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Public awareness, behaviours and attitudes towards domestic wastewater treatment systems in the Republic of Ireland

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SUMMARY

Numerous studies have highlighted and quantified the role of domestic wastewater treatment systems (DWWTSs) as significant sources of human-specific aquatic contaminants in both developed and developing regions, particularly with respect to private and municipal groundwater supplies. However, from a socio-hydrological perspective, little work has focused on these systems and the potential environmental and human burden posed. This is of particular relevance in the Republic of Ireland, where approximately one third of the population is serviced by DWWTSs. The objective of the current study was to examine levels of awareness and subsequent behavioural tendencies among owners and users of DWWTSs in the Republic of Ireland, particularly in light of recent and future (national and EU) legislative amendments. Structured questionnaires were completed bi-modally with 1106 Irish respondents. Analysis identified a number of significant knowledge gaps which currently exist among DWWTS users in Ireland. These were associated with environmentally inadvisable behavioural practises, potentially leading to increased contamination vulnerability and subsequently, increased human exposure to waterborne contaminants. Household water supply type was significantly associated with DWWTS threat acknowledgement ($p = 0.014$), with unregulated private groundwater users exhibited the lowest awareness of DWWTS as a potential source of aquatic contaminants despite being the group at greatest risk. A bi-modal clustering approach was employed, with respondents found to fall into one of three distinct "attitudinal" clusters. Future engagement strategies should strive to provide guidance regarding the role of people and their activities within the hydrological cycle. The current study reinforces this conclusion, while providing evidence-based recommendations regarding provision of demographically focused educational strategies; these will further increase environmental policy compliance, and in so doing, decrease the human health and environmental contamination burden posed by DWWTSs.

1. Introduction

The ability of water systems to meet changing human and environmental needs lies at the core of water security in both developed and developing regions. It is recognised that some of the most critical vulnerabilities in contemporary water systems lie at the intersection between human activities and physical systems (Wheater and Gober, 2011; Sivapalan et al., 2012). The disposal of domestic effluent on-site using domestic wastewater treatment system (DWWTS) is an example of such an interaction. Improperly installed or poorly maintained DWWTSs represent a significant source of nutrients and enteric pathogens, particularly in rural areas; the protection of groundwater resources from such contamination is imperative for the effective management of risks posed to both human health and the environment. Discharge of insufficiently-treated domestic wastewater effluent to aquatic receptors, via direct discharge or baseflow, may lead to excess nutrient enrichment, algal blooms and eutrophication (Gill et al., 2009; Palmer-Felgate et al., 2010: Withers et al., 2011, 2012). It can also lead to waterborne disease; numerous significant outbreaks have been attributed to DWWTS effluent ingress to drinking water sources (Birkhead et al., 1989; Kramer et al., 1996; Karanis et al., 2007; Borchardt et al., 2011).

Development in rural areas of the Republic of Ireland has historically followed a dispersed settlement pattern comprising detached private residential dwellings or "one-off" housing (Scott and Murray, 2009). "One-off" dwellings are defined as "detached dwellings with individual on-site wastewater treatment systems, including septic tanks and other systems" (CSO, 2012). Beginning in the mid-1990s, Ireland experienced a period of rapid economic growth, resulting in a dramatic increase in residential construction (Scott et al., 2007). During this period, approximately one in three newly constructed houses were one-off residential dwellings,

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driven by a cultural predisposition towards rural living and lower development costs, in concurrence with improved infrastructural networks and access to urban centres (Duffy, 2000; Spatial Planning Unit, 2001; Scott and Murray, 2009). While there has been a marked decrease in housing stock growth in recent years, the trend of dispersed single dwellings has continued with one-off houses accounting for one in four of all private residences constructed in the Republic of Ireland since 2006 (CSO, 2012).

The scattered settlement pattern has led to the coevolution of rural inhabitants as both a source and receptor of groundwater contamination in the Republic of Ireland, with rural domestic households playing a greater role in the water quality dynamics of the hydrological cycle. The dispersed nature of rural development largely prohibits the use of municipal sewerage schemes, causing an increased reliance on hydrological systems for the disposal and treatment of domestic wastewater. Consequently, treatment and disposal of domestic wastewater is carried out on-site in over 80% of households in rural areas (approximately 438,000), servicing over one third of the population (CSO, 2012). The factors which make sewerage schemes unfeasible in rural areas also commonly apply to treated water supply networks, and so there has been a parallel increase in the use of untreated groundwater as a source of domestic drinking water. Groundwater sources in the Republic of Ireland currently provide a daily drinking water supply to an estimated 26% of the national population, with private groundwater sources supplying approximately 720,000 people or 17% of the population (EPA, 2009; CSO, 2012).

The most common form of DWWTS in Ireland consists of a septic tank providing primary treatment, followed by secondary and tertiary treatment via a subsoil percolation system (EPA, 2009). Septic tanks use primarily physical processes to remove suspended sediments and permit limited anaerobic digestion of organic materials (Gill et al., 2009). The percolation area, or soil infiltration system (EN 12566), consists of trenches with slotted pipes and gravel aggregates, receiving wastewater from the septic tank (or other system), subsequently transmitting it to subsoil strata for final treatment and disposal (Beal et al., 2005; EPA, 2009). Where DWWTSs have been sited, designed, installed and maintained in accordance with best practice, they have been shown to provide adequate treatment of domestic wastewater (USEPA, 2002; EPA, 2013). However, poorly maintained systems are potential sources of groundwater contaminants, particularly pathogenic microorganisms, and consequently, waterborne disease outbreaks (Beller et al., 1997; Daly, 2003; Borchardt et al., 2011). Scandura and Sobsey (1997) and Ahmed et al. (2005) have previously reported proximity to domestic septic tank effluent percolation areas as being a cause of groundwater contamination, particularly in areas of high groundwater vulnerability (i.e. thin overlying strata of high permeability subsoils). Borchardt et al. (2011) report that 229 patrons of a new restaurant in northeast Wisconsin were affected during a waterborne norovirus outbreak, which was hydrologically and epidemiologically confirmed as being due to ingress of septic tank effluent to an adjacent private well. Hynds et al. (2012) report that septic tank system location was significantly associated with *Escherichia coli* presence ($p = 0.004$) in private wells in diverse hydrogeological settings in the Republic of Ireland. This study identified DWWTS as the hazard source of greatest significance with respect to groundwater contamination in rural areas, particularly during periods of increased antecedent rainfall. As these systems are wholly anthropogenic in nature, this is considered a socio-hydrological issue as they represent a coupled human-water system whereby human activity and behaviour adversely affects water cycle dynamics (Sivapalan et al., 2012).

Private water wells in the Republic of Ireland are primarily located in rural areas lacking municipal sewerage schemes; accordingly, these supplies are situated in areas in which DWWTS are ubiquitously dispersed. Based on data relating to verotoxigenic *E. coli* (VTEC) outbreaks in Ireland during 2008, Garvey et al. (2010) suggest that drinking water in households using private wells were a significant factor in an overall outbreak increase. More recently, a surge in VTEC notifications during the period September to November 2011 has been reported in Ireland, with private well usage again highlighted as a significant source (McKeown and Garvey, 2011). During the reporting period 2011, approximately 37% of VTEC notifications were associated with private well exposure (HPSC, 2013). Thus, exposure to private wells represented a significantly increased likelihood of contracting VTEC infection. Ireland has for some years reported the highest levels of VTEC infection in the European Union, with Crude Incidence Rates (CIRs) of 6.2/100,000 in 2011, compared with 0.8/100,000 within the EU as a whole (HPSC, 2013). While the high reported levels in Ireland may be a result of differing epidemiological definitions, diagnostic procedures and communicable notification status throughout EU member states, the concurrently high dependency on private groundwater and DWWTSs in Ireland is also likely a significant contributory factor.

Recently the issue of DWWTS has come into sharp focus following a ruling by the European Court of Justice (C-188/08, 2009) in October 2009, finding the State (Republic of Ireland) in breach of EU legislation with respect to the regulation of septic tanks and similar systems. Consequently, the Department of the Environment and the Environmental Protection Agency (EPA) have developed and instigated a registration and inspection scheme for DWWTS, as called for under the recent amendment to the Water Services (Amendment) Act 2012 (2/2012). Owners of DWWTS have a duty of care under the Act to ensure appropriate operation and maintenance of their on-site treatment system, and thus not constitute a risk to human health or the environment; the registration and inspection scheme therefore stipulates that DWWTS owners must "self-inspect" their system annually (DoECLG, 2012). However, there is a lack of quantitative information regarding consumer understanding of treatment system processes, maintenance requirements and potential remediation strategies, and so a high level of uncertainty existed pertaining to consumers possessing the necessary tools to adequately inspect and maintain DWWTSs. Previous studies have reported on some of the common inaccurate public perceptions towards DWWTSs, such as the notion that on-site treatment systems are self-maintaining and that septic tank solids need not be regularly emptied or soak-aways inspected for signs of failure (Butler and Payne, 1995; Moelants et al., 2008). The study outlined in this paper for the first time quantifies the levels of awareness amongst Irish DWWTS users on these issues, in the context of adequate system self-inspection as required under national legislation.

A key element of the registration and inspection plan is a public engagement strategy to promote best practice relating to the operation and maintenance of DWWTS (EPA, 2013). The objective of the public engagement strategy is to encourage societal changes which will have a positive impact on water quality. A successful public information campaign requires a clear understanding of current public perceptions, activities, and knowledge gaps in relation to DWWTS. The current study examines levels of awareness, attitudes and behaviour among septic tank users in the Republic of Ireland. Subject areas examined include scheduled guidance measures, environmental and public health threats posed by DWWTSs and system design, operation and maintenance. Trends in public perception and behaviour towards the implementation of environmental policy and legislation, both national and international, have been captured and qualified from a socio-hydrological perspective. Results of this study are being used by myriad shareholders including local authorities and governmental agencies to effectively engage with the public prior to and during implementation processes via incorporation of values and perspectives relating to the meaning, value and use of water and wastewater. The study is among the first