Survey on per- and polyfluoroalkyl substances in leachates and treatment processes in waste landfill site

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INTRODUCTION

Per- and polyfluoroalkyl substances (PFASs) have been manufactured and used in various industries around the globe since the 1940s. Among them, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) have been the most extensively produced and used. Both chemicals are listed in Annexes A (Elimination) and B (Restriction) of the Stockholm Convention on Persistent Organic Pollutants due to their degrees of toxicity, stability, bioaccumulation, and long-range transportation. Much research has focused on PFAS concentration in water and the atmospheric environment. However, although these substances are present in landfill leachates, especially in industrial waste landfill (IWL) leachates, the treatment water of each leachate treatment plant process in landfills remains largely unstudied. In this study, the homology patterns of PFAS in landfill leachates and the changes in PFAS concentration before and after leachate treatments are analyzed.

MATERIALS AND METHODS

Three leachate samples from two municipal solid waste landfills (MWL) and three leachate samples from one IWL were collected six times between September 2019 and January 2021. Water samples from the leachate treatment plants at each landfill were collected three times. One to one hundred milliliters of each sample were used for PFAS analysis. The samples were adjusted to pH 3–4, and stable-isotope labeled reagents were added (Wellington Laboratories). Samples were then flowed into an Oasis WAX cartridge (Waters) and extracted with 0.1%-ammonia methanol. These extractions were concentrated by an N_2 gas purge and then analyzed by liquid chromatography with tandem mass spectroscopy (SCIEX).

RESULTS AND DISCUSSION

The concentrations of each PFAS homolog in the leachates are shown in **Figure 1**. The PFAS concentrations in the leachates from the IWL were higher than those from the MWL. Levels of PFCAs, including PFOA, tended to be higher than other PFSAs, including PFOS, consistent with results obtained by advanced studies on MWL in North American and European countries, as well as China.

Changes in the PFOA and PFOS concentrations of each industrial landfill plant process are shown in **Figure 2**. The mean PFOA and PFOS removal values by the flocculation treatment were 20% and 24% in IWL, and 42% and 66% in MWL, respectively. The mean PFOA and PFOS removal values by the active sludge processes

were 46% and 57% in IWL, and 12% and 24% in MWL, respectively. The means of PFOA and PFOS removal values by the activated carbon treatments were over 95% in all landfills. PFAS removal values by a reverse-osmosis membrane process could not be estimated, as nearly all PFAS were removed in the activated carbon treatment. These results suggest that activated carbon treatment was effective for PFAS removal from leachates.

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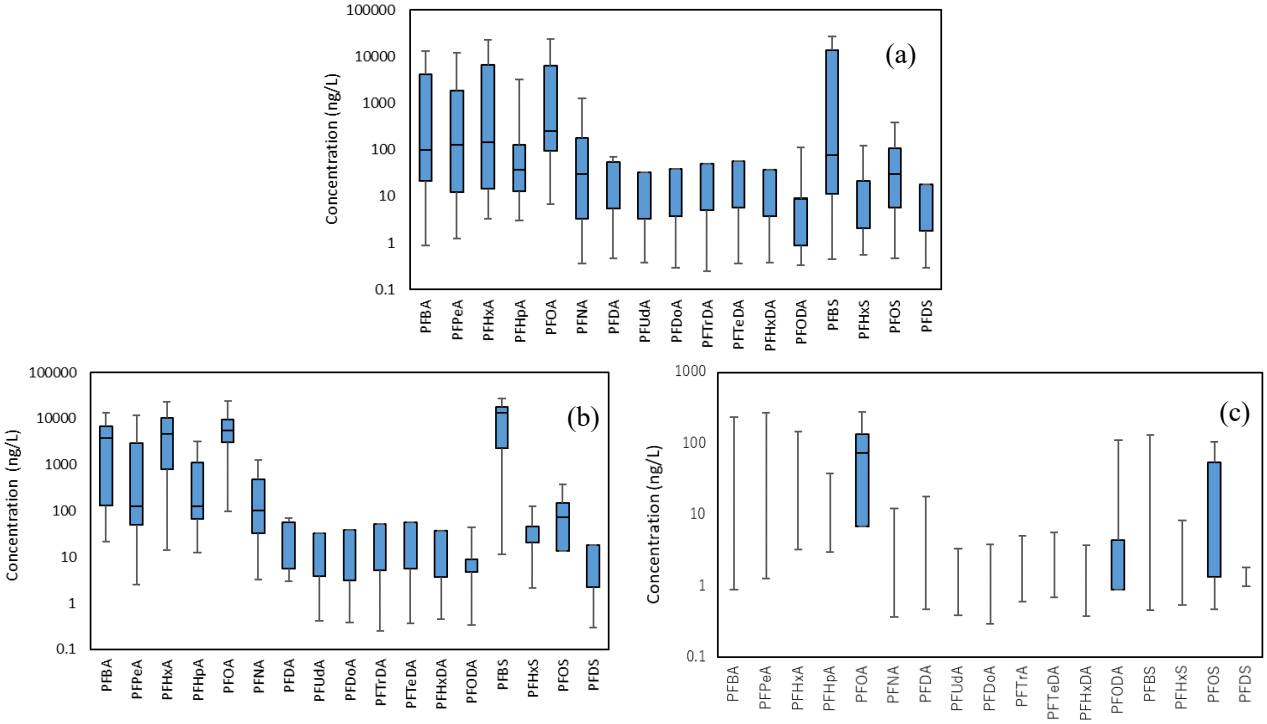

Fig. 1 PFAS concentrations in landfill leachates.
(a): Leachates in IWL and MWLs; (b): leachates in IWL; and (c): leachate in MWLs.

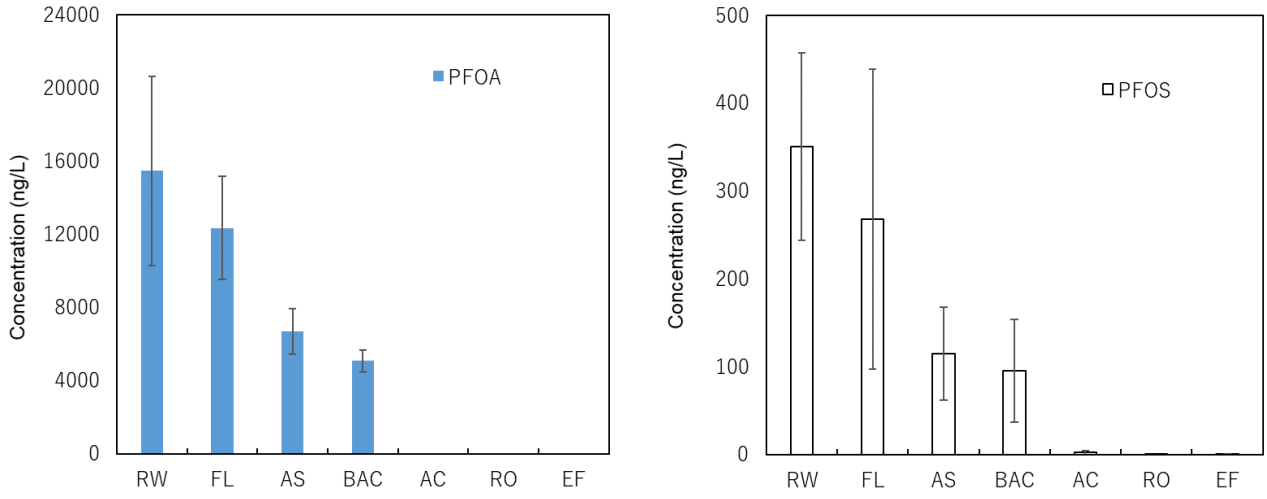

Fig. 2 Changes in PFOA and PFOS at each process in the industrial landfill leachate treatment plants.
RW: raw water; FL: after flocculation treatment; AS: after activated sludge treatment;
BAC: before activated carbon; AC: after activated carbon; RO: after RO membrane treatment;
EF: Effluent.