

# The impact of on-site wastewater treatment for small community developments on groundwater quality

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## **Abstract**

The impact of de-centralised wastewater treatment systems for small community developments (so called cluster developments) on groundwater has been evaluated at separate developments in different areas of groundwater vulnerability. Four study sites were identified and boreholes were drilled upstream and downstream of the cluster developments (with different sampling depths in each borehole). Groundwater quality was monitored in these boreholes over an extended period of time. Interim results have shown increases in groundwater contaminants (particularly nitrates) downstream of the cluster developments. These increases have been identified as being directly associated with the density of the cluster development. Continued monitoring of the study sites will take account of seasonal variances such as agricultural practices and fluctuations in the groundwater table. These results have indicated that the density of cluster developments using de-centralised wastewater treatment systems does have an impact on groundwater quality and future developments should take this factor into account. A generic model linking the vadose zone subsoil processes and aquifer properties that can predict the impacts of cluster developments on groundwater quality must now be developed.

**Keywords:** De-centralised systems, Groundwater quality, On-site treatment systems, Cluster developments

## **INTRODUCTION**

Groundwater is an increasingly important resource in the Republic of Ireland. It is estimated that up to 40% of total water supply in the Republic of Ireland is taken directly from groundwater sources (Daly, 1993; EPA 1999). Increasing pressures on water supply, particularly in the east of the country have led to a projected shortfall in water supply over the next 5 – 10 years. One of the options being examined as part of the solution to meeting this projected shortfall is direct groundwater abstractions in counties Kildare, Meath and in the north Fingal region (Water Supply Project, 2010). It is also estimated that a new water tax will be introduced for all private residents within the next two years. This may lead to a proportion of homeowners switching their supply from public water mains to private groundwater sources. Given the current and projected reliance on groundwater as a source for drinking water in this country, it is therefore necessary to ensure that adequate protection is in place to ensure that groundwater sources are

maintained to a high standard and that they are kept free from sources of pollution. From an environmental perspective groundwater quality must also be protected particularly as significant Irish rivers receive significant baseflows from groundwater sources. In this regard Ireland also has an obligation under the European Groundwater Directive to maintain a high quality standard for its groundwater resources. The main sources of contamination to groundwater resources in Ireland are from a large number of small point sources such as farmyards and single on-site wastewater treatment systems (EPA, 2003) or dispersed pollution from agricultural practices. The new Code of Practice, Wastewater Treatment Systems for Single Houses (EPA, 2009), defines subsoil conditions such as thickness and permeability that will provide an acceptable level of treatment for on-site wastewater effluent in order to protect groundwater resources from contamination. Recent research carried out as part of the preparation of this code of practice has identified how treated effluent from different on-site treatment systems disperses into the subsoil through the percolation area and how pollutants are attenuated (Gill *et al.*, 2009). However, it is uncertain what the effects of higher hydraulic and contaminant loads generated by a cluster development or grouped development would be when discharged into a concentrated area. This project examines the effects of a number of cluster developments on groundwater quality. A number of groundwater quality parameters are being monitored upstream and downstream of each of these developments in order to ascertain the combined impact of effluent loading over the cluster area. The data collected during this research will then be used to develop a generic groundwater model which can then be used by the appropriate authority as a tool for the protection of groundwater quality for existing and future developments.

## METHODS

### Site Selection

In Ireland, aquifer vulnerability is defined according to the subsoil texture (clay, silt, sand, etc) from which the hydraulic conductivity is estimated and the subsoil depth. Hence, these two factors dictate the length of time that pollutants spend percolating through the unsaturated zone which is deemed to be proportional to their attenuation. Four sites were selected across the range of aquifer vulnerability types; extreme, high, moderate and low, as shown in Figure 1. Sites were selected following a detailed desk study and contact with relevant Local Authorities. The primary factors used to assess the suitability of potential study sites included the size of the cluster development, the underlying aquifer vulnerability and the subsoil percolation rate. Other key secondary selection criteria included the maturity of the development, existing boreholes or wells in the area and the proximity to surface water features. Each of the selected sites overlay aquifers either categorised as *regionally important* or *locally important*. The number of dwelling units contained within each of the cluster development study sites ranges from 12 to 21 and the density of these units also varies from site to site. Table 1 below provides a summary of the selected sites.

**Table 1 – Summary of Study Sites**

Site Location	Aquifer Description	Aquifer Vulnerability	No. Units In Cluster
Naul, Co. Dublin	Locally Important	Low	21
Rhode, Co. Offaly	Locally Important	Moderate	12
Faha, Co. Limerick	Regionally Important	Extreme	17
Carrigeen, Co. Kilkenny	Regionally Important	High/Moderate	14

## Instrumentation

Following the selection of the four study sites an initial survey of the sites was completed together with a review of available documentation. An initial estimation was then made as to the direction of groundwater movement. On this basis the locations for drilling the nested multi-horizon sampling boreholes were decided. The boreholes were drilled using a 203mm diameter Air Rotary Casing Hammer drilling rig. 52mm diameter piezometers were then installed at different depths in the aquifer the deepest being 5m into the bedrock. In addition some suction lysimeters were installed in the subsoil in the percolation areas of selected on-site systems at three different depths to assess the pollutant attenuation of the effluent percolating through the vadose zone.

## Sampling and testing

Samples have been collected from each of the study sites on a monthly basis and are then taken to the laboratory and tested for a number of water quality parameters including nitrates, total nitrogen, ammonia, phosphates, faecal coliforms and faecal streptococci with a number of parameters determined on-site including pH, electrical conductivity and temperature. Overall samples will be collected over a two year period in order to take account for seasonal variances such as agricultural practices and fluctuations in the groundwater table.

## RESULTS AND DISCUSSION

The monitoring of the four cluster development cluster sites is on-going. However, interim results have shown a general increase in the levels of some groundwater contaminants (particularly nitrates) associated with on-site treatment systems from the upstream sampling points to the

**Figure 1 – Locations of Study Sites**



downstream sampling points. The sampling of the percolating effluent through the unsaturated subsoil correlates with this groundwater data, showing good attenuation of phosphate and micro-organisms but distinct plumes of high nitrate concentrations moving down to the water table below. Continued monitoring will aim to determine the exact source of these contaminants and will model these results using groundwater flow software.

So far there does not seem to be a significant difference between the results from the sites of different vulnerability, which is surprising, and so further monitoring and modelling is required to fully ascertain the pollutant pathways and / or attenuation processes.

The increase in groundwater contaminants downstream of the study sites has shown that the density of on-site treatment systems is an important factor in the risk of groundwater contamination. As each of the developments were existing prior to this study and include a mix of new and mature on-site systems, it is not known at this stage whether the quality of installation of percolation systems was a contributing factor in the movement of groundwater contaminants into the aquifer. However, given the general increase in nitrate levels in the aquifers over a range of soil types and aquifer vulnerability ratings, it can be safely assumed that this was not a major factor and that the main pathway of nitrates into the aquifer was via the percolation areas.

## **CONCLUSIONS**

Groundwater is an important resource in Ireland and will play a vital role in the future water supply for the country. The density of on-site treatment systems discharging effluent to groundwater in cluster developments together with the subsoil conditions should affect future development planning. Cluster developments that are too dense may lead to groundwater contamination and thus pose both a health risk to groundwater resources and an ecological risk to surface water receiving baseflow from such aquifers.

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