Treatment efficiency of small-scale package plants in northern Sweden and Finland

2. Sewer and wastewater

Brenda Vidal[1] , *Juho Kinnunen*[2], *Annelie Hedström*[1], *Elisangela Heiderscheidt*[2], *Pekka Rossi*[2], *Inga Herrmann*[1]

[1] Luleå University of Technology, Department of Civil, Environmental and Natural Resources Engineering

[2] University of Oulu, Water, Energy and Environmental Engineering Research Unit

On-site wastewater treatment systems are used for treatment and disposal of domestic wastewater in areas where households are not connected to the municipal sewage network. Soil-based systems such as infiltration systems or sand filters have been traditionally used, although their contribution to phosphorus discharge into surface waters is still unclear (Envall et al., 2020). Alternatively, package plants have arisen as an attractive option in areas where there is a lack of space availability or sensitive receiving waters, or where bedrock, soil composition or fluctuating groundwater tables limit the implementation of soil-based systems (Vidal et al., 2019). Package plants are prefabricated treatment units based on widely applied bio-chemical wastewater treatment processes such as solids precipitation, aerobic/anaerobic biological degradation of organic matter and nitrogen, filtration, adsorption or chemical precipitation of phosphorus. Although using well-established processes, the treatment performance of package plants has not been comprehensively studied at full scale and the limited number of available studies and monitoring reports have shown that their performance varies greatly (Heinonen-Tanski and Matikka, 2017; Hübinette, 2009; Lehtoranta et al., 2014). The pollutant loads from on-site wastewater treatment systems are usually estimated based on the person equivalent (PE) discharge of organic matter and nutrients and it is often assumed that the treatment systems work as designed. However, the treatment efficiency is often poor due to construction errors, inadequate operation or maintenance, and the real discharge is expected to be much higher (Heinonen-Tanski and Matikka, 2017; Larsson et al., 2017; Olshammar et al., 2015; Vidal et al., 2018). Increasing restrictions and legal requirements on wastewater discharge by the authorities are putting pressure on property owners to install adequate facilities in order to minimize the risk of pollution and to protect receiving waters. While phosphorus removal has been traditionally studied due to its implications for the eutrophication of the Baltic Sea (e.g. Eveborn et al., 2012), the removal of nitrogen and the influence that a cold climate might have on the biochemical processes in package plants, has not been thoroughly studied.

This study focuses on the monitoring of existing package plants in northern Sweden and Finland of varying sizes (2-50 PE). In total, 22 package plants have been selected after an inspection campaign and sampled on five to ten times during a two-year period covering different seasons. The sampling campaign is planned to be finalized in June 2021. The selected units included batch reactors, activated sludge, trickling filters, combined with chemical phosphorus precipitation or alkaline phosphorus filters. The samples are collected using grab sampling of influent and effluent wastewater at each facility and analysed in accredited labs for biological oxygen demand (BOD_7), total phosphorus, phosphate-phosphorus, total and ammonia- nitrogen, nitrite/nitrate-nitrogen, dissolved organic carbon as well as the indicator bacteria *E.coli* and enterococci. To assess the effect of temperature on the treatment efficiency, temperature was continually measured in the studied package plants. The preliminary results show that BOD and phosphorus were generally removed to a satisfactory level, whereas nitrogen removal was poor in most facilities and pathogen inactivation varied depending on the treatment process.

Selected references

Envall, I., Fagerlund, F., Westholm, L.J., Åberg, C., Bring, A., Land, M., Gustafsson, J.P., 2020. What evidence exists related to soil retention of phosphorus from on-site wastewater treatment systems in boreal and temperate climate zones? A systematic map protocol. Environ. Evid. 9, 1–11. https://doi.org/10.1186/s13750-020-00205-9

Eveborn, D., Kong, D., Gustafsson, J.P., 2012. Wastewater treatment by soil infiltration: Long-term phosphorus removal. J. Contam. Hydrol. 140, 24–33. https://doi.org/10.1016/j.jconhyd.2012.08.003

Heinonen-Tanski, H., Matikka, V., 2017. Chemical and microbiological quality of effluents from different on-site wastewater treatment systems across Finland and Sweden. Water 9, 47. https://doi.org/10.3390/w9010047

Hübinette, M., 2009. Tillsyn på minireningsverk inklusive mätning av funktion [Inspection of package plants including measurement of functioning]. Report 2009:07. Västra Götalands county. (In Swedish).

Larsson, C., Forsberg, B., Engström, T., 2017. Uppföljande kontroll av nya små avloppsanläggningar [Follow up control of new small wastewater facilities]. Kungsbacka municipality, Environmental and Health Administration. (In Swedish)

Lehtoranta, S., Vilpas, R., Mattila, T.., 2014. Comparison of carbon footprints and eutrophication impacts of rural on-site wastewater treatment plants in Finland. J. Clean. Prod. 65, 439–446. https://doi.org/10.1016/j.jclepro.2013.08.024

Olshammar, M., Ek, M., Rosenquist, L., Ejhed, H., Sidvall, A., Svanström, S., 2015. På uppdrag av Havs-och vattenmyndigheten Uppdatering av kunskapsläget och statistik för små avloppsanläggningar [The state of knowledge and statistics for small sewage plants. Swedish Agency for Marine and Water Management]. Report 166. Norrköping. (In Swedish).

Vidal, B., Hedström, A., Barraud, S., Kärrman, E., Herrmann, I., 2019. Assessing the sustainability of on-site sanitation systems using multi-criteria analysis. Environ. Sci. Water Res. Technol. 5, 1599. https://doi.org/10.1039/c9ew00425d

Vidal, B., Hedström, A., Herrmann, I., 2018. Phosphorus reduction in filters for on-site wastewater treatment. J. Water Process Eng. 22, 210–217. https://doi.org/10.1016/j.jwpe.2018.02.005