geoconvention
Virtual Event
September 21-23
2020
CSPG • CSEG • CWLS • GAC • MAC • IAH

Discharge of Landfill Leachate-Affected Groundwater Containing Emerging Contaminants into a Pond

Tammy Hua[1], Amila O. De Silva[2], Christine Spencer[2], Susan Brown[2], James E. Smith[1], James W. Roy[1,2]

1. School of Geography and Earth Science, McMaster University

2. Water Science and Technology Directorate, Environment and Climate Change Canada

Summary

Many thousands of closed landfills without liners or leachate-collection systems across Canada can potentially leak leachate-affected groundwater, which can then travel and discharge to surrounding surface waters and impair their associated ecological communities. However, there is limited understanding of the spatial and temporal variation in the risk posed to the aquatic ecosystems of the receiving waters, especially for landfill plumes that contain emerging contaminants, such as per- and poly-fluoroalkyl substances (PFAS), artificial sweeteners, and organophosphorus flame retardants (OPFR). Thus, the objective of this study is to improve our understanding of these spatio-temporal variations through detailed full-year measurements of a leachate plume containing emerging contaminants discharging to a small pond. Key areas of focus include spatial variation in composition of the leachate plume, seasonal variability in concentrations and mass flux (including winter and snowmelt) to and from the pond, and delineating zones of ecological risk (i.e., organisms living within, on, or above the sediments). Temperature based methods, in-pond piezometers, pond sediment interface electrical conductivity loggers, stream gauging, and head measurements were used to determine mass fluxes in and out of the pond. The principle findings thus far indicate that a leachate plume is most likely entering the pond from the northern portion along the east bank. Additionally, there is potentially ecological risk to endobenthic (living within the sediment; burrowing) , and epibenthic organisms (living on the sediment) as they are experiencing undiluted concentrations of landfill constituents.

Theory / Method / Workflow

The site contains a constructed retention pond that lies 40m west of a sanitation landfill that closed in 1970. A previous leachate survey conducted in 2018 sampled twenty closed landfills for emerging contaminants. Samples collected from the pond edge and nearby municipal wells at the site showed elevated concentrations of PFAS and OPFRs. PFAS and OPFRs are persistent chemicals that can bioaccumulate and cause adverse health effects in humans. PFAS and OPFRs also can be found in many manufactured goods that end up in landfills.Compared to other sites within the leachate survey in 2018, this pond had higher concentrations of emerging contaminants, and therefore motivated a more detailed investigation. Furthermore, there was evidence of groundwater seeps along the east bank which had biofilm, and iron staining suggesting landfill leachate influence. Previous sampling and visual inspection of the site provided evidence of a leachate plume that could possibly be discharging into the pond, and further investigation can provide understanding of spatio-temporal variations within the plume, and associated ecological impacts. Particularly, within the endobenthic, and epibenthic communities, which have not received much attention compared to surface water aquatic organisms.

Preliminary screening of samples of shallow groundwater, using analysis of chloride, ammonium, and the artificial sweetener saccharin, revealed a plume discharging to the northern portion of the pond along the east bank. Based on this data, locations of solution samplers used for seasonal shallow groundwater sampling campaigns (with analysis of standard chemistry plus artificial sweeteners, PFAS, and OPFRs), temperature rods, and pond sediment interface electrical conductivity (EC) loggers, were selected (Fig. 1). More specifically, the temperature rods contain a vertical string of temperature loggers beneath the sediment at discrete depths for groundwater flux calculations. Pond sediment interface EC loggers measure EC and temperature at the pond sediment interface to capture spatial variation within the water column. Saccharin is being used as a conservative tracer for landfill leachate, because it is persistent and commonly abundant in leachate (Roy et al., 2014). Additional information on the temporal and spatial variation in groundwater discharge to the pond is being determined using outflow stream gauging, continuous measurements of well and piezometer head level, and pond-bed temperature mapping. These will be combined with shallow groundwater concentration data to estimate contaminant mass fluxes throughout the different seasons.

Results, Observations, Conclusions

Results from a summer field campaign indicate many landfill constituents at potentially toxic levels occurring in the shallow pond sediments within the discharging plume footprint, presenting a risk to endobenthic organisms (Fig 2). There was substantial spatial variation in plume composition within the plume footprint (though note: analysis for PFAS and OPFR are still in progress). It is predicted that winter and spring melt will induce greater groundwater fluxes, and possibly increase the plume area extent, as well as increase contaminant mass flux into the pond. Several of the EC loggers placed within the footprint of the discharging landfill plume have shown high EC compared to locations outside the plume footprint. This indicates that both the endobenthic and epibenthic aquatic organism communities are experiencing exposure to landfill leachate constituents, possibly including the emerging contaminants. Intermittent sharp increases in EC were also observed, which may reflect increasing groundwater fluxes following rain events. Temperature mapping revealed areas where temperature near the pond sediment interface were cooler than surface water temperatures, therefore suggesting areas of groundwater discharging into the pond. It is expected that this study will reveal potential ecological impacts from landfill leachate plumes discharging to ponds and other non-flowing surface waters and provide guidance to landfill operators and regulators on improved monitoring protocols for such sites.

Novel/Additive Information

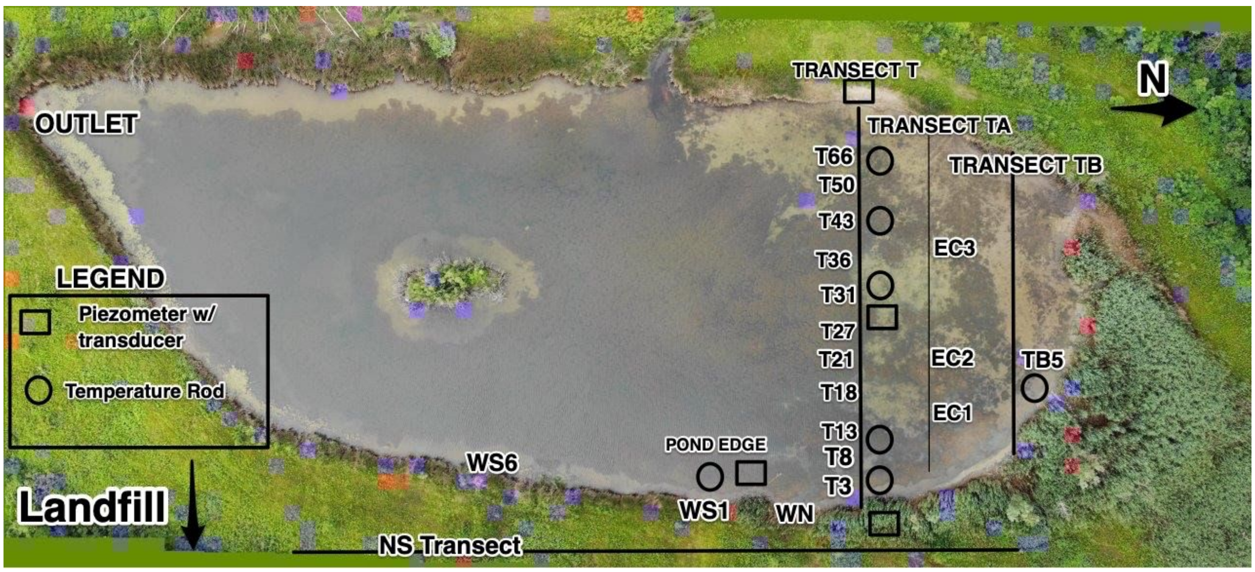

Figure 1: Map of study area and current instrumentation for long term groundwater monitoring. "EC" represents the electrical conductivity data loggers installed ~1 cm above the sediment surface. "T" and "WS"/"WN" represent the solution samplers used to collect shallow groundwater. Box and circles represent piezometer and temperature rod locations, respectively.

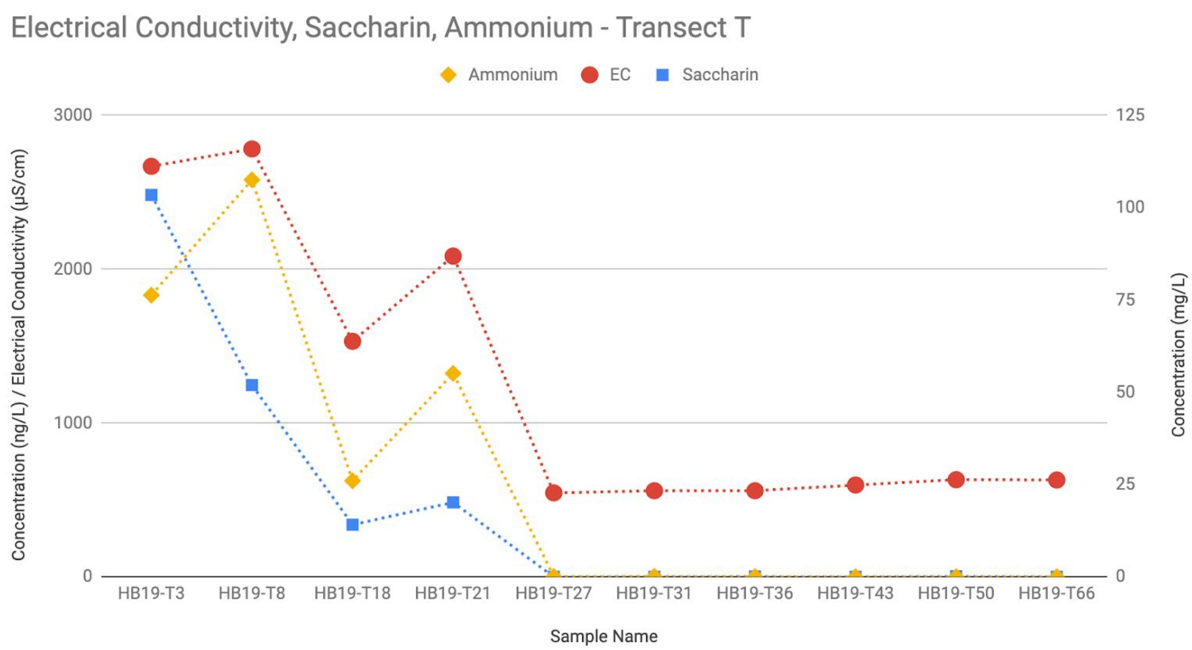

Figure 2: Concentrations of saccharin, and electrical conductivity of groundwater (right axis), and concentrations of ammonium (left axis) at each long-term monitoring site along transect T from the summer sampling campaign.

Acknowledgements

Funding provided by the Ontario Ministry of Environment, Conservation and Parks and Environment and Climate Change Canada. Field and lab assistance provided by Pam Collins, Grant Hodgins, Victoria Propp, Shuyang Wang, and Shannon James.

References

Roy, J. W., Stempvoort, D. R. V., & Bickerton, G. (2014). Artificial sweeteners as potential tracers of municipal landfill leachate. Environmental Pollution, 184, 89–93. doi: 10.1016/j.envpol.2013.08.021