ADVANCEMENTS IN ATMOSPHERIC PARTICULATE MATTER MEASUREMENT USING FAST-SCANNING LIDAR

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Keywords: Dust mitigation, LiDAR, Atmospheric Physics, Aerosols, Atmospheric particulates

1. Introduction

Mining operations are essential for meeting global resource demands but encounter environmental challenges, notably dust generation, which poses risks to human health and ecosystems (Yadav & Jamal, 2018). Effective dust control is paramount in mining operations, especially at mine sites near a regional township, due to health impacts, environmental concerns, and regulatory compliance. Dust from mining activities contains particles such as those from coal, overburden, and drillings. These particles can disperse beyond the mining perimeter, affecting air quality, soil composition, and vegetation health.

This study investigates the use of water application at a mine site for dust mitigation, focusing on the temporal aspect. Combined with dustiness characterization, this information could optimize effectiveness in the future. By exploring the immediate temporal dynamics following water application, the study contributes valuable insights to sustainable mining practices.

2. Dust Control Methods

Traditionally, water carts spray water onto dusty areas to suppress particulate matter (Colinet, Halldin, & Schall, 2021). Currently it is human observation that determines when to apply water. There are some guidelines that >2 litres/m²/hr will supress dust (Katestone Environmental Pty Ltd, 2011). The efficiency of this approach depends on various factors, including meteorological conditions, soil composition, and frequency of application.

3. Methodology

This study utilises a LiDAR system design by UoN to explore the impact of the timing of water application on dust suppression effectiveness, emphasizing immediate dust suppression and temporal dynamics Field observations capture real-world conditions, which are essential for understanding dust control effectiveness. Meteorological variables like wind speed, temperature, and humidity were monitored concurrently. Experimental methods were employed to identify optimal revisit intervals for water cart deployment.

4. Results and Discussion

Field observations captured the real-world conditions essential for understanding dust control effectiveness. Figure 1 illustrates a haul truck with a dust plume, immediately in the volume of air above it.

Figure 1 Haul truck with dust plume from vehicle movement.

During the LiDAR scanning period, samples were collected from both the water cart wetted area and an adjacent unwetted/dry region. Laboratory analysis quantified the moisture content and Dust Extinction Moisture (DEM) of these samples (Australia, Standards, 2016). The primary objective was to determine the difference in moisture added to the soil by the passing water cart.

The LiDAR scans measured dust emission intensity before and after water application, providing a detailed temporal view of dust suppression. The temperature at the time of the scans was 32 degrees Celsius, with wind speed and direction detailed in Figure 2.

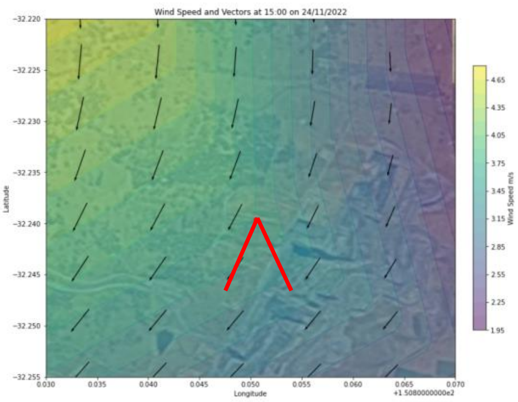

Figure 2 Wind speed and direction for the area scanned by LiDAR (scan area red).

Statistical comparisons and graphical representations with meteorological data (Figure 2) supported this qualitative image.

The analysis showed that the dust number for the dry sample was 850 with a moisture content of 4.6%. In contrast, the wetted sample had a significantly reduced dust number of 1.2, correlating with a higher moisture content of 12.7%. This relationship is depicted in Figure 3. While the data indicates sufficient moisture to minimise dust emissions in the sample, it does not show duration of effectiveness,

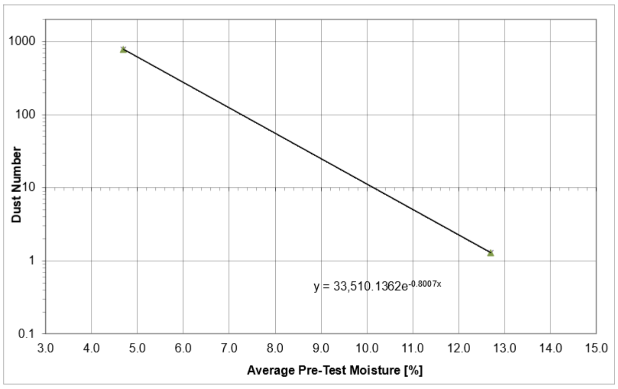

Figure 3 DEM testing of haul road before and after water implementation.

LiDAR scans (Figure 4) showed minimal dust immediately after the water cart passage, with dust levels increasing slightly after about 5 minutes. The scans were conducted immediately after the water cart application, covering a 50-degree arc and taking 15 seconds to complete, scanning from left to right or vice versa. These conditions suggested that most of the water evaporated within 5-6 minutes, forming a temporary dust cap on the surface.

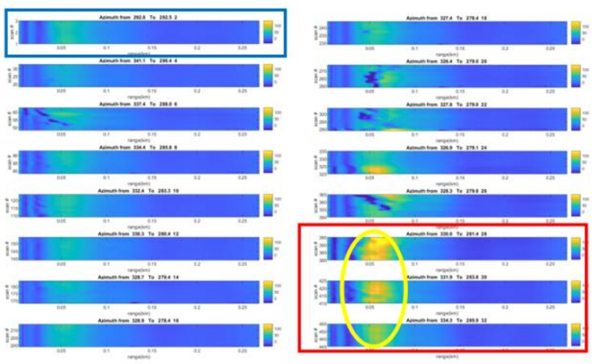

Figure 4 LiDAR signal just after water cart (blue) with no dust, and dust starting to generate after 6 minutes (red).

Figure 4 indicates the immediate reduction in dust concentration following water application, followed by a gradual increase over time. The initial scans showed minimal dust, with slight increases observed as the water began to evaporate. This temporal data is crucial for understanding the short-lived effectiveness of water applications under specific environmental conditions.

Examination of the bulk haul road sample revealed that the water created a cap of approximately 40mm on the surface, which mixed with the underlayer when sampled. Although the aim was to capture only the cap material, the slight mixing with the underlayer during sampling likely reduced the measured moisture content, resulting in a moisture level of the cap layer to be higher than the measured 12.7%. It is possible that heavy machinery, such as haul trucks, could disrupt this top wetted layer before it stabilized, leading to a premature and/or immediate return of dust.

To optimize dust control, it is essential to adjust the frequency of water applications and consider supplemental measures such as using binding agents or optimizing traffic flow to allow the water to settle adequately. Economic considerations, including the cost-effectiveness of the route optimization strategy, are a major factor. Potential savings in water usage, maintenance costs, and overall efficiency of mining operations must be considered.

5. Conclusions

The study highlights the need for continuous improvement and adaptation to evolving environmental and operational contexts. The present focus has been on understanding temporal dynamics and implementing a route optimization strategy based on real-time observations. However, integrating machine learning algorithms for predictive route optimization based on historical data and prevailing meteorological conditions could provide deeper insights into these dynamics.

6. References

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