Highly Sensitive and Quantitative Measurements of Atmospheric Methane with On-the-fly Rapid Data Handling for UAV based monitoring

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Abstract:
Monitoring of the hazardous and toxic gases in landfill sites adjacent to highly urbanised areas, where huge amount of toxic, hazardous and explosive gases is produced on daily basis, has become obligatory in recent days. Quantitative measurement of fugitive release of methane gas in the real conditions are always challenging because of continuous change of the sample concentrations with meteorological conditions. Optical sensors based on nondispersive infra-red (NDIR) spectroscopic technique with automated on-the-fly data handling competency offers fast responsive and real time data producing potency to deploy for this purpose. In this work, we design a highly sensitive NDIR spectroscopy based detection system of atmospheric methane gas with rapidly pulsed IR LED (ca. 2 μs pulses with a typical repetition rate of 1 kHz) at 1.65 μm wavelength using field programmable gate array (FPGA) based microcontroller for flexible pulse generation and data processing facilities. The proposed detection system was deployed for measuring the concentration of atmospheric methane gas at McRobies Gully Waste Management Centre of Hobart City Council which is located within ~500 meter periphery from the urban community. Measurement of methane was undertaken through discrete point sampling within 10X10 meter grids and methane concentrations were recorded as quasi-continuous data with time where 0.5% to 2.75% methane were reproducibly quantified within the sampling area with a typical precision of ±0.05%. All the data were processed and stored automatically in the SD card of the microcontroller and retrieved at the end of the measurement. The system was calibrated in the lab using pure methane gas (~99.0%) before and after the real-world application. The limit of detection (LOD) of the investigated detection system was 300ppm (0.03%) methane. This detection system presents so far, the most sensitive and quantitative in-filed measurements of methane and each of the individual methane concentration data points is associated with GPS coordinates, allowing 3D terrain mapping of the data. It offers not only portable and fast response for real time measurements but also possess future potential for atmospheric trace gas analysis from a remote platform such as, unmanned aerial vehicle (UAV).