Characteristics of on-site wastewater effluent in Ireland and implications of new European legislation

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Abstract
The results of detailed monitoring of several septic tank and packaged plant effluents at single house sites in Ireland have been characterised in terms of chemical and microbiological parameters as well as hydraulic loading. The measured hydraulic loads were significantly less than the assumed values used for design purposes, with average effluent production figures on the study sites of approximately 100 litres per capita per day. Equally, the concentration of typical on-site effluent is higher than that presumed by the new CEN standards, possibly due to the lower than average water use. The study has also ascertained typical concentrations of oestrogens and caffeine in such Irish on-site effluent, as well as the range of values for the Cl/Br ratios. Such ratios can be used in future studies to ascertain potential sources of on-site effluent groundwater pollution.

Keywords: septic tank, package plant, on-site wastewater

INTRODUCTION

Groundwater in Ireland is at risk from the increasing numbers of decentralized houses and their respective on-site wastewater treatment systems. Domestic wastewater from over one third of the population is treated by on-site systems and, with more than 25% of all water supplies provided by groundwater (EPA, 2005), the protection of groundwater resources from contamination by on-site effluent is imperative. Over the past 10 years several linked research projects have been carried out in Ireland investigating the fate of different effluent from septic tanks, packaged treatment plants, sand filters and reed beds discharging into different subsoils. The results of this work have had significant influence in the production of a new Code of Practice *Wastewater Treatment and Disposal Systems Serving Single Houses* (2009). The results of the treatment performance of these processes and subsoil have been detailed elsewhere, for example, nutrient attenuation in subsoils (Gill et al., 2009a), sand filter performance (Gill et al., 2009b) and reed beds (O'Luanaigh *et al.*, 2010). However, there are now a series of European standards on small wastewater treatment systems by the European Standards Committee (CEN) comprising seven parts which all EU members must comply with. Part 3 of the 12566 series (CEN 2005) deals with packaged and/or site-assembled domestic wastewater treatment plants. Part 3 does not specify an effluent quality for a septic tank but it does state that packaged plants have to be tested according to a specified influent range in order to gain the accreditation for their product (currently carried out at the test house in Aachen, Germany). Once tested, the performance against each one of these parameters must be recorded in terms of percentage removal and stated by the manufacturers. Hence, this paper investigates the typical on-site effluent quality being discharged by septic tanks and packaged treatment plants in Ireland and

compares these concentrations to the specified influent range used to test new package plants under the new CEN regime.

METHODS

In total, on-site effluent from 15 single house premises were investigated: 9 sites with effluent from septic tanks and 5 sites with effluent from secondary treated package plants (2 peat filters, 2 RBCs 2 BAFFs). All rainwater, surface water and runoff associated drainage had been diverted in accordance with the Code of Practice (EPA, 2009). The flow from the on-site systems was continually monitored using tipping bucket flow-gauges (Unidata, Australia) if the flow was by gravity or Ultrasonic flow monitors (Siemens Milltronics) in sumps if the effluent was subsequently pumped to the percolation area. Samples of the effluent were collected on average every two weeks at the different sites. Automatic samplers (Bühler Montec) were programmed to sample hourly to produce 24 hour composite samples. Samples were not taken of the influent to the septic tanks due to the sporadic nature of the quantity and quality of discharges from the various domestic wastewater sources (sinks, showers, baths, toilets, washing machine, dishwashers etc) which would have proved relatively meaningless to attempt to summarise. All samples were analysed for ammonium (NH_4), nitrite (NO_2), nitrate (NO_3), chemical oxygen demand (COD), orthophosphate (ortho-P) and chloride (Cl) as well as bromide (Br). All samples were also analysed for total coliforms and *E. coli*, with analysis also carried out for enterococci, faecal streptococci and faecal coliforms on some occasions. Analyses of 15N/14N ratio in the effluents were also made by continuous flow-isotope ratio mass spectrometry (Thermo Delta^{plus} CF-IRMS). Five Endocrine Disrupting Compounds (EDCs) were also targeted for analysis on selected samples based on their previously documented existence in domestic wastewater, variety in terms of source and also their likely persistence through the unit treatment processes and thus levels in the effluent: steroid oestrogens (oestrone, 17β-oestradiol, oestriol and ethynyloestradiol), organic oxygen compound (bisphenol A) and a consumer chemical product chemical (caffeine).

RESULTS AND DISCUSSION

The domestic wastewater generation measured on all sites was considerably less than the EPA design value, with the average per capita hydraulic load on each of the sites varying from 60 to 123 litres per day. The typical flow distribution characteristics of septic tank effluent discharge are shown as an example in Figure 1. The most common flow rates for over 85% of the time were between 0.1-1 L/min over the 18 month period with a volumetric mean flow observed for this period was 2.5 L/min indicating that the flow from the septic tank that needs to be evenly distributed between the percolation trenches was most often in the form of intermittent, small volume pulses.

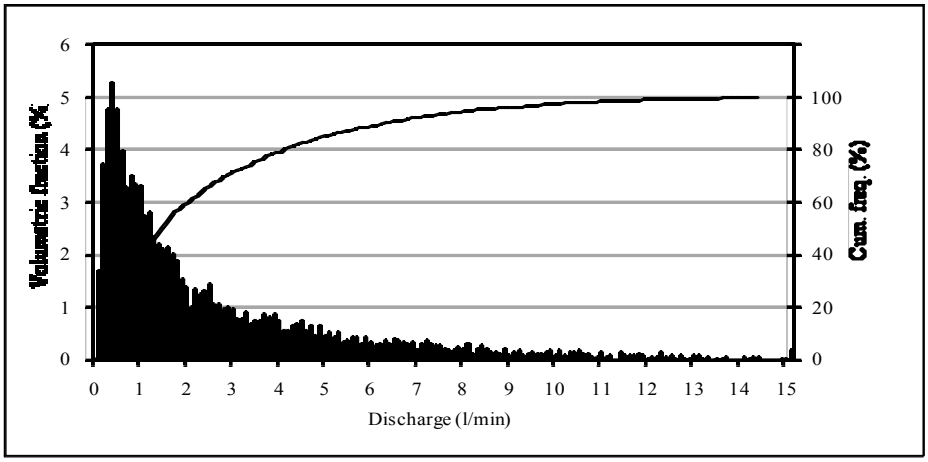

Figure 1. Typical flow distribution from a septic tank (based on volumetric fraction).

The range of mean values of standard wastewater determinants collected on site from the septic tanks are shown on Table 1. Further investigations into the time series between flow rates versus effluent quality on the septic tanks revealed an inverse relationship between flows and effluent concentration of COD, ammonia and orthophosphate, which is consistent with the fact that these soluble determinants are partly products of the anaerobic digestion of the solids in the tank.

Table 1. Range of means for septic tank effluent on site and back-calculated mean influent against CEN 12566 influent standards.

	COD (mg/L)	NH_4-N (mg/L)	TKN (mg/L)	Ortho-P (mg/L)	Total-P (mg/L)	Total coli. (cfu/100mL)	E. coli (cfu/100mL)
Site data	383-1322	44-117	61-162	8.2-32.5	9.6-38.2	2.9×10^6 – 2.9×10^9	1.2×10^6 – 5.6×10^9
Back-calc. Irish influent	478-1652	31-81	59-157	8.2-32.5	9.6-38.2	2.9×10^6 – 2.9×10^9	1.2×10^4 – 5.6×10^6
CEN 12566 influent	300-1000	22-80	25-100	-	5-20	-	-

As the influent sewage quality into the treatment systems was not monitored at any of the research sites due to the sporadic nature and diverse characteristics of discharges, information from the available literature concerning the performance and processes within septic tanks was used to back-calculate the likely influent values from the project effluent data, which could then be compared against the specified influent range set out in prEN 12566: Part 3 (CEN 2005). The comparison between the specified CEN 12566 influent range and project derived typical Irish influent data in Table 1 shows that for all quality parameters, the Irish influent is on the upper side of the range and in some parameters just above the range of assumed effluent quality required by CEN 12566. Hence, this has implications as to the relevance of the test (and corresponding award of CEN accreditation) for secondary treatment package plants being used under Irish conditions, i.e. whether they are being tested at high enough influent concentrations.

The $\delta^{15}N$ (‰) values for septic tank secondary effluent yielded some interesting information. The $\delta^{15}N$ values in the septic tank in both organic (2.5 ‰) and ammonium forms (4.9 ‰) were slightly enhanced with respect to the reference, as expected from waste products. The $\delta^{15}N$ values for secondary treated plant effluent showed slightly elevated inorganic forms of nitrogen (5.2 ‰) compared to the septic tank, probably due to ammonia volatization in the aerobic conditions of the package plant process Equally, the secondary effluent typically had more elevated organic nitrogen $\delta^{15}N$ values (8.5 ‰) indicative that the source for such organic fraction is from the biomass in the plant which has taken in the soluble ammonium nitrogen from the waste – i.e. it's not ammonium molecules in the household influent passing straight through the process.

The mean concentrations of oestrogens coming from septic tank were 21 ng/l (oestrone), 13 ng/l (oestriol) and 14 ng/l (17β-oestradiol). The effect of aerobic treatment on the oestrogens was clearly seen in the secondary treated effluent with mean values considerably lower (e.g. oestrone (4.4 ng/l), oestradiol (0.4 ng/l) etc). The Cl/Br ratio for septic tanks returned a range of values from 440 to 720. These values can be used to determine potential septic tank impacts on groundwater quality as the values in rainfall are normally considerably lower (150 to 300). The average concentrations of caffeine from the septic tank (32 µg/l) again compares in size to other studies but showed significant degradation with mean values in secondary plant effluent at 640 ng/l. Hence, the use of caffeine as a conservative indicator of on-site treatment effluent is questionable as it is obviously degraded in aerobic conditions.

CONCLUSIONS

The concentration of typical on-site effluent in Ireland is higher than that presumed by the new CEN standards, possibly due to the lower than average water use. The study has also ascertained typical concentrations of oestrogens and caffeine in such Irish on-site effluent. Finally, the range of values for the Cl/Br ratios have been established which can be used in future studies to ascertain potential sources of on-site effluent groundwater pollution.

REFERENCES

CEN (2005). Small wastewater treatment systems for up to 50 PT - Part 3: Packaged and/or site assembled domestic wastewater treatment plants. European Standard prEN 12566-3. European Committee for Standardization. Brussels, Belgium.

EPA (2005). Water quality in Ireland 2001–2003. Environmental Protection Agency, Wexford, Ireland.

EPA (2009). Code of Practice: Wastewater Treatment and Disposal Systems Serving Single Houses. Environmental Protection Agency, Ireland.

Gill L.W., O'Súilleabháin, C., Misstear, B.D.R., Johnston, P.M. (2009a). A comparison of stratified sand filters and percolation trenches for on-site wastewater treatment. ASCE J. Env. Eng., 135(1), 8-16.

Gill, L.W., O'Luanaigh, N., Johnston, P.M., Misstear, B.D.R, O`Suilleabhain, C. (2009b). Nutrient loading on subsoils from on-site wastewater effluent, comparing septic tank and secondary treatment systems. Wat. Res., 43, 2739-2749.

O'Luanaigh N.D., Goodhue R., Gill L.W. (2010). Nutrient removal from on-site domestic wastewater in horizontal subsurface flow reed beds in Ireland. Ecol. Eng., 36, 1266-1276.