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Inorganic chemical quality of European tap-water: 1. Distribution of parameters and regulatory compliance

David Banks [a,b,*], Manfred Birke [c], Belinda Flem [d], Clemens Reimann [d]

[a] Holymoor Consultancy Ltd., 360 Ashgate Road, Chesterfield, Derbyshire S40 4BW, UK
[b] School of Engineering, James Watt Building (South), University of Glasgow, Glasgow G12 8QQ, UK
[c] Federal Institute for Geosciences and Natural Resources, Berlin Office, Wilhelmstrasse 25-30, 13593 Berlin, Germany
[d] Geological Survey of Norway, Postboks 6315 Sluppen, 7491 Trondheim, Norway

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ABSTRACT

579 tap water samples were collected at the European scale and analysed in a single laboratory for more than 60 parameters. This dataset is evaluated here in terms of the statistical distribution of the analysed parameters and compliance with EU and international drinking water regulations. For most parameters a 99% (or better) degree of compliance was achieved. Among the parameters with the higher rates of non-compliance are: arsenic (1% non-compliance in EU member states, 1.6% when samples from non-EU states are also considered) and sodium (0.6%/1.0%). The decision by the WHO to raise its provisional guideline from 15 μg/L (WHO, 2004) to 30 μg/L (WHO, 2011) has reduced non-compliance for uranium from 1.0% to 0.2%. Despite the fact that tap water (i.e. presumed treated water) was collected, many observations can still be interpreted in terms of hydrogeochemical processes. The dataset demonstrates the potential value of very cost-effective, low-density sampling approaches at a continental (European) scale.

1. Introduction

European bottled mineral waters have been studied in several surveys during the past 15 years. For example, Misund et al. (1999) collected 56 samples from 14 European countries and analysed for 66 parameters. Bertoldi et al. (2011) collected 571 bottled mineral waters from 23 countries and analysed for 39 parameters. The largest study hitherto on European bottled water was performed by the EuroGeoSurveys (EGS) Geochemistry Expert Group (GEG) in 2009: the study covered 40 countries and comprised 1785 samples analysed for 70 parameters. The full results of this survey are published in an Atlas compiled by Reimann and Birke (2010). In addition, bottled water chemistry from the 2009 Survey was also evaluated and reported at a national level by, e.g., Birke et al. (2010a) in Germany, Cicchella et al. (2010) in Italy, Peh et al. (2010) in Croatia, Bityukova and Petersell (2010) in Estonia and Demetriades (2013) in Greece.

In the WHO Guidelines for Drinking-Water Quality (4th Edition – WHO, 2011), guideline values for chemical contaminants are based on the assumption of a 60 kg adult consuming 2 L per day or 730 L per year of drinking water. Of this, an average of 104.4 L is obtained from bottled water and the remainder is consumed as tap water or other similar sources. This means that although the consumption of bottled water has increased strongly over recent years, tap water is still the most important source of potable water. Hitherto, however, no European-scale hydrochemical surveys of tap water have been published. In order to provide a "control" data set against which the inorganic chemical quality of the bottled waters could be compared, the EGS GEG together with some other organisations (the EGG Project team – Reimann and Birke, 2010) also collected a large set ($N = 579$) of tap water samples from 30 European countries in 2009. The samples were analysed at a single laboratory – that of the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR – the *Federal Institute for Geosciences and Natural Resources*) in Hannover, Germany. Parts of the tap water data have already been published at a national scale, e.g., the results for uranium in Germany by Birke et al. (2010b), tap water data for Greece by Demetriades (2013) and tap water data for Italy by Dinelli et al. (2012). Cidu et al. (2011) also compare tap water and bottled water quality in Italy.

This tap-water data set is regarded as a valuable resource in itself, as it is possibly the first time that such a large multi-national drinking water sampling campaign has been conducted, using to a single methodology and within a short time frame, with the samples being analysed at a single laboratory and thus fully harmonised and directly comparable at the European scale.

* Corresponding author at: School of Engineering, James Watt Building (South), University of Glasgow, Glasgow, G12 8QQ, UK. Tel./fax: +44 1246 230068.
E-mail address: david@holymoor.co.uk (D. Banks).

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Table 1
Sample numbers acquired from each of the participating countries.

Country	EU member status*	No. of samples
Austria	Y	16
Bosnia & Herzegovina	PC	15
Belarus	N	1
Bulgaria	Y	15
Croatia	Y	15
Cyprus	Y	4
Czech Republic	Y	11
Estonia	Y	15
Finland	Y	15
Former Yugoslav Republic of Macedonia (FYROM)	C	15
France	Y	12
Germany	Y	164
Greece	Y	53
Hungary	Y	19
Italy	Y	25
Latvia	Y	3
Lithuania	Y	9
Luxemburg	Y	10
Norway	N	12
Poland	Y	15
Portugal	Y	15
Slovakia	Y	15
Slovenia	Y	35
Spain (& Canary Islands)	Y	19
Serbia	C	14
Sweden	Y	6
Switzerland	N	9
Ukraine	N	12
United Kingdom	Y	10
Total		579
Total (EU Members Only)		501

* EU Member status as of December 2013. Y = member, C = candidate for membership, PC = potential candidate, and N = non-member.

This paper compiles inorganic chemical parameters in tap water at a European scale and compares them with international and European legislation and guidelines. The national characteristics and the reasons for chemical variations between them will be discussed in a subsequent paper (Flem et al., submitted for publication).

2. Methodology

Within each of the 30 European countries, the EGG project team contacted one or more coordinators to collect samples of tap water from a selection of households within that country. Each country was recommended to collect a geographically representative selection of potable water, supplied to households via a piped distribution system. In most cases, but not all, the countries in question were able to comply with this request. In most cases, this was achieved through a network of colleagues of the EGG project team and those of the EGS GEG country coordinators, the objective being that the samples should be collected largely by engineers or geologists with an understanding of the importance of the sampling methodology. No instructions were given regarding the representativity of the samples as regards population coverage or ultimate potable water source. Thus, the resulting sample set, while moderately well geographically distributed (Table 1, Fig. 1) may contain biases towards urban or rural population centres within each country. The source of the water (groundwater or surface water) and nature of any treatment is not known in most cases. Although most nations aimed at around 15 samples, some countries (e.g., Germany, Greece, Italy) collected large numbers of samples, while others (e.g. Latvia and Belarus) collected only a handful of samples.

The sampling methodology was kept as simple as possible to ensure sample consistency and to minimise the possibilities for sample error. The samplers were instructed as follows:

- To use a clear, PET bottled water flask; and to rinse it thoroughly with the tap water to be sampled. PET flasks were selected because the main EGG bottled water project had carefully investigated leaching of elements from various bottle materials and found that Sb is the only element to be significantly leached by common PET bottle types on the European market (Reimann and Birke, 2010).
- To run the household tap in question for a minimum of five minutes. The national teams were instructed to avoid waters that had been subject to household-scale water treatment (e.g. household ion exchange softening or filtration).

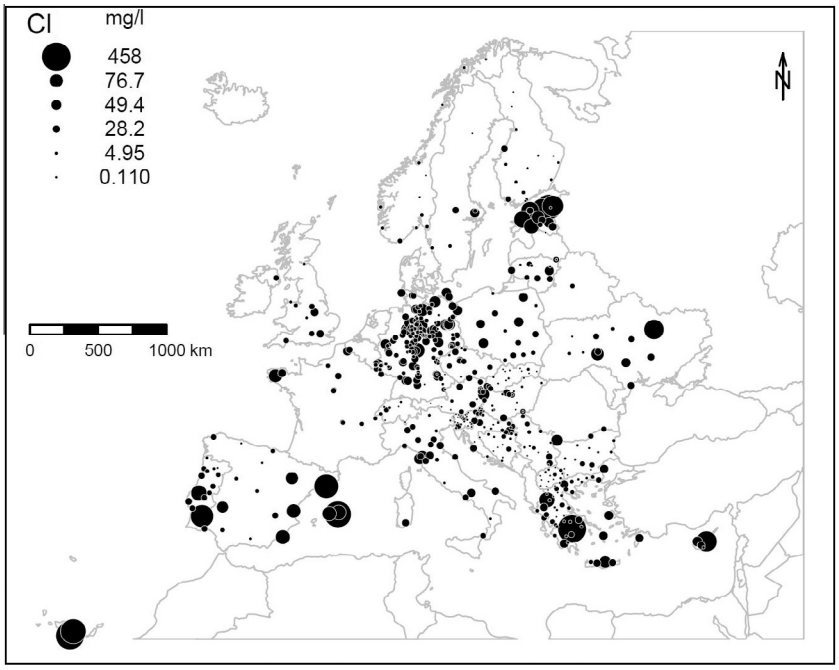

Fig. 1. Map of Europe showing distribution of locations of sampled tap waters and chloride concentrations in these waters. The Canary Islands are considered a part of the Spanish data set. *N* = 579.