TA6 – Radiation Protection of the Public and the Environment

A SURVEY OF RADIOACTIVITY IN DRINKING WATER IN UPPER AUSTRIA

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Abstract The University of Natural Resources and Applied Life Science Vienna, in co-operation with the environmental department of the government of Upper Austria, realizes a 3 year program (2004-2006) to investigate the radioactivity in drinking water in Upper Austria. The superior purpose of the project is to protect the population from radiation exposure by drinking water. Therefore the measurements should yield basic data for further processing (guidelines, regulations [ON S5251]) and their realisation (precaution, mitigation). To get an overview of the situation water samples are taken from water supplies and consumers' houses (population radiation exposure) as well as directly from springs and fountains to obtain hydrogeological-radiological basic data.
The first 230 water samples (to get a general idea, distributed among the area of Upper Austria) are analyzed for different radionuclides (Rn-222, Ra-226, H-3, U-238) and alpha-beta-total activity concentration by liquid scintillation technologies. On the basis of these results more samples are taken in regions with elevated activity concentrations and besides in regions of particular geological interest (e.g. Bohemian Massif – granite rocks; along geological disturbances; in regions with elevated Uranium and Thorium-values in the rocks). These samples are analyzed for Radon on-site by a mobile liquid scintillation instrument (Triathler, by Hidex) and additionally in the laboratory for Ra-228, Po-210, Pb-210. So far, 145 samples have been taken in this way in about 23 communities. First results indicate that the Radon activity concentrations in some springs and fountains range to 1000 Bq/l, but after preparation of the water in the supplies the activity concentrations are usually much lower. To determine this behaviour (e.g. for different preparation facilities), samples are taken at several places within the run of the water from the spring to the consumer. Besides special attention is given to U-238, because little data exist about it in Austria, although it is harmful not only because of its radioactivity but its chemical toxicity.
Finally the results are classified and mapped to realize geological and geographic correlations.
In the framework of this investigation program, the method of the on-site liquid scintillation measurements by the Triathler should get established as a standard procedure for drinking water regulations monitoring. In the future the basic data net from the program should be intensified.

1. Introduction

In course of the implementation of guidelines for radiation protection of the public and the quality of the drinking water (e.g. [EC2001]) and the legal general framework of Austria (present and future, e.g. [ONORM2005], [Schönhofer2005]) a broad survey of radioactivity in drinking water is required. Therefore the University of Natural Resources and Applied Life Science Vienna in co-operation with the environmental department of the government of Upper Austria[1] started an investigation program of radioactivity in drinking water in Upper Austria (area: 12 000 km^2,

[1]The investigation program is funded by the Government of Upper Austria, Contr.No.U-UT-930001/182-2004-K

population: 1,4 million). The purposes of this program are: the protection of the population from radiation exposure by drinking water, a survey of hydrogeological-radiological basic data and providing a basis for realisation of official (Upper Austria, Austria, EU) directives, tasks and measures.
The project is part of a major survey by the Government of Upper Austria to investigate the radiation exposure of employees (drinking water supplies) and the population (radionuclides in drinking water).
Basic data about radioactivity in drinking water (especially Rn-222) resulting from former surveys [Schönhofer2005, Schönhofer1992, Friedmann1999, Gegner2002, Governmental Office of Upper Austria1997] in Upper Austria already exist. This project should broaden the knowledge and the data net by more detailed measurements (more radionuclides, more measurement points) and new considerations (e.g. correlations with geology, chemical parameters and water flow).

2. Methods

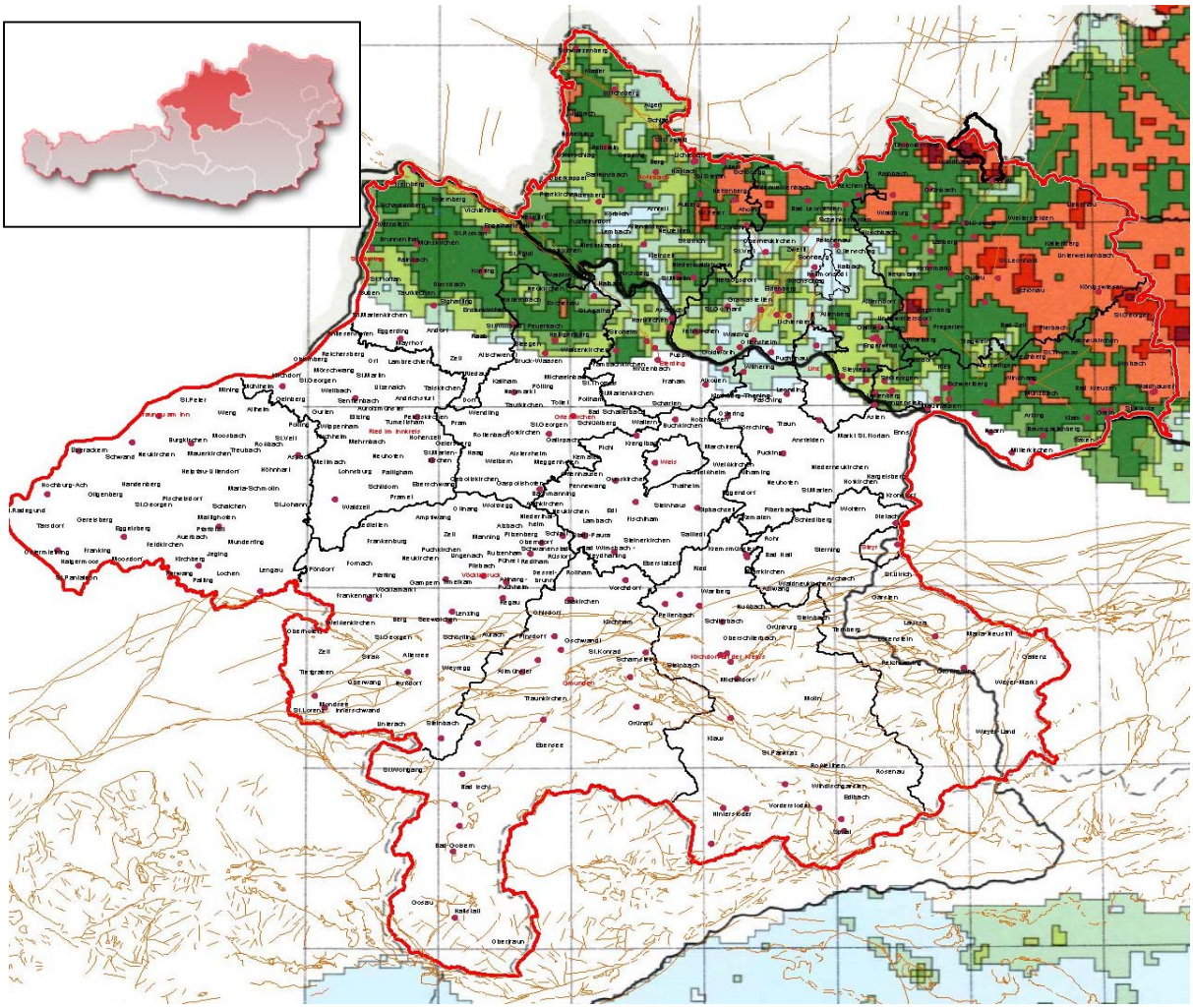
The first sample collections to get a general idea were operated in November/December 2004 in municipal and private water supplies representatively distributed among the area of Upper Austria (partially executed together with the second part of the project in water supplies). These 230 water samples were measured and analyzed by LSC and ICP-MS in the laboratory of the Austrian Agency for Health and Food Safety (AGES) Vienna for Rn-222, Ra-226, H-3, U-238 and alpha-beta-total activity concentration.

Table I. Classification of the activity concentration

Measurement	Number of Classes	Name of Class	Classification [Bq/l]
total	3	1	<1,0
Alpha/Beta		2	1,0-3,0
		3	>3,0
H3	3	1	<30
		2	30-100
		3	>100
Ra-226	5	1	<0,049
		2	0,049-0,49
		3	0,49-1,5
		4	1,5-4,9
		5	>4,9
Rn-222	5	1	<30
		2	30-100
		3	100-300
		4	300-1000
		5	>1000
U-238	5	1	<0,037
		2	0,037-0,37
		3	0,37-1,11
		4	1,11-3,7
		5	>3,7
total Alpha	3	1	<0,33
		2	0,33-1,00
		3	>1,00
total Beta	3	1	<0,66
		2	0,66-2,00
		3	>2,00
Ra-228	5	1	<0,02
		2	0,02-0,2
		3	0,2-0,6
		4	0,6-2
		5	>2
Pb-210	4	1	<0,1
		2	0,1-0,2
		3	0,2-0,5
		4	>0,5

Taking into account the results of the first survey, more sophisticated samplings based on defined selection criteria were executed: Anew sampling in regions with elevated activity concentrations and in areas with particular geological interests (Bohemian Massif – granite; along geological faults; areas with elevated Uranium and Thorium concentrations in rocks [Geolgical Survey1987], dolomite). So another 146 water samples in 23 different communities were taken from June to November 2005. The samples were taken at several points within the water flow from the spring to the consumer (e.g. spring, fountain, before and after preparation in the supplies, elevated tank, etc.). These samples were additionally measured for Ra-228, Po-210 and Pb-210 and chemical parameters in the laboratory of the AGES, and on-site with the mobile liquid scintillation instrument Triathler (Hidex) for Radon [Frenzel1999]. This measurement method is tested in this project and should get established as a standard procedure for drinking water regulations monitoring. Therefore, all measurements were operated with 2 different Triathlers and different LSC-Cocktails, and additionally by gammaspectroscopy for comparison and verification. Besides an – easy as possible – measurement method with the Triahtler for U-238 and Ra-226 will be adapted.
Finally all results were classified relating to applied standards [EC2001, ONORM2005, Risica2000] (Table I) and mapped in different geological [Geological Survey2003] and physical maps (Fig.1).

Fig.1. First 230 measurment points in the Thorium-map of Upper Austria (Geochemical Atlas [Geological Survey1987])



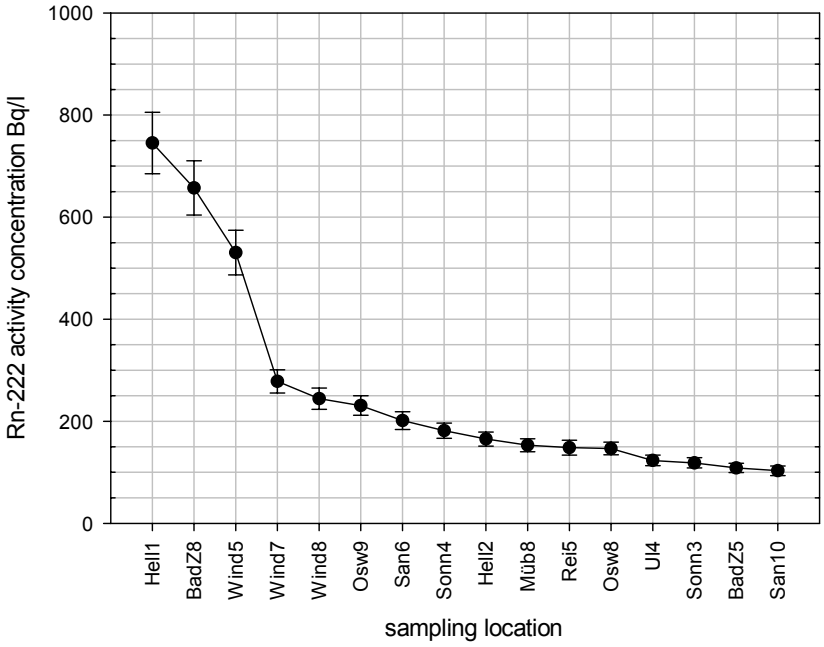
3. Results

6% of the first 230 measured Rn-222 activity concentrations are above 100 Bq/l, the highest values are situated in the Bohemian mass and along the so called Danube-disturbance. 8% of U-238 values are slightly elevated – evenly distributed among the whole tested area. Interestingly there is no coherence between elevated Rn-222 and elevated U-238 values in this case. In this first survey no H-3, Ra-226 and alpha-beta-total activity concentrations above class 2 have been detected.
The analysis and measurements of the samples of the sophisticated sampling sessions at the AGES laboratory are not finished yet. The first results show no elevated H-3 concentrations and also no alpha and beta-activity concentration above class 2 – the highest values in the Bohemian massif. Only few results of nuclide-specific analysis exist so far (about 30) – until now no elevated Ra-228 concentration has been detected. U-238 and Po-210 results do not exist yet.

The Rn-222 activity concentrations measured by Triathler from the sophisticated sampling sessions are consistently high (class 4, up to 1000 Bq/l) in wells and fountains, but after preparation of the water in the supplies and after piping, the activity concentrations at the consumers' houses are usually much lower (from Class 4 to class 2 or 1), which is interesting for radiation

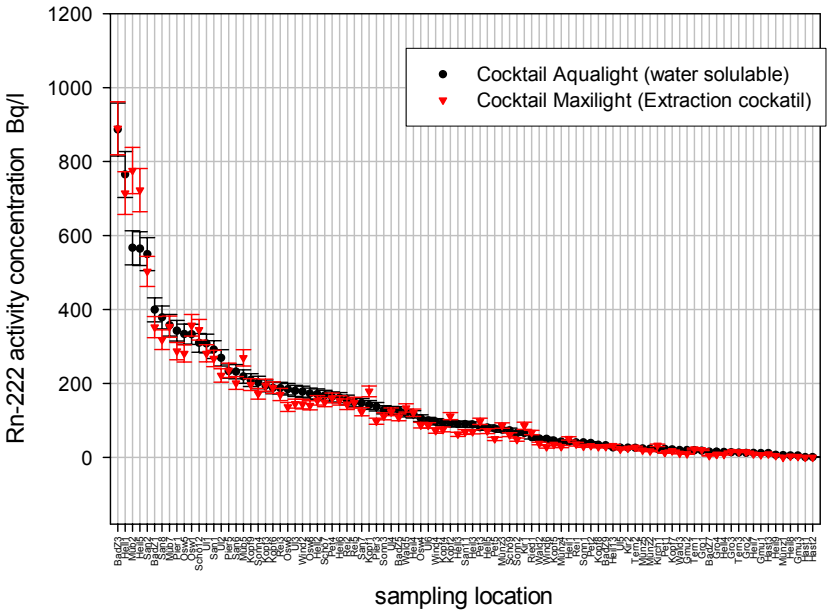
protection of the public. So there are only few cases (Fig. 2) of class 4 Rn-222 activity concentration of the water from the pipe at the consumer's house is in class 4 (all in Bohemian massif). In the foothill of the Alps no elevated Rn-222 activity concentrations in wells were detected. The results also demonstrate that water from deeper fountains not automatically shows higher radon activities. Near-surface wells out from weathered rocks often show higher Rn-222-activity concentrations.

Fig.2 Rn-222 activity concentration results (class 3 and 4) at the consumers houses



The Rn-222 results of the two different Triathlers correspond well, although the alpha-beta separation is better in the newer one (version 1.8) than in the older one (version 1.6) especially for the AquaLight Cocktail (water soluble). The Radon activity concentration results by the MaxiLight Cocktail (extraction cocktail, measurement at least 3 hours after the sample taking) are verified by comparison measurements by gammaspectroscopy in the LLC-laboratory. The Radon values measured with AquaLight Cocktail are mostly little beyond the MaxiLight results, but not more than 10-15% (Fig.3). So the instant Rn-222 measurement with the AquaLight Cocktail and Triathler is a practicable method to get a general survey.

Fig.3. Relation of Rn-222 activity concentration measured by Triathler (Vers.1.8.) and different cocktails



4. Conclusions & Prospects

After finishing the measurements and analysis all results will again be mapped (GIS) to investigate geological and geographic correlations [Schubert2003, Krakhofer2002]. Besides we search for coherences between activity in the water and the water flow (different water preparation, duration of dwell, [Annanmäki1999, Katzlberger2000]). Another aspect is to find correlations between the different radionuclides among themselves and to chemical parameter in the water.
Furthermore special attention is given to U-238, because of its radiological and toxicological harmfulness. For that purpose we are involved with adaptation of a LSC methodology to measure U-238 with the Triathler.
In the future at least the tested on-site Rn-222 measurement with the Triathler will be a routine standard procedure for drinking water regulations monitoring and thereby the basic data net of the program should be increased. The 3 year program "Radioactivity in drinking water in Upper Austria" yields a broad overview of the situation and a good starting position for regulation and implementation of guidelines and reconstruction measures. On the other hand it also determines basic scientific data for further studies.

5. Acknowledgements

The authors are grateful to Christian Katzlberger and Claudia Landstetter of the Austrian Agency for Health and Food (AGES) for carrying out the radiometric analytics of the water samples.

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