FIELD SCALE ASSESSMENT OF CONTAMINANT TRANSPORT FROM AN ON-SITE WASTEWATER MANAGEMENT SYSTEM: RISK TO GROUNDWATER

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ABSTRACT

Municipal wastewater treatment plants service nearly 75% of New Zealand's current population with the remaining population (>1 million) relying on on-site wastewater management systems (OWMS) (GDH, 2021). This number increases throughout the year when those who typically dwell in reticulated wastewater urban areas visit peri-urban, rural or sensitive environments (e.g. holiday hotspots and national parks) where on-site wastewater systems are the only available treatment system. In New Zealand on-site wastewater systems range from servicing a single dwelling (e.g. rural home or holiday house) to a rural school, holiday park or marae with systems that can service several hundred people and experience the stress of high, variable and seasonal loads. Inadequate treatment, inappropriate land application systems, aging, poorly serviced and unmaintained systems, can result in a risk to environmental and public health. On-site wastewater systems can be located overlying shallow groundwater systems in which nearby shallow wells are utilised for drinking water, creating a potential public health issue.

The paper will present results from a pilot study tracer experiment conducted in Canterbury alluvial gravels from an on-site wastewater management system (OWMS) land application system (LAS) which allows the exploration of:

- the fate and transport of chemical and microbiological tracers within a newly formed LAS which has not yet been conditioned with human effluent.
- the risk to groundwater quality down gradient from the LAS as indicated by the microbial tracers.

For years to come this research site will provide an opportunity to monitor groundwater quality down gradient from a domestic on-site wastewater system testing five different design stages in one of New Zealand's most vulnerable and utilised groundwater aquifer types: alluvial gravels. The paper contributes to the knowledge of residence times within the unsaturated zone (vadose zone) of alluvial gravels which is crucial to understanding the fate and transport of chemical and microbial contaminants in the vadose zone where opportunities for removal occur. Information from the study site will assist and enable councils to determine

the impact of on-site wastewater systems on the environment and potential risks to drinking water and ultimately public health.

KEYWORDS

On-site wastewater, groundwater, contaminants public health

PRESENTER PROFILE

Bronwyn has 20 years' experience in the water sector, as a consultant, in council and as a researcher. She currently researches groundwater quality issues, with a focus on wastewater, and the impact on environmental and human health. She supports New Zealand councils, scientists, engineers and consultants with the latest land treatment research and technologies through the New Zealand Land Treatment Collective.

INTRODUCTION

The release of contaminants from on-site wastewater management systems (OWMS) presents a risk to groundwater quality and ultimately environmental and public health. Within a New Zealand context OWMS's are typically small point sources of contamination, scattered throughout rural and remote environments resulting in an impact that is difficult to quantify. Some locations throughout New Zealand however contain high density, clustered OWMS's such as unreticulated subdivisions and small towns. These higher density OWMS locations present an increased risk to groundwater quality and down gradient receiving environments.

To adequately assess the impact of on-site wastewater on groundwater quality it is essential to determine the chemical and microbial contaminant contribution from on-site wastewater management systems (OWMS). Accurately determining this contribution is difficult for a New Zealand context resulting in a reliance on international studies. Set-back distance guidelines (Moore et al., 2010) are considered too conservative in some subsurface media. Safe and realistic separation distance updated guidance is needed, hence the development of this study site.

It has been observed that microbial removal rates measured in porous media which have been repacked into columns or intact cores within a controlled laboratory environment differ from those measured in the field (Pang, 2009). In addition, it is widely recognized that removal rates measured in 'clean' aquifer material differs from aquifer material that has been conditioned with human effluent (Wall et al., 2008; Pang, 2009; Harvey et al., 2010; Sinton et al., 2010; Weaver, et al., 2013). This is due to the blocking of potential attachment sites on the surface of porous media by organic matter, which is abundant in domestic effluent. Over time this can lead to a decrease in the attachment rate and enhance the transport of micro-organisms (Schijven et al., 2017).

The use of chemical and microbial tracers to determine the fate and transport of contaminants sourced from OWMS's is a valuable evaluation tool. By applying the same method of delivery as a typical on-site wastewater land application system (LAS), chemical and microbial tracers can be applied to land with their fate and transport monitored via down gradient groundwater monitoring wells. The chemical and microbial tracers used should be conservative, stable, non-toxic to humans and the environment, easy to detect and should replicate the transport of the contaminants of concern (Richards et al., 2017).

The hypothesis is that chemical and microbiological tracers can be detected down gradient of an OWMS to determine flow paths along with their fate. The aims of this pilot study are to determine the concentration and flow paths of chemical and microbial tracers down gradient from a domestic OWMS land application system which has been newly formed and not yet receiving human effluent.

METHODS

The pilot tracer study site is located in North Canterbury and 13 groundwater monitoring wells support the investigation at the site (Figure 1).

Figure 1: A. Location of the study site in Eyreton, north Canterbury; B. Site layout.

For the tracer experiment the selected microbial (*E. coli* J6-2 and MS2 bacteriophage) and chemical tracers (potassium bromide, KBr) were mixed into a 200L tank of upgradient groundwater and applied to the LAS conventional trench (17m x 0.6m x 0.6m) (Figure 2) within approximately 6 minutes as a single tracer dose event. To mimic the dosing schedule of a real-life domestic OWMS 200L of upgradient groundwater (containing no tracers) was applied to the trench after the single tracer dose event morning and night for a period of 9 days. Samples were taken from down gradient groundwater monitoring wells throughout the tracer experiment and within three purpose built in-situ samplers that were installed at the base of the LAS conventional trench (Figure 3).

A description of the characteristics of the bacterial indicator organism *E. coli* J6-2 and the viral indicator organism MS2 bacteriophage can be found in Weaver et al. (2013). The propagation and enumeration methods Weaver et al. (2013) used were also replicated for this experiment. Bacterial counts (*E. coli* J6-2) were calculated as CFU per ml, and viral counts (MS2 bacteriophage) were calculated as plaque forming units (PFU) per ml. The detection limit was 1 CFU or PFU per ml.

Figure 2: A) 40mm diameter PVC delivery line incased in 100mm diameter Novaflo pipe, B) trench filled with AP20 washed river gravels, C) completed conventional trench covered with topsoil.

Figure 3: ESR designed in-situ vadose zone sampler.

RESULTS AND DISCUSSION

The results from the pilot tracer study show the variation in KBr breakthrough curves (Figure 4) from the three monitoring wells (EW11, EW12 and EW13) which were 2m down gradient from the conventional trench. The difference in KBr concentration in EW13 in comparison to EW11 and EW12 can most likely be attributed to the pump that was used to dose the conventional trench, which was not powerful enough to fully charge the delivery line for its full length. Based on field observations while logging the trench, it is assumed that the difference in KBr breakthrough curves for EW11 and EW12 can be attributed to the presence of a 100mm thick sand lens in the vicinity of EW11. This sand lens was well sorted, clearly visible within the trench profile and approximately 1m below the ground surface (below the base of the LAS trench, 0.6 m bgl). In contrast the sand lens was not present in the vicinity of EW12, rather the profile consisted of poorly sorted sandy alluvial gravels with pockets of highly permeable open framework gravels. It is assumed that the presence of the sand lens has slowed the transport of KBr through the vadose zone.

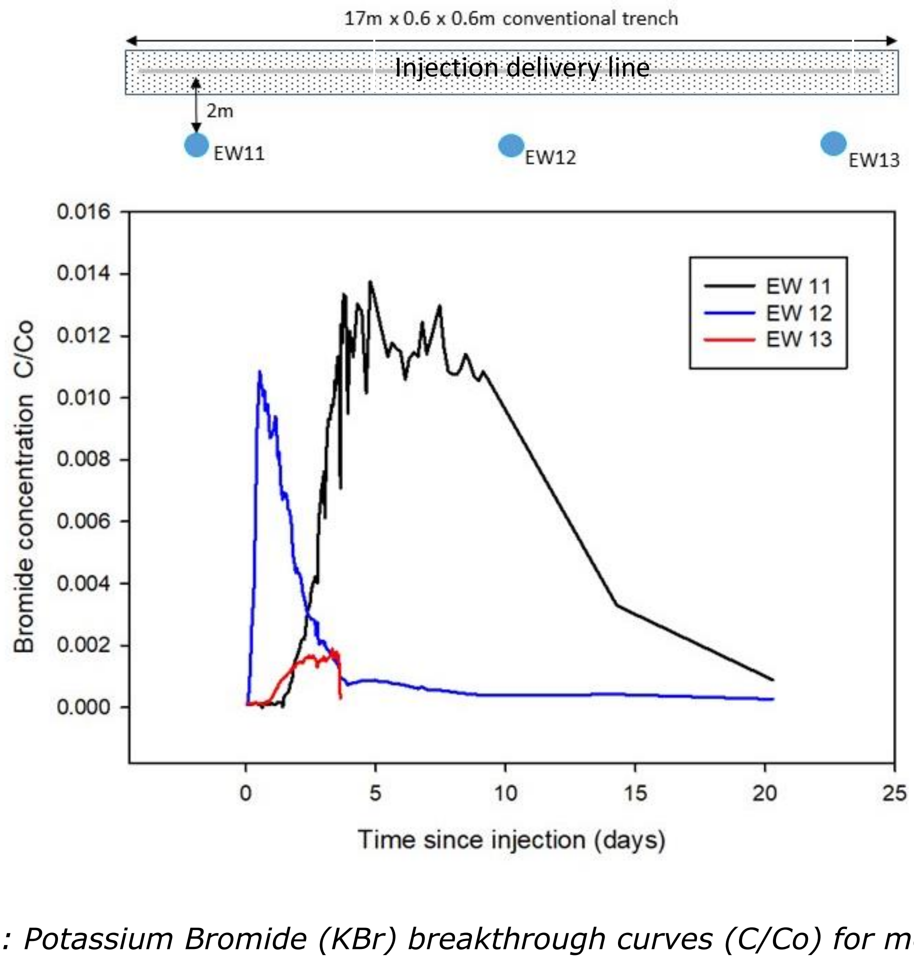

Figure 4: Potassium Bromide (KBr) breakthrough curves (C/Co) for monitoring wells EW11, EW12 and EW13 which were all 2 meters down gradient from the conventional trench.

The pilot tracer experiment results for the microbial tracers (*E. coli* J6-2 and MS2 bacteriophage) will be presented at the conference.

CONCLUSIONS

The pilot study results show the importance of on-site wastewater LAS placement to avoid the intersection with open framework gravels which are exceptionally permeable and have the potential to rapidly transport contaminants in groundwater. The results also highlight the heterogeneous nature of alluvial gravels over short distances which contain both sand lenses and open framework gravels. The pilot study also highlights the risk to shallow groundwater that is utilised for drinking water down gradient of on-site wastewater systems.

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