**University of Leicester**

**College of Life Sciences /College of Science and Engineering**

**HPRU Grant studentship**

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**Section 2 – *Project Information***

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| **Project Title** | **Predicting Odorous Events: AI-Enhanced Sensor Networks for Public Health Protection near Landfills**  |
| **Project Summary**  |
| **Project description** **Current Position** Landfill sites are often associated with unpleasant odours1. The EA has acknowledged that the most serious pollution incidents are often associated with permitted non-hazardous waste sites receiving gypsum. Its presence in landfills can result in elevated levels of sulphates which can be broken down by anaerobic bacteria to release hydrogen sulphide (H₂S) and other sulphur-containing compounds, such as mercaptans, as by-products. These compounds are volatile and have very low odour thresholds, creating malodorous events. At some landfill sites, such as Walley’s Quarry in Staffordshire, these events have been protracted and have resulted in substantial public disquiet and health concerns.  Scientists in the EA and UKHSA have been investigating this high-profile site because of recurrent odour annoyance episodes. A primary challenge for public health professionals is understanding the processes contributing to fugitive emissions of malodorous compounds. Initial investigation using synoptic charts showed an association between elevated H₂S levels and particular meteorological conditions. It has also been hypothesised that Katabatic flows associated with cold air drainage, where cold, dense air containing H₂S moves down topographic gradients towards adjacent homes, could exacerbate odour issues, but this needs further investigation.  A better understanding of these environmental controls should allow more accurate forecasts of fugitive gas emissions and dispersion, leading to an improved odour event warning system and improved landfill management. Predictive understanding has been limited by a lack of spatio-temporal data on the concentrations of key compounds. Conventional *in-situ* monitoring typically relies on a few expensive sampling stations. This project aims to address this by deploying a larger number of relatively low-cost sensors across and around landfill sites to yield data at a much higher spatio-temporal resolution.  Electrochemical sensors based on molecularly-imprinted polymer (MIP) technology are being developed at the University of Leicester. This PhD project aims to improve our understanding of fugitive landfill gas dynamics by deploying these sensors in the field, along with collecting spatio-temporal meteorological data. Artificial Intelligence (AI) will be used to unpick the complexity of existing relationships to better-predict when future odorous episodes will occur and to quantify the corresponding H₂S/CH₄/mercaptan concentrations. This information will assist public health professionals in producing early alerting advice, support input data for public health risk assessments as a potential impact for the HPRU.  **Work Package 1: Sensor Array Calibration and Validation** Rigorous testing of the MIP-based micro-sensor array in outdoor conditions. The array will be systematically calibrated against certified gas standards of H₂S and key mercaptans in controlled laboratory and outdoor settings to determine its sensitivity and selectivity. The sensor array will then be co-located with high-precision reference instruments within the UKHSA air monitoring trailers to validate its performance.  **Work Package 2: Landfill Deployment and Data Collection Campaigns** Deploy calibrated sensor arrays at and around a UKHSA-selected landfill site for long-term, autonomous data collection. A strategic network of sensors will be established to capture high-resolution spatio-temporal data on malodorous compound concentrations time-registered to meteorological data.   **Work Package 3: Machine Learning Malodour Prediction Modelling** Leverage the collected sensor and meteorological data to develop data-driven predictive models using machine learning. Classification and regression algorithms will be trained to identify the complex relationships between forecasted weather predictors (e.g., wind speed, wind direction, temperature, atmospheric pressure), landfill site intrinsic/distinct/characteristic variables, and the fugitive emission of malodorous compounds.  **Work Package 4: Spatiotemporal Analysis of Malodour Dispersion** Analyse high-resolution data from the sensor network and develop computational fluid dynamics (CFD) dispersion models to understand the transport and dispersion dynamics of malodorous plumes from the landfill. The analysis will create dynamic maps to visualise how emissions move through the local environment under different meteorological conditions, such as cold-air drainage (e.g., katabatic flows), to explain how pollutants accumulate in nearby residential areas.  **Work Package 5: Prediction Model Validation and Public Health Application** Independently test and refine the predictive models developed in WP3. The model's forecasts will be systematically compared against new, unseen observational data from the sensor array to quantify its real-world accuracy and reliability. Based on this validation, a framework will be developed to translate the model's outputs into actionable, collaborative early-warning alerts for public health professionals and the local population, demonstrating the project's practical impact.  |