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Changing organic matter stability and redox state govern contaminant mobility in landfills – An experimental landfill simulation reactor study.

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Contaminant emissions from landfill waste are a threat for the environment and human health. In the Netherlands, current regulation demands landfills to be isolated from the environment by means of protective barriers. Although effective, these barriers limit waste decomposition. The landfills' contamination potential is thus preserved which leads to the regulatory requirement of indefinite aftercare. A sustainable alternative has been proposed, based on active treatment of the waste by aeration and leachate recirculation (Ritzkowski & Stegmann, 2012; Wang et al., 2006). Active treatment aims to increase waste decomposition, and to flush out or degrade contaminants. The remaining waste is expected to be more stable and enriched in binding sites, improving leachate quality. When the latter can be improved to such an extent that it complies with environmental protection criteria, the landfill can become exempt from indefinite aftercare (Brand et al., 2016).

To determine whether active treatment reduces contaminant emissions, understanding contaminant solid:liquid partitioning is essential. Yet, in-situ sampling of landfill solid waste is technically challenging. Therefore, 16 Landfill Simulation Reactors (LSRs) filled with 30 kg (dry wt.) waste were operated for >1.5 years. The organo-geochemistry of the leachate, pore water and solid waste affected by leachate recirculation and aeration was closely followed. In Figure 1a-b, the dynamics of contaminants with affinity for organic matter binding are shown for the leachate of a LSR where operational conditions were switched from leachate recirculation under anaerobic conditions to aerobic conditions without leachate recirculation. Evident is the strong relation between Cr, Sn and DOC. Surprisingly, Cu, normally largely controlled by organic matter (Ren et al., 2015), follows an opposite trend and its mobility appears to be more related to redox conditions. In Figure 1c-d, contaminants whose biogeochemistry is largely controlled by redox conditions are shown. Evident is the trade off in contaminants of concern. While for the priority contaminant NH_4^+ concentrations drop after aeration starts, the concentration of Cu, Fe and Mn peak together with S. The results exemplify the interaction of processes that govern contaminant mobility in landfills and help us assess if active treatment is a sustainable alternative to current landfill management.

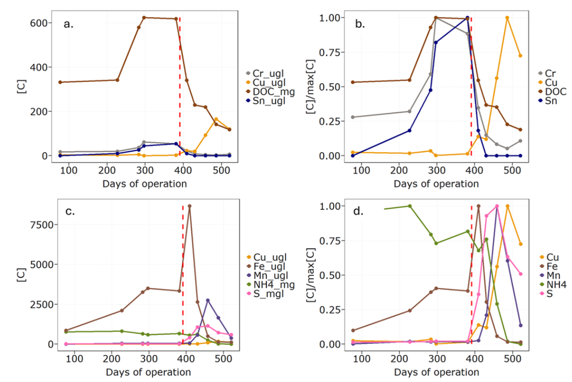

Figure 1: The dynamics of a selection of the measured elements in the leachate of one of the 16 operated landfill simulation reactors (LSR). Panels a. & c. show the absolute measured values of the selected elements. Panels b. & d show a normalized value where the measured element concentration is divided by the maximum measured element concentration during LSR operation. The red dotted line indicates the moment (391 days after start of operation) when operational conditions were switched, from leachate recirculation under anaerobic conditions to aerobic conditions without leachate recirculation.