Technical Fact Sheet: Air Quality – Dust Monitoring

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Sydney:	02 9262 6989
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Overview

This Fact Sheet has been prepared by the EDO NSW with assistance from members of the EDO NSW Expert Register. The aim of the Fact Sheet is to provide general information on dust issues in the Hunter Valley due to open cut coal mining as well as practical information on how to undertake your own dust monitoring.

The Fact Sheet provides information on the following:

- What is dust?
- Sources and types of dust from mining
- Health impacts of dust
- Main methods for monitoring dust
- Monitoring dust deposition rates using a dust deposition gauge in accordance with AS/NZS 3580, including:
    - how to collect a dust sample
    - how to analyze a dust sample
    - how to interpret the results of the analysis
    - how to report on the results of the analysis
- References and further reading

[1] http://www.edonsw.org.au/legal_advice

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What is dust?

Dust is a generic term used to describe fine particles that are suspended in the atmosphere. Dust is formed when fine particles are taken up into the atmosphere (entrained) by the action of wind, by disturbance of fine materials, or through the release of particulate-rich gaseous emissions (primary particles).

In addition, gases such as sulfur dioxide and oxides of nitrogen may react over time to form particles, such as ammonium sulfate and ammonium nitrate (secondary particles).

Dust comes from a wide variety of sources, including soil, vegetation (pollens and fungi), sea salt, fossil fuel combustion, burning of biomass, and industrial activities.

Dust is typically not classified according to its composition, but rather, its particle size, as follows:

- Deposited matter refers to any dust that falls out of suspension in the atmosphere.
- Total suspended particles (TSP) typically refers to particles 50μm (micrometers) (0.05mm diameter) in size or less.
- PM10 refers to particles 10μm (0.01mm) in size or less.
- PM2.5 refers to particles 2.5μm (0.0025mm) in size or less.

Dust particle size is an important factor influencing dispersion and transport in the atmosphere and potential effects on human health.

Fine particles are of size PM10 or less. Characteristics of these particles include:

- They are easily entrained by wind or disturbances and generally take a long time to settle once airborne, although they may be washed from the air by rain or snow. For example, a recent study found that fine particles of sea salt in the Hunter Valley area originated in the Great Australian Bight.
- They may settle permanently on land or only temporarily before being picked up and moved again, and may settle on water, dissolve in water, or both.

- They may stick together or break apart changing the size distribution over time.
- They may undergo chemical changes and reactions with other substances (depending on their composition).

Sources and types of dust from mining

Sources of dust

A wide range of mining activities may generate dust, including :

- removal of vegetation and topsoil
- removal of overburden material
- blasting and drilling operations
- operation of crushing and screening equipment
- loading and unloading of material on-site and subsequent transport off-site
- transport by vehicles on access roads and haul roads
- wind action affecting stockpiles and exposed areas of the site.

Dust generated from coal mines is typically termed 'fugitive dust', which refers to dust derived from a mixture of sources, or sources which are not easily identifiable.

Different mining activities generate different amounts of dust. In open cut mining, the removal of topsoil and overburden, and the transport of this material, may be the major contributor to dust emissions (Table 1).

The levels of dust generated at a particular mine are substantially influenced by climatic factors such as rainfall, temperature, and winds. Consequently, similar mines in different climatic areas may generate very different levels of dust.

Table 1: Dust emissions from typical controlled coal mining operations

Sources	**Truck and shovel operation** **Percent of total dust emissions**	**Dragline operation** **Percent of total dust emissions**
Dragline	n/a	27
Haul roads		
Overburden	37	-
Coal	7	42
Loading		
Overburden	12	-

Coal	4	5
Drilling (overburden and coal)	1	2
Blasting (overburden and coal)	5	1
Truck dumping	7	5
Topsoil removal	18	10
Exposed areas	6	7
Haul road repairs	5	1
Total	100	100

Source: *State Pollution Control Commission (1983) 'Air Pollution from Coal Mining and Related Developments' SPCC, Sydney*

Dust particle size and composition

The size and composition of dust particles generated by mining will depend on the type of mining activity and the geology of the site. Mining typically generates dust particles between 1μm to 100μm in size. Typical size ranges are:

- submicron size (less than 1μm): 0.2 percent (generally generated from diesel
- emissions) of total emissions
- PM2.5: 2 to 5 percent of total emissions
- PM2.5 to PM10: 15 to 45 percent of total emissions
- greater than 10μm: 50 to 70 percent of total emissions.

A survey of dust sizes from coal mines in the United States (sampled up to 100m from the source) found that dust had a median size of 24μm. Dust in the range PM10 or less comprised between 11 to 23 percent of total dust emissions (by total mass).

The Metropolitan Air Quality Study (MAQS) identified coal mining in the Hunter Valley as a significant source of TSP (50μm or less), contributing 26 percent of human sources in the greater MAQS region. In addition, the National Pollutant Inventory (NPI) estimates the mass of PM10 emissions due to coal mining in the Hunter Valley area for the period 2003 – 2004 is 42,000,000kg.

It should be noted that while mining does generate fine dust particles, the bulk of very fine particles in the atmosphere appears to come from other sources. For example, studies in the early 1990s in the Sydney, Newcastle and Wollongong areas estimated that soil particles (the sources of which include mining but also other activities such as agriculture) make a relatively small contribution (6 per cent) to the total ambient level of very fine particles (PM2.5) in the atmosphere compared to other components such as ammonium sulfate (23 per cent) and elemental carbon (22 percent), which are generated through combustion processes.

A more recent study indicated that soil particles make a larger contribution to the total ambient level of fine particles in the atmosphere – the average contribution was about 10 percent and 22 percent for PM2.5 and PM10 size fractions respectively.

Dust particles generated from coal mining may contain various metals and other potentially hazardous substances. For example:

- The NPI has estimated emissions to the air of toxic metals and their compounds due to coal mining in the Hunter Valley area for the period 2003 – 2004 of between 14kg and 55,000kg. These metals included arsenic, antimony, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium and zinc.
- Silica is a very common mineral found in most rocks. Dust generated from the crushing of rock (for example, in mining operations in the Hunter Valley) that contains a lot of quartz (a form of crystalline silica) may generate silica dust, which is potentially hazardous.

Note: Industrial facilities are required to report emissions to the NPI if they use more than a certain amount of one or more substances on the NPI reporting list. Emissions are estimated by each facility using techniques outlined in industry handbooks. The pollution exposure to humans and the environment cannot be determined solely from the NPI. Many additional factors determine whether a pollutant emission is felt as ground level pollution. Examples of additional factors are the nature of the receiving environment, the chemical reactivity of the substance and the prevailing weather conditions. Since the NPI does not attempt to collect information about these additional factors, NPI data can only give an indication of pollutant emissions at the source of the emission.

Health impacts of dust

The factors that influence the health effects of dust are:

- size of the dust particles
- composition of the dust particles
- concentration of the dust particles in the air
- duration of exposure (possibly in years) to the dust particles.

There is considerable debate over the relative importance of these factors in relation to health effects.

The health impacts of dust are generally related to suspended particles in the air, rather than dust deposited from the air. Dust particles PM10 or less in size are likely to have the greatest health impacts because they may be drawn deep into the lungs. Particles larger than PM10 tend to be trapped in the nose, mouth, throat or major bronchi and are typically expelled from the body.

Dust particles may be termed ‘inhalable’ or ‘respirable’. Inhalable particles are usually less than PM10 and greater than PM2.5 in size. These may be deposited in the upper sections of the lungs. Respirable dust particles are less than PM2.5 and may be deposited in the lower sections of the lungs, including the alveoli.

The NPI has given particulate matter of size PM10 or less a health hazard rating of 1.2 out of 3. A score of 3 represents a very high hazard to health, a score of 2 represents a medium hazard and a score of 1 is harmful to health.

Health effects include:

- Absorption of the dust into the blood through the lungs, with potentially toxic effects. As identified above, coal mining in the Hunter Valley generates dust particles that may contain various metals. Dusts containing mercury, arsenic or cadmium are particularly hazardous to human health.
- Diseases of the lungs, including cancer. Particles that penetrate deeply into the lungs may be permanently lodged, which may result in diseases of the lung. As identified above, mining may involve the crushing of rock that contains a lot of quartz, which may generate silica dust. Long term inhalation of silica dust may lead to the formation of scar tissue in the lungs and can result in silicosis, a serious and life threatening lung disease.
- Long term negative effect on lung function causing marginally increased death rates and sickness in sensitive people.
- Allergic or hypersensitivity effects.
- Irritation of mucous membranes.

According to NPI, recent health research in relation to dust particles of size PM10 or less suggests there is no threshold at which health effects do not occur.

However, this does not appear to be the case for some potentially hazardous substances. For example, it appears very unlikely that people exposed to ambient levels of silica dust will develop silicosis. A recent Australian Government Senate Committee (2005) identified that there were no reports of people developing silicosis due to ambient levels of silica dust in the international literature, and an expert appearing before the committee confirmed the potential for such an occurrence as being very remote. A United States Environment Protection Authority study (1996), which specifically focused on this issue, also supports this view.

Main methods for monitoring dust

The main methods for monitoring dust levels are:

- **Dust deposition gauges**: This method measures dust deposition rate and involves the passive deposition and capture of dust within a funnel and bottle arrangement. Data is usually collected over monthly periods and results are expressed in g/m2/month (ie. the mass of dust deposited per m2 per month). This method enables determination of the relative ‘dustiness’ of sampling locations. It does not provide data on dust concentrations or enable determination of dust levels from a particular event or source. It does not give an indication of the potential health effects of the dust because it does not measure the amount of fine and very fine particles in the atmosphere.
- **High volume samplers**: This method determines average dust concentrations and comprises the collection of dust by drawing a constant flow rate of ambient air through a filter. Data is usually collected over a 24

hour period and results are expressed in g/m3/24hr (ie. mass of dust per volume of air per 24 hrs). A selective inlet may be fitted to a high volume sampler to restrict the particle size being sampled (for example, to ensure only PM10 particles are sampled). When coupled with a wind direction vane or matched with records of wind data, this method enables determination of dust levels from a particular event or source. It also gives an indication of the potential health effects of the dust because it allows measurement of fine and very fine particles in the atmosphere.

- **Continuous particle monitors**: This method determines real-time (continuous) dust concentrations. A number of monitors are available including TEOM and Beta gauges. A selective inlet may be fitted to a particle monitor to restrict the particle size being sampled (for example, to ensure only PM10 particles are sampled). This method enables determination of short term dust events. As for high volume samplers, when matched with records of wind data, this method enables determination of dust levels from a particular event or source. It also gives an indication of the potential health effects of the dust.

Monitoring dust deposition rates using as/nzs 3580

The most cost effective method for undertaking your own dust monitoring is to monitor dust deposition rates using a dust deposition gauge. The method for this is set out in ‘Australian/New Zealand Standard: Methods for sampling and analysis of ambient air: Method 10.1: Determination of particulate matter – deposited matter – gravimetric method (AS/NZS 3580.10.1:2003).

Importance of using Australian/New Zealand Standards for dust monitoring methods

It is vitally important that dust monitoring is undertaken exactly in accordance with relevant Australian/New Zealand Standards. These standards are used to ensure that activities are undertaken in consistent and correct ways.

If you do not undertake dust monitoring exactly in accordance with a relevant standard, then your monitoring results may not be accurate and it is easy for your results to be disregarded.

Copies of Australian/New Zealand Standards are available from SAI Global (ph: 1300 65 46 46; website: www.standards.com.au/catalogue/script/search.asp).

Relevant dust criteria

The Department of Environment and Conservation sets the criteria for dust deposition rate:

Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Annual	2g/m2/month	4g/m2/month

Source: *Department of Planning and the Environment and Conservation (2005) 'Approved Methods & Guidance for the Modelling and Assessment of Air Pollutants in NSW'.*

The following points apply to the criteria:

- The 2g/m 2 /month criteria is used when baseline data on deposited dust levels exists, while the 4g/m 2 /month criteria is used when no baseline data exists.
- The criteria refer to all sources of deposited matter (including sources from mines, agriculture, unsealed roads, etc) and cumulative impacts. If the criteria are exceeded, there is no need to prove to the Department of Planning and Environment the source of the dust.
- The criteria mean that a mine may be allowed to add a certain amount of dust to the atmosphere. A mine may increase deposited dust levels by up to 2g/m 2 /month. However, the total deposited dust level (including sources from mines, agriculture, unsealed roads, etc) must not exceed 4g/m 2 /month.
- A dust deposition rate of 4g/m 2 /month equates to a visible layer of dust on outdoor furniture or on a clean car.

How to collect a dust sample

What equipment should be used and how?

AS/NZS 3580 identifies the equipment to use in collecting a dust sample and how to use it.

The key equipment is:

- A deposit gauge, which comprises a 150 ± 10mm diameter funnel inserted into a glass bottle (at least 4 litres in size) through a rubber stopper.
- A stand approximately 2m tall and a canister which holds the glass bottle to protect it from sunlight.
- A tight fitting lid to seal the glass bottle for transport to the laboratory.

Key aspects of using the equipment include:

- The bottle should be cleaned prior to use and rinsed with 10mL of copper sulphate solution to prevent algal growth (the laboratory where samples are taken to can usually provide this service).
- Set up the deposit gauge and stand so that the height of the top of the funnel is 2m ± 0.2m above the ground level of the immediate surrounding area.
- The glass bottle may also collect rainwater and other material such as insects and leaf litter, etc. This does not contaminate the sample and should not be removed in the field. This material is removed by the laboratory.
- After 30 days ± 2 days, wash any deposited matter in the funnel into the glass bottle using distilled water.
- Remove the funnel and seal the glass bottle with a lid.

- Identify the glass bottle with a label showing site location, the date sampling began and ended, and the funnel diameter to the nearest mm.
- Insert a clean funnel into a fresh glass bottle containing 10mL of copper sulphate solution and leave for the next sampling period.

What is the cost of the equipment and where can it be obtained?

The equipment required is affordable. The total cost would depend on whether all the equipment is bought from retail outlets or whether some of it was 'home-made'.

The funnel must be bought from a laboratory to ensure its size is accurate.

Glass bottles may be obtained from the laboratory where the samples are taken to be analysed (and may be included in the cost of the analysis).

A tripod may be purchased or a fence post may be used as long as it allows the funnel to be horizontal and the height of the top of the funnel to be 2m ± 0.2m above the surrounding ground level.

The canister can be made of anything as long as it protects the glass bottle from sunlight.

For example, a tin container may be used as a canister, which can be bolted to a fence post.

Funnels and bottles can be purchased in the Hunter Valley area from Australian Scientific Pty Ltd, 11 McDougall St, Kotara (ph: 02 4956 2299).

How often should samples be collected?

Samples must be collected every 30 days ± 2 days.

Sampling at each site should be undertaken for a minimum of 3 months, but preferably longer.

AS/NZS 3580 recommends that gauges be changed on or as near to the first day of each month.

At what locations should samples be collected and how much sampling should be undertaken?

Dust gauges should be located at sensitive receivers. The NSW Department of Planning and Environment defines a sensitive receiver as "a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area".

If the concern is dust generated from mining, then dust gauges should be located at sensitive receivers near a mine in order to gain a better indication of the contribution of the mine to dust levels. If dust gauges are located across a wider area, it will be more difficult to determine whether the measured dust levels are due to mining or other sources such as agriculture, unsealed roads, etc.

Dust gauges should be located in consideration of surrounding land uses. They should not be located in 'dusty' locations (except where that dust appears to be generated from mining). For example, dust gauges should not be located on or near bare paddocks or where earth moving or sowing or harvesting is occurring, near landfills, near construction sites, near unsealed roads, etc.

At any particular site, the dust gauge must be located in accordance with the standard AS 2922 - 1987 'Ambient Air - Guide for the Siting of Sample Units'. This provides that the gauge must be located in a clear area (with a clear sky angle of 120 degrees), away from trees, buildings, etc.

The number of dust gauges to be employed depends on the number of sensitive receivers affected. For example, if there are 20 sensitive receivers surrounding a mine, at least 5 dust samples would be required to ensure an adequately representative sample is obtained.

How to analyse a dust sample

Samples should be taken to the laboratory and analysed as soon as possible within 30 days of collection. The sample should be kept in a cool dark environment to prevent the growth of algae.

Where can samples be taken to be analysed?

Samples may be taken to ALS Environmental Newcastle (ph: 02 4968 9433; fax: 02 4968 0349; website: www.alsglobal.com).

What is the cost of analysis per sample?

Analysis costs about $40 per sample, depending on what analysis is undertaken. This cost includes the glass bottle, which contains the dust sample.

What information should be provided to the laboratory?

The following information should be provided to the laboratory:

- Location of samples, including coordinate reference on a topographic map to within 100m.
- Height of the sampling above the surrounding ground level.
- The classification of the area where samples were taken from (for example, industrial, residential, agricultural or urban).
- The date sampling started and finished.
- Any other relevant data (for example, climate conditions, proximity of bushfires, farm ploughing activities, traffic on unsealed roads).

What should the laboratory analyse?

You should request the following to be analysed by the laboratory:

- Insoluble solids: this is the matter that does not dissolve in water.
- Ash content: this is the matter that remains after the sample has been combusted in the laboratory.
- Ash content provides an indication of the mineral content (or soil dust) of the sample. The mineral content may be attributable to mining, but may also be attributable to other sources such as agriculture, unsealed roads, etc. The material making up the insoluble solids that has been combusted will not be attributable to mining or other sources because this is mostly organic matter.

How to interpret the results of the analysis?

What do the results mean?

Example of analysis results:

Analysis	Units	Location 1	Location 2
Ash content	g/m2/month	2.0	0.5
Total insoluble matter	g/m2/month	2.6	3.2

Location 1: The results indicate that most of the total insoluble matter is mineral content (soil dust) because a large proportion of the insoluble matter is not combustible. This mineral content may be attributable to mining, but may also be attributable to other sources such as agriculture, unsealed roads, etc.

Location 2: The results indicate that only a small proportion of the total insoluble matter is mineral content (soil dust) because a large proportion of the insoluble matter is combustible. Therefore the insoluble matter is mostly organic matter, which is not attributable to mining.

How to report on the results of the analysis?

A report on the results of the analysis should include:

- the results of the laboratory report
- location of samples, including coordinate reference on a topographic map and the proximity of the samples to mines
- the classification of the area where samples were taken from (for example, industrial, residential, agricultural or urban)
- any other relevant data (for example, climate conditions, proximity of bushfires, farm ploughing activities, traffic on unsealed roads).

References and further reading

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