Low-cost spark-induced breakdown spectroscopy for real-time characterization and source identification of toxic metals

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***Abstract*:**

Real-time characterization of airborne toxic metals is crucial for air quality monitoring, particularly for environmental justice communities disproportionately impacted by Hazardous Air Pollutants. While conventional methods like X-Ray Fluorescence (XRF) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) offer high accuracy, their significant cost and operational complexity limit widespread deployment. To address this, we developed the Toxic-metal Aerosol Real-Time Analyzer (TARTA), a low-cost instrument based on Spark-Induced Breakdown Spectroscopy. This system has demonstrated Limits of Detection comparable to commercial XRF systems at approximately 1/80th of the price.

In this work, we present key hardware and software advancements to further improve the performance and portability of the system. Structurally, an air pulling system was integrated into the nozzle assembly to minimize particle loss and enhance particle collection efficiency. Furthermore, spectrometer exposure time was optimized to minimize background noise, enhancing the signal-to-noise ratio (SNR). On the software side, a source identification algorithm was implemented to enable real-time determination of pollution origins alongside elemental concentration. Additionally, the system transitioned to an onboard Raspberry Pi to simplify field operation. These improvements significantly enhance the robustness and portability of TARTA, providing an accessible tool for communities to rapidly identify and respond to hazardous emission events.

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