³). Na podstawie przeprowadzonych badań okazało się, że badane wody, które uznawane są przez pielgrzymów jako mające właściwości lecznicze i uzdrowiające, spełniają kryteria ustalone dla jakości wód przeznaczonej do spożycia dla ludności.

Słowa kluczowe: woda, metale, święte źródła