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# Effectiveness of applying dust suppression palliatives on haul roads

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## ABSTRACT

Dust emissions from mining activities and their impact on the surrounding environment have been and remain one of the major environmental impacts associated with surface mining. Dust emissions caused by the transportation of mined material on surface mines are the most significant contributor. In previous studies, as much as 93% of total dust emissions were found to be associated with this activity. Dust emissions not only have a negative environmental impact, but also impact on vehicle maintenance and operating costs, and can affect the health of the surrounding communities. A controlled study was conducted on haulage roads to assess the efficacy of using a lignosulphonate-based dust palliative, compared with a water-only strategy to suppress dust. A section of road that is representative of a typical mine haulage road was chosen for the study. The road was divided into two sections: one section was treated with water only and the other section was treated with a lignosulphonate-based dust palliative. The water-only method was used as the baseline for the study. Operational parameters influencing haulage road dust emissions were monitored and data concerning vehicle frequency, water usage, product application frequency and dust fallout were recorded. Dust fallout on the individual test sections was measured over the study period using non-directional dust buckets, and real-time dust concentrations were measured using a personal Data Ram (pDR).

The study results showed that the application frequency required decreased by 50% when the road was treated with a ligno-sulphonate-based dust palliative. The water usage associated with this palliative reduced by 50.2% and dust fallout by 53.8%. From the study the financial impact of savings on the maintenance, running and fuel cost of vehicles associated with dust suppression was calculated and found to result in a net saving of 30% when using a lignosulphonate-based dust palliative. It was concluded that using a lignosulphonate-based dust palliative can reduce dust emissions originating from haulage roads and the associated operating cost when compared with a "water only" scenario.

## INTRODUCTION

Dust emissions caused by surface mine activities can impact environmental, health and safety aspects and can lead to increased production downtime, as well as increased maintenance costs. Dust emission caused by the transportation of mined material ore on surface mines is the most significant contributor. In a study conducted by Thompson & Visser (2001), results indicated that as much as 93.3% of total dust emissions were associated with the transportation of mine material. Dust emissions generated by the haulage of mined material are dependent on the erodability of the haulage road, wearing course and the erosivity of the actions that the haulage road is subjected to (Thompson and Visser, 2007).

Haulage road dust emissions contain a full spectrum of dust particles, referred to as total dust (all airborne particles) (Du Plessis and Belle, 2014). In ambient air $PM_{10}$ measurements, which contain particulate matter with a 50% cut-point of 10μm, as well as $PM_{2.5}$ measurements, which contain particulate matter with a 50% cut-point of 2.5μm, are used. In simple terms, this means that 50% of all 10μm and smaller particles are collected.

Dust emission particles smaller than 10μm pose a health risk as they do not get trapped in the upper respiratory tract but travel down to the alveoli and increase the potential for chronic health implications in affected individuals (Sahu and Panda, 2013). The generation of respirable dust particles on opencast mines has been shown to be associated with irreversible diseases such as lung cancer and silicosis (Kumari et al., 2011). In addition, the suspension of dust particles also impacts mine worker safety negatively by reducing visibility to the extent that it becomes dangerous to operate mine haulage trucks. Sources of air pollution originating from mines include carbon and particle emissions from transport vehicles, dust from ore-crushing and processing plants, blasting activities and dust from the transportation of iron ore by means of unpaved haulage roads (Kumari et al., 2011).

Road dust suppression techniques involve spraying the road surface with water or a dust suppression palliative consisting of a water and chemical solution, frequently referred to as a dust palliative. The dust palliative can either attract atmospheric moisture or bind soil particles together (Edvardsson, 2010). The alternative water-only strategy is associated with a high application frequency and, consequently, increased vehicle operating costs. The high vehicle operating costs together with the fact that South Africa is a water scarce country, makes this technique inefficient and costly (Thompson and Visser, 2007). The demand for minerals is increasing on a global scale because of global population growth, and thus mining is set to expand and with it the amount of dust generated by mines. As mining houses are consistently trying to reduce their environmental footprint, the need arises for a study on the efficacy of an organic dust palliative such as lignosulphonate. This product was developed as an alternative to the available bitumen based palliatives with the aim to be a more environmental friendly substitute (du Plessis, 2013). Furthermore, important aspects to be investigated include cost effectiveness, reduction in water use and ensuring that the product is environmentally friendly.

In a study completed by Adams (1988) he stated that lignosulphonate contains no dioxins and very low toxicity towards fauna and flora, which makes it environmentally friendly as a dust palliative.

The study presented in this paper was carried out to determine whether the use of a lignosulphonate-based dust palliative (Road dust control – RDC) is more effective in suppressing dust emissions when applied to a haulage road of a South African opencast iron ore mine when compared to a water-only dust suppression method.

## METHODOLOGY

A representative section of haulage road was selected to conduct the study. This section was divided into two sections each 300 m long. The configuration of both sections in terms of straightness, gradient, etc. that could affect vehicle speed was equivalent for both. Section A was treated with water only to suppress dust emissions and Section B was treated with a lignosulphonate-based dust palliative (further referred to as the Treated Section). The two sections of haulage road were exposed to the same ambient climatic conditions and the same traffic volumes.

The airborne particulate matter released from and measured near the individual sections was used to compare the efficiency of the two strategies. Both application frequency and the amount of water used were also measured. The application frequency needed to suppress dust emissions effectively was used to determine the associated operating efficiency and application costs.

The ambient climatic conditions were recorded using meteorological data obtained from the nearby Kathu weather station for the duration of the study. The lowest and highest daily mean data for parameters included: temperature ($^oC$), solar radiation ($W/m^2$), humidity (%), rainfall (mm), barometric pressure (mbar). The prevailing wind direction and speed were also recorded.

### Airborne particulate matter

A Thermo Scientific personal DataRAM (pDR) monitor was used to measure the respirable fraction of the airborne particulate matter released into the ambient air for both sections of the treated road. Measurements were taken at a designated fixed location for each test section every hour over the study period.

The pDR uses single-beam nephelometry by incorporating a light-scattering photometer for the measurement of respirable and thoracic particles in the 0.1–10µm particle size range. The pDR logs a measurement every second for the sampling period for up to five days (Thermo Scientific, 2014). The average peak readings were determined by analysing the peak concentration for each monitoring period and dividing it by the total number of monitoring runs for each test section during the study period.

### Dust fallout

Dust fallout was measured using six single non-directional dust buckets per haulage road section. The positioning of the dust buckets in relation to the roadway and environment adjacent to it was equivalent for each section. Each dust bucket was filled with distilled water and covered with a piece of netting to prevent contamination by insects and small-sized clods.

The buckets were placed in a stabilising stand 1 m from the ground surface to minimise contamination. Sample preparation was carried out before analysis. The sample contents from each bucket were filtered through a mesh coarse filter with a pour size of 1 mm to remove any insects and coarse detritus. The sample was then filtered through a pre-weighed paper filter to remove the dust fall (i.e. the insoluble fraction). The sides and base of the bucket were rinsed with distilled water and also passed through the paper filter. The filter containing the dust fall was dried in an oven and gravimetric analysis was conducted to determine the insoluble fraction (Gondwana Environmental Solutions, 2013).

### Traffic volume

The traffic volume on each test section was measured continuously from 3 to 7 June 2013 every hour for a period of 15 minutes. The traffic volume was divided into three categories, namely:

*Delivery vehicles (LDVs)* – All transport, maintenance and general light commercial vehicles were classified as LDVs.

*Construction vehicles* – All pieces of moving mine machinery operating on the mine but not responsible for production activities were classified as construction vehicles.

*Production vehicles* – All vehicles associated with the production operations, mainly load and haul equipment at the mine were classified as production vehicles.

### Water and product usage

For the study, dedicated water tankers were used to apply the water and lignosulphonatebased dust palliative. Water and product usage for each of the individual test sections were recorded at the refilling stations for the water tankers.

## RESULTS

This section provides the results obtained from this field test.

### Ambient climatic conditions

A summary of the measured and recorded data is shown in Table 1.

*Table 1. Prevailing ambient climatic conditions*

| | | Daily mean | |
|---|---|---|---|
| Station | Parameter | Lowest | Highest |
| Kathu | Temperature (°C) | 5.4 | 13.4 |
| | Solar radiation ($W/m^2$) | 156.8 | 185.2 |
| | Humidity (%) | 22.8 | 57.2 |
| | Rainfall (mm) | 0 | 0 |
| | Barometric pressure (mB) | 885.7 | 889.8 |

The lowest daily mean temperature for the study period recorded by the Kathu's Weather Station was 5.4$^oC$, with a highest daily mean temperature of 13.4$^oC$. The predominant wind direction (see Figure 1) recorded at the weather station was from the south-east (22% of the time), east-south-east (11% of the time), south-south-east (15% of the time) and north-west (9% of the time). Calm conditions were recorded 26% of the time (Gondwana Environmental Solutions, 2013).

### Dust fallout results

The lowest average dust fallout recorded next to the Water Treated Section was 5 274 $mg/m^2/day$, and the highest average dust fallout recorded of 16 204 $mg/m^2/day$ was measured.

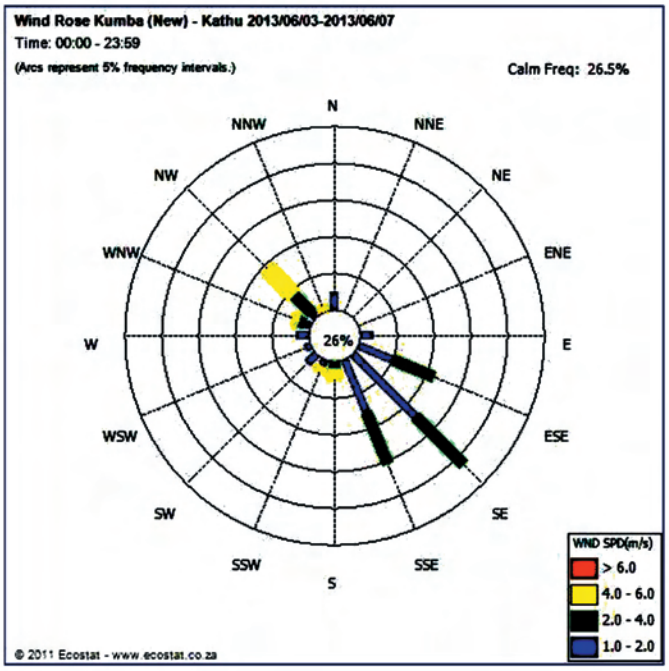


*Figure 1. Surface wind rose at Kathu Weather Station for the study period*

During the test period, the maximum average dust fallout of 7 360 mg/m²/day and the lowest average dust fallout of 1 486 mg/m²/day was recorded in the Treated Section. The dust fallout results for this monitoring period are shown in Table 2 (Gondwana Environmental Solutions, 2013).

*Table 2. Non-directional dust fallout data for the monitoring period*

| Dust fallout | | | |
|---|---|---|---|
| Sample ID | Section | Dust deposition (mg/m²/day) | Area average (mg/m²/day) |
| 7 | Water | 5 720 | 10 184 |
| 8 | Water | 5 274 | |
| 9 | Water | 9 968 | |
| 10 | Water | 11 181 | |
| 11 | Water | 12 755 | |
| 12 | Water | 16 204 | |
| 13 | Treated | 2 972 | 4 705 |
| 14 | Treated | 3 389 | |
| 15 | Treated | 1 486 | |
| 16 | Treated | 7 333 | |
| 17 | Treated | 4 687 | |
| 18 | Treated | 7 360 | |

When comparing the combined deposition averages the water treated section calculated average was 10 184 mg/m²/day when compared to the Treated section calculated average of 4 705 mg/m²/day. This is a reduction of 53.8% in the deposited dust.

**Respirable fraction of airborne particulate**

A total of 50 pDR readings were taken along the Treated Section of the road and 49 readings along the Water Section of the road. The average of the peak readings was calculated for each of the two sections and is shown in Table 3.

*Table 3. pDR average peak reading results*

| Measurements | Treated section (mg/m³) | Water section (mg/m³) |
|---|---|---|
| Average peak reading | 0.24436 | 0.46365 |

The results showed a reduction in the respirable fraction of the airborne dust of 0.21929 mg/m³ or a calculated reduction in the peak average concentration of 47.3%.

**Traffic volume**

In Figure 2 the average traffic volumes (vehicles per hour) for the duration of the study are plotted.

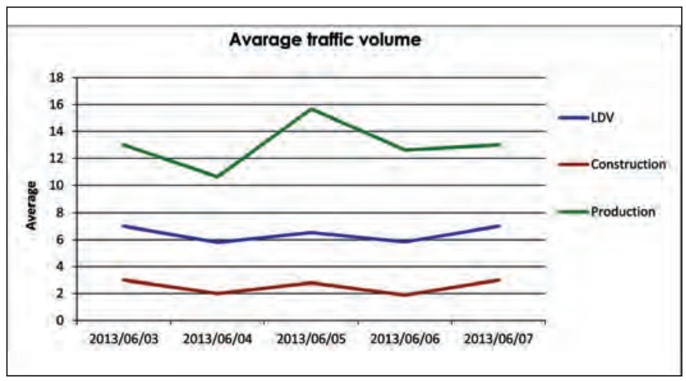


*Figure 2. Average traffic volumes for the duration of the study*

The average combined vehicle volume per hour was 22.4. The highest average traffic volume of 26 vehicles per hour was recorded on 5 June 2013 with an average of 16 production vehicles, 3 construction vehicles and 7 light delivery vehicles per hour. The lowest traffic volume was recorded on 4 June 2013. This can be attributed to blasting taking place in the vicinity of the study section and thus clearance of all traffic in the blasting area of the mine was issued prior to blasting.

**Product application frequency**

The results indicate that during the study period, water had to be applied on the Water Section at least twice as frequently as on the Treated Section to suppress dust emissions to visually safe and acceptable levels. The highest application frequency for the Water Section of the road was on 5 June 2013 when eight applications were required.

The highest application frequency of lignosulphonate dispersant was measured on 5 and 6 June 2013, when it was applied four times in a 24 hour period, as shown in Figure 3. The decision for additional applications was solely up to the site manager when a certain level of visible dust was observed. From the observations it was calculated that the Treated Section of the road required, on average, approximately 50% less water than what was needed for the Water Section of the road.

## DISCUSSION

From the observations and the recorded measurements it is clear that a direct correlation exists between traffic volume and application frequency required for effective dust suppression for

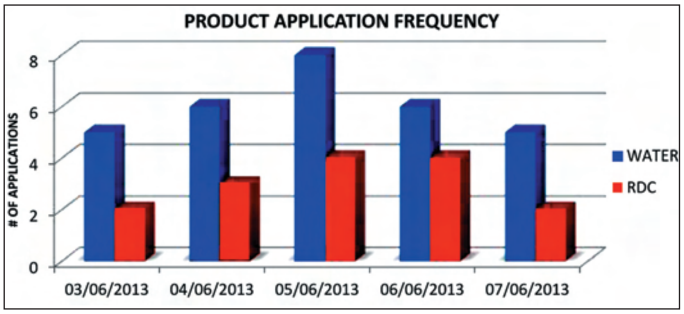

*Figure 3. Product application frequency comparison graph*

both the Water Section and the Treated Section. From the study it can be concluded that the application frequency needs to increase as the traffic volume increases to suppress or allay the dust emissions to acceptable levels. Furthermore, the application frequency requirement for the Water Section of the road increases significantly, whereas one additional application to the Treated Section of the road was sufficient to maintain good dust allaying conditions. It was furthermore observed that the application of the lignosulphonate dust palliative improved both the road structure and particle bonding. This is shown in Figure 4. This leads to more efficient dust suppression and a lower application frequency when compared with the water only application strategy.

*Figure 4. Photographs shows improved road structure and particle bonding after application (courtesy, I-Cat Environmental Solutions, www.i-cat.co.za)*

*Table 4. Comparative performance*

| Description | Result | | Result | Comparison Comments |
|---|---|---|---|---|
| | Water Section | Treated Section | | |
| **Application frequency** Total number of applications for the study period. | 30 | 15 | 50% less | During the study the application frequency in the water only section was double. |
| **Water usage (litres)** Actual water usage for the study period. | 252 332 | 125 664 | 50.2% less | Approximately double the amount of water was used to keep dust levels at safe levels on the Water Section. |
| **Dust fallout (mg/m²/day)** Av. per bucket in each section for the study period. | 10 184 | 4 705 | 53.8% less | Higher dust fall out was recorded on the Water Section, even though water was applied more frequently. |
| **pDR Readings (mg/m³)** Av. max figures of all readings during the study. | 0.464 | 0.244 | 47.3% less | Readings were only taken when vehicles travelled past the sampling position (low back-ground dust levels without traffic). The average maximum readings of the Water Section were significantly higher. |
| **Vehicle running cost (R)** Cost to treat each section for the duration of the study. | R525.24 | R262.62 | 50% less | Double the number of trips were needed to apply water to the Water Section resulting in double the associated cost. |
| **Fuel usage (litres)** Actual usage to treat each section for the duration of the study. | 25.76 | 11.96 | 53.6% less | Just more than double the amount of fuel was used to refill the water bowser (distance depen-dent) when compared with the Treated Section. |
| **Carbon footprint** *($kgCO_{2e}$)* Calculated using fuel usage figures. | 18.85 | 8.75 | 53.6% less | The carbon footprint of diesel usage was used in the calculations and is directly related to the fuel usage. |

The use of the lignosulphonate dust palliative resulted in significant water savings. From the observations and the calculations done during the study it was clear that it would be an impossible task for the mine to wet all the haulage roads with water only. This observation is based on the minimum application frequency (at least six times per day) and the current number of spray bowsers available at the mine. Each bowser, based on a cycle time, of refilling and wetting the road is capable of treating a certain section of the road per day. The number of bowsers available will have to be increased to meet the requirement of at least six water-only applications per day to keep dust emissions at a "safe" and acceptable level on haulage roads.

From the dust measurements it was clear that the haulage road section treated with the lignosulphonate dust palliative experienced significantly lower levels of dust emissions, as confirmed by both the respirable dust fraction measurements (pDR) and the total dust estimate (dust fall bucket analysis), confirming that the dust palliative is much more effective at dust suppression than water. It can also be concluded that the current bowser fleet will be sufficient to treat the roads effectively when using a dust palliative as additive to the water.

As part of the study a detailed cost-benefit analysis for the use of a dust palliative was done. A short summary of all the benefits is shown in Table 4.

From Table 4 it is clear that a significant decrease in operational time, maintenance and related costs is achieved, due to a lower application frequency. This overall cost-benefit was calculated to be approximately 30%.

## CONCLUSION

Dust emissions from mining activities and their impact on the surrounding environment have been and remain one of the major environmental impacts associated with surface mining.

Dust emissions caused by the transportation of mined material on surface mines are the most significant contributor.

From this study the benefits of using a linosulphonate-based dust palliative are:

- A reduction of the application frequency of at least 50%;
- The water usage was reduced by 50.2%;
- Dust fallout decreased to 53.8%.

The financial impact of savings in the maintenance, running and fuel costs of vehicles associated with dust suppression was calculated to result in a net saving of 30% when a lignosulphonate-based dust palliative was used.

In conclusion, it was found that use of a lignosulphonate-based dust palliative will reduce the dust emissions originating from haulage roads and the associated operating costs when compared with a water-only strategy.


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