A cross-sectional study of the association between arsenic consumption from private drinking water supplies and measured biological levels in the population of Cornwall, UK

Project Update – February 2015

Background to the study
Between 2011 and 2013, Public Health England (PHE), the British Geological Survey (BGS), with later involvement from the University of Manchester (UoM), worked together on a two-phase sampling programme of private water supplies (PWS) in Cornwall. Results were collected for around 500 households and showed that, in the case of arsenic (As) alone, 5.5% of drinking-water samples exceeded the 10 µg/L prescribed concentration or value (PCV) as prescribed by the private drinking water supply regulations, 2009. Comparisons were made for other chemical substances to their respective PCVs, and a total of 35% of the population exceeded one or more of their corresponding PCVs (including arsenic). These findings, in addition to the well documented high environmental arsenic concentrations in the region, warranted further investigation into the potential uptake of this element by the local population.

Households that were previously involved in the PWS water sampling campaign were sent a letter inviting them to participate in a follow-up biomonitoring investigation. Households which had arsenic levels above the PCV measured in their water were prioritised and targeted with follow-up telephone calls. If residents consented to participate, they were sent information on their participation and an appointment was made for the field sampling team to visit and collect biological and environmental samples. In total 214 adults (aged 18 and over) from 129 households volunteered to take part in the biomonitoring study.

Field survey
In November 2013, sampling teams from BGS visited participants in their homes to collect samples of urine, toenail clippings and a small cutting of hair from the nape of the neck. An electronic exposure assessment questionnaire was completed with the volunteer by a member of the sampling team. The questionnaire asked participants about food and drink as well as the activities that they undertook, such as outdoor activities, which could explain variations in exposure to arsenic in the environment.

Environmental sampling was conducted to use in conjunction with biomarker results in an attempt to assess the relevance of various exposure routes. A tap water sample from the private supply was taken to capture the exposure level relevant via this pathway at the time of biomonitoring. Where possible a garden topsoil sample, an indoor dust wipe sample and a small amount of rice (a foodstuff known to contribute to population arsenic intake) were collected from each household.

Analysis of samples
BGS and UoM have completed the analysis of the water, biological and soils samples in their laboratories, and will soon be analysing the household dust wipe and rice samples. Sample preparation, analysis and validation of the samples have taken time and their biological sample results are now ready to be given to participants. The results of the water samples were sent to householders in June 2014. We plan to send participants the results of their soil samples in a third results letter. The results from the analysis of arsenic in rice and household dust wipe samples will not be given to participants (these were collected for the purpose of looking at their associations with uptake across the whole population, not at an individual level). There are no reference values available for arsenic in dust samples and ingestion of rice are likely to vary greatly between participants, therefore the results will only be used for research purposes to investigate possible exposure routes of arsenic from the environment.

Results of the analysis of the water samples collected during the biomonitoring study
We previously reported the results of the water samples in the last project update in June 2014. The water samples collected during this study showed similar levels of arsenic and other naturally occurring substances as those found in the previous sampling campaigns (2011-2013). Analysis of the water samples showed that 41 households (32%) had elements in their PWS at levels which exceeded current UK drinking water standards. Exceedances of eight chemicals were found, these were; arsenic, aluminium, copper, iron, lead, nickel, manganese and antimony.

The drinking water from 15 households (12%) exceeded the arsenic PCV. Since households with high arsenic levels were targeted for recruitment, this is higher than the proportion of households with arsenic exceedances in the previous PWS study.

Results of the analysis of the biological samples
Eight urine samples (4%) exceeded the guidance value of 35 µg/l of inorganic arsenic plus methylated metabolites set by the American Conference of Governmental Industrial Hygienists (ACGIH)\(^1\).

There are no guidance values available for arsenic levels in either hair or toenails; however it is possible to compare the results from the study population with normal levels of arsenic. The US Agency for Toxic Substances and Disease Registry's (ATSDR) normal human level of total arsenic in unexposed individuals is ≤ 1 µg/g for both hair and nails\(^2\). We found that the arsenic measured in 9 participants’ toenail samples (4%) and three participants’ hair samples (3%) was greater than this value. A summary of the concentrations found in the biological samples are set out in Annexe A.

Communicating the results from the analysis of the biological samples to householders
Participants will shortly receive the results of the analysis on their biological samples. Participants will be sent the results of their samples by means of a letter; the results sheet will give participants the levels of arsenic measured in their urine, toenail and hair samples. Participants will be able to compare their results to the range of results found in the study population and the guidance value for arsenic in urine. The participants with arsenic levels above the guidance value in their urine samples will be provided with tailored advice. A public health advice sheet for arsenic will be included if arsenic in the participant’s drinking water sample exceeded the PCV for arsenic. Results from the soil samples will be sent out at a later stage.

Communicating the results from the biological samples to stakeholders

Project updates and results of the study are being circulated to relevant stakeholders, including the Cornwall County Council (public health and environmental health departments), NHS (Kernow clinical commissioning group, Royal Cornwall Hospitals Trust), Department of Health, the Drinking Water Inspectorate, Environment Agency, the Department for Environment, Food & Rural Affairs, South West Water, PHE colleagues (at the Centre for radiation, chemical and environmental hazards, the National Poisons Information Service, field epidemiology services and the local PHE centre - Devon, Cornwall and Somerset) and the project funders NERC (the Natural Environment Research Council). A special communication, describing the study, will be sent to all GPs in Cornwall before the results letters are sent to participants.

For further information;
Please visit the project website: http://www.bgs.ac.uk/cornwallPWS
Or contact:
   PHE team members on EPHT@phe.gov.uk

   Dr Tony Fletcher (PHE principal investigator)
   tony.fletcher@phe.gov.uk

   Daniel Middleton (PhD research student)
   daniel.middleton@postgrad.manchester.ac.uk

   Dr Michael Watts (BGS principal investigator)
   mwatts@bgs.ac.uk

   Prof David Polya (UoM principal investigator)
   david.polya@manchester.ac.uk

ANNEXE A - A summary of arsenic concentrations measured in biological samples

A total of 214 participants from 129 households provided biological samples for the study. 212 of these participants from all of the 129 households provided urine samples, sufficient toenail samples were collected from 203 participants from 126 of the households and sufficient hair samples were collected from 107 participants from 73 households.

<table>
<thead>
<tr>
<th>Biological sample</th>
<th>Range of levels found in study population</th>
<th>Guidance value*</th>
<th>Number of samples exceeding guidance value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine</td>
<td>0-124 µg/l</td>
<td>35 µg/l</td>
<td>8</td>
</tr>
<tr>
<td>Toenail</td>
<td>0-3 mg/kg</td>
<td>Not available</td>
<td>-</td>
</tr>
<tr>
<td>Hair</td>
<td>0-3 mg/kg</td>
<td>Not available</td>
<td>-</td>
</tr>
</tbody>
</table>

*For urine we have used the recommended limit for these arsenic compounds developed in the USA for workers, by the American Conference of Governmental Industrial Hygienists (ACGIH)\(^3\). There are no guidance values established for the general population, but this value for workers is helpful for comparison.