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Microplastics in a UK Landfill: Developing Methods and Assessing Concentrations in Leachate, Hydrogeology, and Release to the Environment

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Inadequate management of plastic waste has resulted in its ubiquity within the environment, and presents a risk to living organisms. Harm caused by large plastics is well documented, but progressive understanding of microplastics (< 5mm) reveals an ever more unsettling issue. Microplastics contamination is considered an emerging global multidisciplinary issue that would be aided by further research on sources, distribution, abundance, and transport mechanisms. Landfills are a suspected source of such, but research at these sites is insufficient. Although the risks surrounding microplastics are still inconclusive, there is concern over their accumulation in organisms, leaching constituents, and hydrophobic nature. Studying microplastics in the environment, let alone landfill, is challenging as standard and accepted methodologies are presently non-existent.

Here, microplastics (1mm to 25µm) were evaluated at one particular and long-running UK landfill after first developing a simple, replicable, efficient, and cost effective sampling and analysis approach. Concentrations and types of microplastics were quantified in raw leachate, treated leachate, waste water, groundwater, and surface water, to characterise abundance, distribution, and released loads to the environment. Samples were filtered in-situ, with subsequent purification at the laboratory by Fenton's reagent. Analysis relied heavily on microscopic sorting and counting, but use of Scanning Electron Microscopy – Energy Dispersive X-Ray Spectroscopy enabled instrumental interrogation of particles suspected to be plastic. Many factors investigated here appear novel to the literature, and comprehensively explore: temporal variation of microplastics in raw leachate across different landfill phases and waste ages; their abundance in local groundwater, and surface water discharge; microplastics distribution within a leachate treatment plant; and their subsequent release to the environment from a waste water treatment facility. The results build upon the small collection of existing work, but also offer new insights into microplastics' occurrence in, around, and released from a landfill site.

In total, 62 samples were taken, and particles considered microplastics (MP) were most abundant in groundwater, followed by raw leachate > waste water > treated leachate > surface water.

Average concentration in groundwater was 105.1±104.3 MP L^{-1}, raw leachate 3.3±1.7 MP L^{-1}, and waste water was 1.8±0.73 MP L^{-1}. Consistent with other research, fibres were most dominant, but blank samples highlight the great potential for secondary contamination. Imaging of suspect particles revealed the extreme nature and conditions of landfill sites in their generation of microplastics. Analogous to waste water treatment, leachate treatment is shown to be reducing microplastics in the discharge by 58.1%, and it is expected that microplastics are retained in the treatment plant sludge. Daily loads from leachate treatment were 142,558±67,744 MP day^{-1}, but from waste water this was approximately 45.2±18.3 million MP day^{-1}. Ultimately, the landfill is not a final sink of microplastics but a source, for those >25 μm, to the environment: yet, it is unlikely to be a significant one. Results highlighted the need for reduction strategies at waste water treatment plants and in the site's groundwater boreholes, as well as further investigation to determine the source of abundant fibres in the surface water.