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## Extended Abstracts

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title: **The level of awareness of groundwater quality issues among private well users in Ireland**

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## INTRODUCTION

Private groundwater schemes in Ireland currently supply water to an estimated 720,000 people from two main source types: small private supplies (SPS) - private, unregulated groundwater supplies typically serving individual households - and private group water schemes (PrGWS), which are committee or shareholder run schemes serving fewer than 50 people, or supplying <math>10\text{m}^3/\text{day}</math> (Tab. 1). It is estimated that a further 200,000 people regularly use groundwater from non-transient, non-community (NTNC) systems (workplaces, schools, licensed premises, etc), equating to approximately 21.7% of the total population (CSO, 2007). Recent figures indicate that 31.4% of PrGWS showed evidence of *E. coli* contamination at least once during the period 2007-2008, with an average figure of 33% over the period 1998-2008 (EPA, 2009). A higher proportion of microbial contamination is to be expected among SPS, which are currently unmonitored and unregulated.

**Table 1.** Sources of domestic water supply in Ireland (After CSO, 2007; EPA, 2009).

| Source                 | % (Total Population) | Number Supplied |
|------------------------|----------------------|-----------------|
| Surface Water (Public) | 73                   | 3,095,089       |
| Groundwater (Public)   | 9                    | 381,586         |
| SPS                    | 12.9                 | 546,940         |
| PrGWS                  | 4.1                  | 173,833         |
| Other/Unknown          | 1                    | 42,398          |

The main groundwater contaminants of concern in terms of human health are microbial enteric pathogens including verocytotoxigenic *Escherichia coli* (VTEC), *Cryptosporidium parvum*, *Giardia lamblia*, and the enteric viruses (*Rotavirus*, *Adenovirus*, etc). There is a wide range of symptomatic illnesses which may result from direct consumption of one or more of these pathogens via groundwater (Macler, Merkle, 2000; Strauss et al., 2001; Nwachuku, Gerba, 2004), the most commonly diagnosed being acute gastrointestinal illness (AGI) or gastroenteritis. Although, the majority of AGI cases are minor, of short duration and self resolving, some cases, particularly those encountered in vulnerable sub-populations including infants, elderly and immunocompromised individuals may lead to more serious infection or even death. On a global scale, inadequate treatment of gastroenteritis kills 5-8 million people per year (Kasper et al., 2005).

Sources of groundwater contamination in Ireland include point sources such as septic tank systems, farmyards, silage pits and waste disposal sites, and diffuse sources including landspreading of animal manures and chemical fertilisers, plus grazing animals. All of these contamination sources may be associated with both microbial and chemical contaminants.

A research project is being carried out to assess the health risks associated with small private well schemes in Ireland. This research includes sampling of private groundwater sources and assessment of the susceptibility of these wells to potential contamination sources. Owners and users of private well schemes are also being surveyed about their level of awareness of their wells and about the linkages between water contamination and health. This paper focuses on the results of the awareness survey of well owners and users in Ireland.

## **RESEARCH OBJECTIVES**

The main objectives of the awareness survey were to establish the level of knowledge among private groundwater users in Ireland regarding the status of their well supplies and the potential health hazards associated with the consumption of contaminated groundwater.

The work presented in this paper is part of a larger overall research project which seeks to quantify groundwater awareness as a factor in private groundwater source susceptibility and subsequently to develop a set of guideline documents for owners/users of private groundwater sources in Ireland.

## **METHODS**

This study was conducted in 5 separate study areas in the Republic of Ireland (population 4.24 million in 2006 (CSO, 2007)).

### **Design of the questionnaire**

The survey questionnaire was devised to examine the overall level of awareness amongst private well users with regard to a variety of contamination issues including specific knowledge of their own private source i.e. design and construction details, source age, use and importance of water treatment processes and maintenance of sources. Respondents were also surveyed on their knowledge of potential groundwater contaminants and potential health effects of these contaminants in addition to potential sources of contaminants and the presence of these hazard sources in relation to their own well. Finally, to aid in the completion of a human health risk assessment, which is being developed as part of the overall research project, household composition, groundwater consumption patterns and historical health patterns with regard to gastrointestinal illnesses were examined.

### **Identification of population and sample**

For the purposes of this survey, the sample population was defined as those members of the Irish population who own or are served by a private groundwater source. This population is mainly located in rural areas, outside the perimeter of towns and cities served by public/local authority water schemes. Using standard sample size calculation equations (Moore & McCabe, 2006) and a total population of approximately 720,000, a sample size of approximately 400 surveys was calculated as being necessary to achieve a 95% level of confidence, with 5% error.

### **Study area selection**

Four study areas were chosen from a variety of potential locations using a site selection matrix developed for this project. This selection matrix ensured that suitable sites were chosen based on hydrogeology (groundwater vulnerability, aquifer type) and practical factors (laboratory proximity and availability of existing data). Three study areas were selected where the groundwater vulnerability was classed as "high" or "extreme", with a fourth area of low vulnerability for comparison. Three of the study areas contained regionally or locally important limestone aquifers, with one area having poor or locally important igneous and metamorphic rock aquifers. Additionally, awareness surveys were completed in a fifth area (not selected as a full study area) owing to its large number of private wells.

## Statistical analyses

Responses were numerically coded and analysed using the Statistical Package for Social Sciences (SPSS, 16.0) (SPSS, 2007). A chi-square ( $\chi^2$ ) test of independence (two-way analysis) was carried out in order to investigate significant associations. The p-value (significance) less than 0.05 is used by convention (Agresti, 1996).

## RESULTS

To date, 590 awareness surveys have been completed: 227 completed on a face-to-face interview basis and 363 completed as self-administered group surveys. The following section presents interim results from the 227 face-to-face interview surveys, completed over 5 study areas as outlined above (95% confidence interval, 6.5% error).

### General findings

Slightly over half of respondents were male (56%). 75% of surveys were completed with owners/users of boreholes (Bored SPS), with the remainder (25%) being completed with users of hand dug or spring wells (HD SPS/Spring wells). There are no data available regarding the relative proportion of HD SPS to Bored SPS in Ireland; however, it is unlikely to exceed 10%.

A high level of awareness was found with regard to knowledge of previous water quality analysis, with only 6.3% of respondents unaware of previous testing. However, approximately 37% of respondents' sources had never been tested for microbial or chemical quality, with this figure increasing to 54% for HD SPS sources. Furthermore, although there was no significant difference in the level of importance attributed to regular testing between Bored SPS and HD SPS respondents, a significant proportion of HD SPS users (55.3%) indicated that they would not be prepared to pay for water quality analysis of their source ( $p = 0.02$ ).

Approximately 8.8% of consumers served by groundwater supplies used bottled water as the main source of water for domestic consumption, the most common reason given for this being a lack of confidence in the quality of the groundwater, especially in cases where infants and young children were present in the household. The median consumption of water from their own private source has been found to be in the range 0.5-1 litres per capita per day.

### Source investigation

Approximately 59% of respondents identified at least one potential hazard within 100m (a generalised inner protection zone) of their well. However, further questioning revealed that approximately 73%, 88% and 82% were aware of the presence of slurry/fertiliser spreading, grazing animals and septic tanks, respectively, within the generalised inner protection zone. This suggests that 14%, 29% and 23% respectively, did not consider these activities as being "potential contamination sources". There was no significant difference found between Bored SPS and HD SPS respondents in relation to contaminant source awareness.

### Pathway investigation

Respondents were asked a series of questions about the design and construction details of their sources including well diameter, well depth, use of a casing/liner and presence of a grout seal.

Previous studies have shown that “localised” pathways (rapid bypass mechanism where contaminants enter the intake of the water supply due to poor design and/or construction) can be more prevalent routes for contaminant ingress than aquifer pathways, particularly in developing countries (Howard et al., 2003; Godfrey et al., 2005). There was found to be an overall higher level of awareness of well design/construction details among HD SPS respondents ( $p = 0.002$ ) (Tab. 2).

**Table 2.** Level of awareness of design and construction details of private wells.

|                          | Total (% aware) | Bored SPS (%) | HD SPS (%) |
|--------------------------|-----------------|---------------|------------|
| Well diameter            | 48.9            | 44.5          | 64.3       |
| Well depth               | 63.4            | 61.4          | 71.4       |
| Average watertable depth | 33.9            | 27.7          | 53.5       |
| Use of liner/casing      | 61.2            | 59.6          | 67.8       |
| Use of grout seal        | 22.5            | 16.9          | 39.3       |
| Pump type                | 59              | 59.6          | 60.7       |

### Receptor investigation

Respondents were asked if they were aware of particular contaminants in relation to groundwater and the potential human health effects of these contaminants. Results showed a relatively high overall awareness of faecal coliforms/*E coli*, *Cryptosporidium* and nitrate as groundwater contaminants; however, there is a knowledge gap exists concerning other contaminants, particularly *Rotavirus* and *Giardia* (Tab. 3), both highly infectious enteric pathogens. Further questioning found that 30% of respondents were not aware of any illnesses or symptoms associated with drinking from contaminated water supplies.

**Table 3.** Level of awareness of potential groundwater contaminants.

|                  | Total (% aware) | HD SPS (%) | Bored SPS (%) |
|------------------|-----------------|------------|---------------|
| Faecal coliforms | 94.7            | 94.6       | 94.5          |
| Rotavirus        | 26.4            | 23.2       | 27.1          |
| Cryptosporidium  | 74              | 69.6       | 74.7          |
| Giardia          | 4.4             | 0          | 5.4           |
| Manganese        | 33              | 25         | 34.3          |
| Lime (hardness)  | 96.4            | 96.4       | 96.4          |
| Nitrate          | 78.4            | 69.6       | 80.7          |

Additionally, it was found that there are a higher proportion of elderly groundwater users (>65 years) in households supplied by HD SPS. Approximately 47% of HD SPS supplied households had at least one elderly resident, while this figure was 18% in households using Bored SPS.

### CONCLUSIONS

The surveys confirmed that private groundwater sources in Ireland are not regularly tested for water quality, with levels of water quality analysis lower in HD SPS, which are commonly constructed in areas with a shallow water table and are therefore particularly vulnerable to contamination. The awareness surveys have identified a number of knowledge gaps amongst private groundwater users. Around a quarter of groundwater users did not recognise adjacent septic tanks or grazing animals as potential contamination threats (23% and 29%, respectively). Considering that the majority of private groundwater sources are located in rural, un-serviced

areas, these particular contamination sources are widespread and typically the most common sources of microbial contamination.

Approximately 30% of respondents were unaware of potential illnesses or symptoms associated with contaminated groundwater consumption, with 73% and 95% having no previous knowledge of *Rotavirus* and *Giardia*, respectively.

It is unclear as yet whether these knowledge gaps may be responsible for increased contamination susceptibility and therefore increased risk to human health. The next phase of the research will investigate if this is the case and if it is found to be, will seek to quantify the overall burden of illness which may be attributed to private groundwater sources as a result of low levels of awareness.

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