DUSTWATCH
Dust Monitoring Specialists

DUSTWATCH CC
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DustWatch Training Handout

1. Introduction:

Looking up at the sky, we would never guess that our atmosphere contains between one and three billion tons of dust and other particles at any given time. Wind assists in keeping this dust airborne, but gravity wins most of the time, forcing the dust particles earthward, proving the old adage: "what goes up, must come down."

Dust comes from many different sources. Some, like the byproducts of the combustion of fossil fuels, are man-made. Others come from natural sources – like sea-spray blowing off the ocean, or dust blowing in from the desert. Dust comprises inorganic matter, such as sand particles, as well as a large amount of organic matter, including pollen, spores, moulds and viruses. These minute particles, ranging in size from around 100 micro metres (μm) to a few nano metres (nm), invade our airspace every day, a part of life that we aren't even aware of, except when we dust the furniture!

Definitions

- Aerodynamic diameter is the diameter of a spherical particle that has a density of $1g/cm^3$ and which has the same terminal settling velocity as the particle of interest.

- Atmospheric dust – Dust that is in the atmosphere.

- Brownian Motion – The continual random movement, due to molecular agitation, of fine particles suspended in a gas or a liquid.

- d_{50} – In a sample of dust the d_{50} diameter is the diameter above which fifty percent of the particles are larger, and below which fifty percent of the particles are smaller.

- Dry deposition – The collection of precipitant dust during periods with no rainfall.

- Export bucket – The export bucket can be the north, south, east or west bucket that is closest to the dust source. When the wind blows over the dust source towards the sampling location then the export bucket is open and dust from the dust source is collected in the bucket.

- Fugitive dust – Dust that is not emitted from a point source that can be easily defined, such as stacks. Sources are open fields, travel routes, stockpiles and process buildings.

- Meteorology – the earth science dealing with phenomena of the atmosphere (especially weather).

- Occult deposition – Increasing particle size due to moisture that results in deposition due to increased mass of particle.

- $PM_{2.5}$ – Sampling of atmospheric dust where the aerodynamic d_{50} diameter is 2.5 µm.

- PM10 – Sampling of atmospheric dust where the aerodynamic d50 diameter is 10 µm.

- Precipitant dust – Any particulate matter that has an aerodynamic diameter below 100 µm.

- Wet deposition – The collection of precipitant dust and any soluble substances in the rainwater during periods of rainfall.

- Total deposition – The sum of wet and dry deposition. Occult deposition is also included.

- Environmental monitoring - The process of checking, observing, or keeping track of something for a specified period of time or at specified intervals.

Why do we monitor for fallout dust?

- To create awareness of environmental pollution.

- To comply with legislation and audit requirements.

- The monitoring is continuous and will therefore indicate all dust generating events or activities taking place on the site.

2. What is Precipitant Dust

Precipitant dust, as the word implies, is dust that precipitates or falls down.

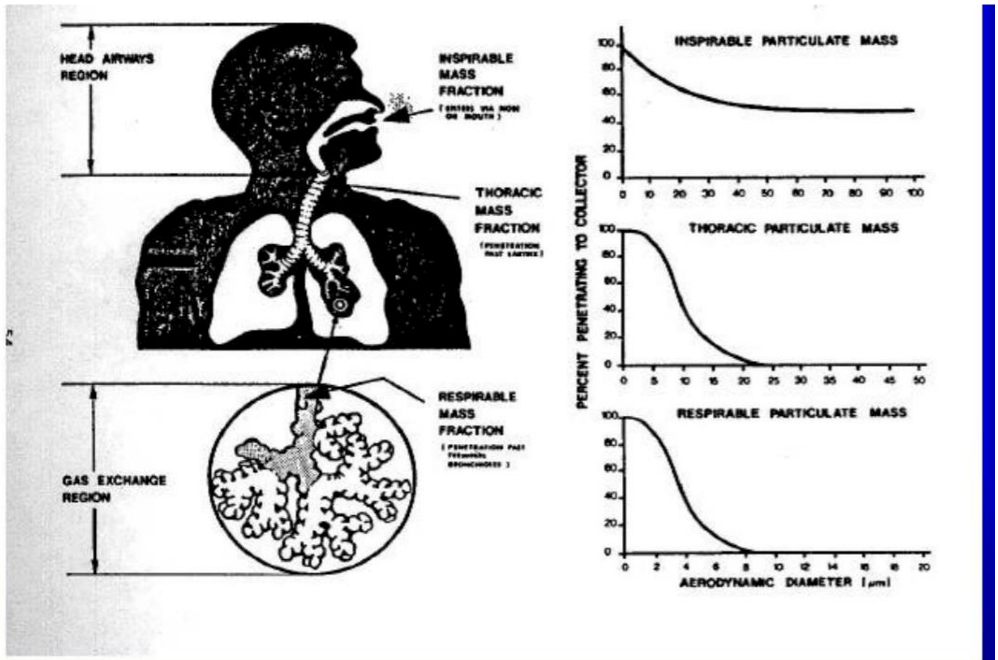
Precipitant dust refers to any particle with an aerodynamic diameter less than 100 µm.

Precipitant dust is broadly defined as particulate that ranges in size up to 100 µm in diameter.

1. Inhalable particulate mass is for those materials that have health effects associated when deposited anywhere in the respiratory tract. This is the particulate that will pass from the air into the nose or mouth and will travel up to the beginning of the throat.

2. Thoracic Particulate mass is for those materials that have health effects associated when deposited anywhere within the lung airways and the gas-exchange region. This is the particulate that will pass through the throat and up to the small bronchiole.

3. Respirable particulate mass is for those materials that have health effects associated when deposited in the gas-exchange region.



Phalen RF: Introduction and recommendations. In: ParticleSize-Selective Sampling in the Workplace. American Conference of Governmental Industrial Hygienists, Cincinnati, OH (1984).

Inhalable	
Particle Aerodynamic Diameter (µm)	**Mass % Inhalable Particulate**
0	100
1	97
2	94
5	87
10	77
20	65
30	58
40	54.5
50	52.5
100	50

The Mass % of Inhalable Dust that can be deposited.

Thoracic	
Particle Aerodynamic Diameter (µm)	**Mass % Thoracic Particulate**
0	100
2	94
4	89
6	80.5
8	67
10	**50**
12	**35**
14	**23**
16	**15**
18	**9.5**
20	**6**
25	**2**

Mass % that can be Deposited in the Lung Airways and the Gas-exchange Region

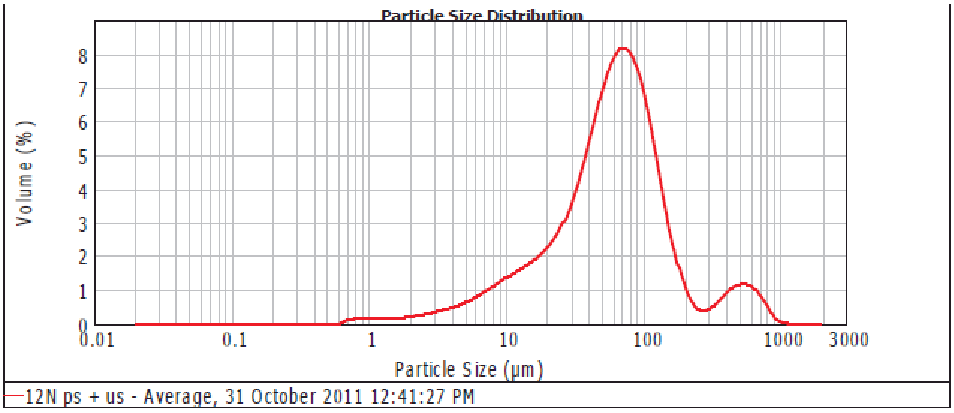
Result Analysis Report

Sample Name: 12N ps + us - Average	**SOP Name:**	**Measured:** 31 October 2011 12:41:27 PM
Sample Source & type: Customer = Biograde	**Measured by:** Lab	**Analysed:** 31 October 2011 12:41:28 PM
Sample bulk lot ref: SDS 6715	**Result Source:** Averaged	

Particle Name: Default 1.52 0.01	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.520	**Absorption:** 0.01	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 6.75 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.692 %	**Result Emulation:** Off

Concentration: 0.0225 %Vol	**Span :** 2.432	**Uniformity:** 1.04	**Result units:** Volume
Specific Surface Area: 0.251 m²/g	**Surface Weighted Mean D[3,2]:** 23.872 um	**Vol. Weighted Mean D[4,3]:** 94.996 um	

d(0.1): 12.723 um d(0.5): 61.210 um d(0.9): 161.559 um

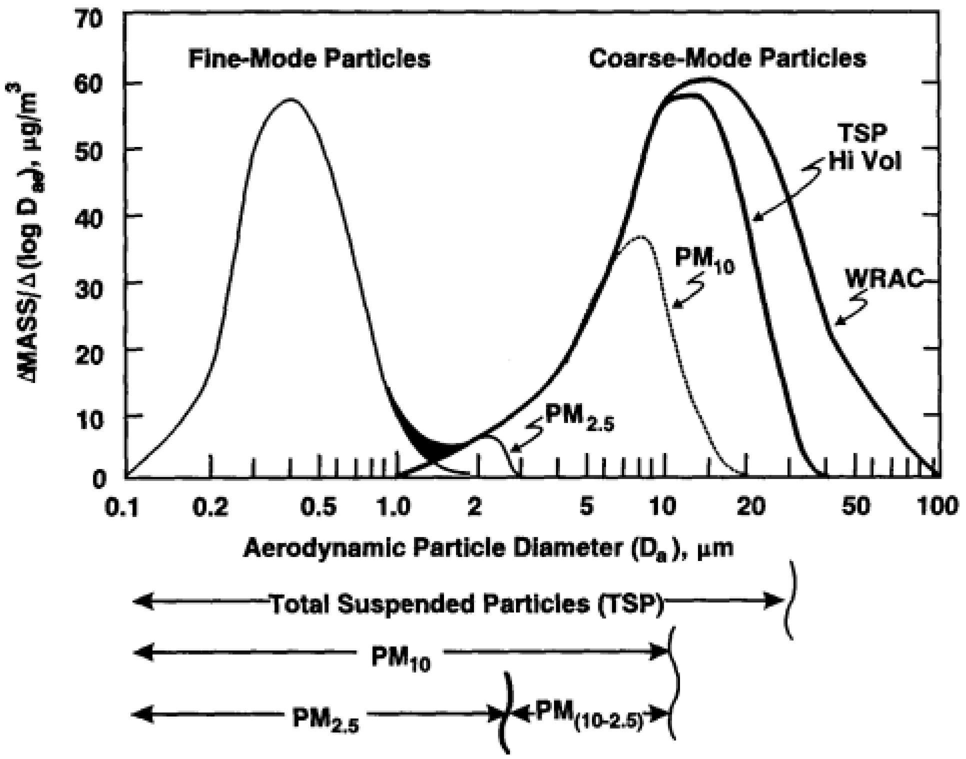


Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	0.38	7.096	5.09	50.238	40.42	355.656	94.44
0.022	0.00	0.159	0.00	1.125	0.49	7.962	5.86	56.368	45.85	399.052	95.04
0.025	0.00	0.178	0.00	1.262	0.60	8.934	6.72	63.246	51.70	447.744	95.78
0.028	0.00	0.200	0.00	1.416	0.71	10.024	7.69	70.963	57.79	502.377	96.63
0.032	0.00	0.224	0.00	1.589	0.82	11.247	8.75	79.621	63.91	563.677	97.52
0.036	0.00	0.252	0.00	1.783	0.95	12.619	9.91	89.337	69.82	632.456	98.36
0.040	0.00	0.283	0.00	2.000	1.09	14.159	11.17	100.237	75.29	709.627	99.08
0.045	0.00	0.317	0.00	2.244	1.25	15.887	12.53	112.468	80.11	796.214	99.61
0.050	0.00	0.356	0.00	2.518	1.44	17.825	13.99	126.191	84.15	893.367	99.90
0.056	0.00	0.399	0.00	2.825	1.66	20.000	15.59	141.589	87.35	1002.374	99.98
0.063	0.00	0.448	0.00	3.170	1.91	22.440	17.36	158.866	89.72	1124.683	100.00
0.071	0.00	0.502	0.00	3.557	2.19	25.179	19.36	178.250	91.35	1261.915	100.00
0.080	0.00	0.564	0.00	3.991	2.52	28.251	21.67	200.000	92.40	1415.892	100.00
0.089	0.00	0.632	0.00	4.477	2.90	31.698	24.36	224.404	93.02	1588.656	100.00
0.100	0.00	0.710	0.05	5.024	3.33	35.566	27.52	251.785	93.39	1782.502	100.00
0.112	0.00	0.796	0.15	5.637	3.84	39.905	31.23	282.508	93.68	2000.000	100.00
0.126	0.00	0.893	0.26	6.325	4.42	44.774	35.53	316.979	94.00		

Operator notes:

High Sensitivity	Medium Sensitivity	Low Sensitivity
Hospitals and clinics	Schools	Farms
Retirement homes	Residential areas	Light and heavy industry
Hi-tech industries	Food retailers	Outdoor storage
Areas where painting is being done	Greenhouses and nurseries	
Food processing	Horticultural land	
	Offices	

Schematic representation of the size distribution of particulate matter in ambient air (USEPA 1996)



WRAC - Wide Range Aerosol Classifier

TSP – Total Suspended Particulate

"The percentage of total aerosol mass less than 10 micron varied from about 50 to 90%, depending on the sampling location and sampling conditions." (R. M. Burton & Dale A. Lundgren (1987) Wide Range Aerosol Classifier: A Size Selective Sampler for Large
Particles, Aerosol Science and Technology, 6:3, 289-301, DOI: 10.1080/02786828708959140
To link to this article: http://dx.doi.org/10.1080/02786828708959140)

“PM10: The mass concentration of particles smaller than 10 μm. In practice, PM10 samplers do not provide perfectly sharp cuts at 10 μm. Instead, size-dependent collection efficiencies typically decrease from 100 percent at ~ 1.5 μm to 0 percent at ~15 μm, and are equal to 50 percent at 10 μm.”

Referenced from:http://www.aerosols.eas.gatech.edu/EAS%20Graduate%20Lab/Class%20Notes%20Aerosols%20and%20Size%20Distrn.pdf

Look at the particle settling velocity spreadsheet.

Speed = distance / time

Time = distance / speed

Distance = speed X time

The fall-out dust standards from National Dust Control Regulations, 2013.

Restriction Areas	**Dustfall rate (D) (mg/m2/day) – averaged over 30 days.**	**Permitted frequency of exceeding dust fall rate**
Residential area	D < 600	Two within a year, not sequential months.
Non-residential area	D < 1200	Two within a year, not sequential months.

Table 1: Acceptable Dust Fall Rates – National Dust Control Regulations, 2013.

Visit this site - http://www.dustwatch.com/dcr.pdf

Compare the new proposed draft legislation to the current legislation

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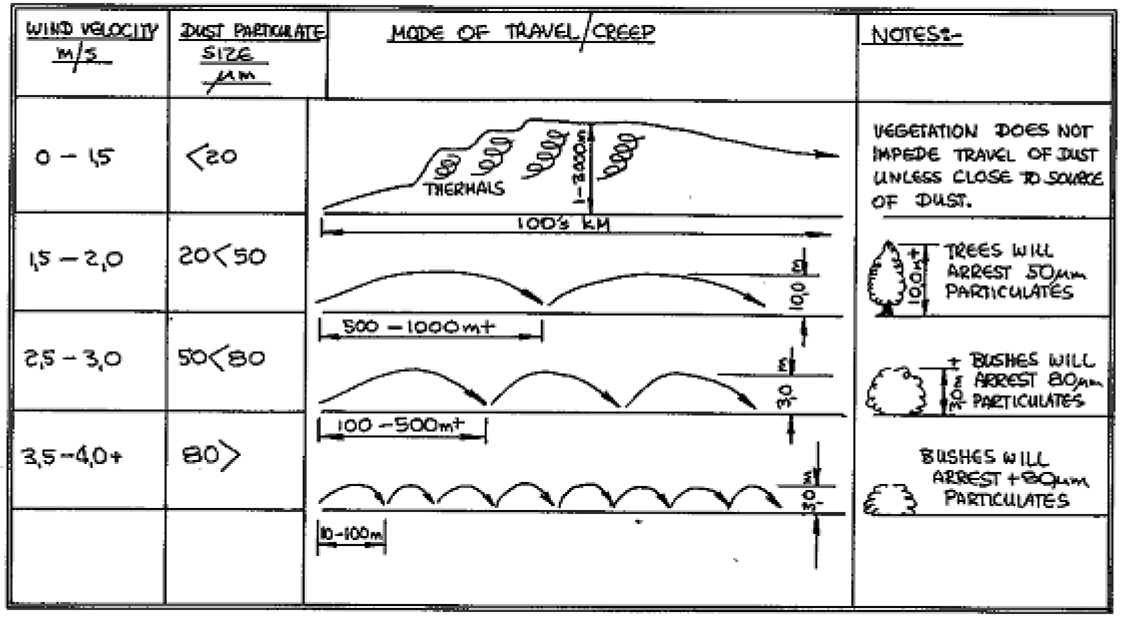


TABLE TWO – CARRIAGE OF AIRBORNE PARTICULATES

WIND VELOCITY m/s	DUST PARTICULATE SIZE µm	MODE OF TRAVEL/CREEP	NOTES:-
0 – 1,5	<20	THERMALS; 1–3000m; 100's KM	VEGETATION DOES NOT IMPEDE TRAVEL OF DUST UNLESS CLOSE TO SOURCE OF DUST.
1,5 – 2,0	20<50	500 – 1000m+; 100m	10m TREES WILL ARREST 50µm PARTICULATES
2,5 – 3,0	50<80	100 – 500m+; 30m	3m BUSHES WILL ARREST 80µm PARTICULATES
3,5 – 4,0+	80>	10-100m; 30m	BUSHES WILL ARREST +80µm PARTICULATES

Notes:

With factors like particulate density and shape playing a major part in the distance that the particle will travel, the above table is only an indication based on test work with tracer dust. The height to which particulate is lifted depends on air turbulence, temperatures, humidity, density and thermals which can be encountered. Vegetation and Bush can impede and capture larger particulates.

Vegetation does not impede travel of dust unless close to source of dust

Trees will arrest greater than 50 micrometre or 50 micron dust particulates up to a height of 10 metres

Bushes will arrest greater than 80 micrometres or 80 micron particulates up to a height above the ground of 3 metres.

Bushes will arrest greater than 80 micrometres or 80 micron particulates.

3. How to collect fallout dust.

The present method to establish precipitant dust levels is the ASTM (American Standard Test Method or American Society for Testing and Materials) D-1739 of 2017 “Standard Method for Collection and Analysis for Dust Fall (Settleable particulates)”

While single open buckets partly-filled with a capture medium will accumulate all precipitating dust, this does not establish precipitant dust emanating from a given direction unless the bucket is closed to any dust from other directions. Such open buckets are also subject to inaccuracies due to wind turbulence within the buckets, lower air densities over the bucket and other factors.

The single bucket precipitant dust collection method “is a crude and nonspecific test method, but it is useful in the study of long-term trends.”

4. How to Calculate fallout dust Results and Interpretation.

CALCULATIONS

- The cross-sectional area of the buckets is a standard constant in all of the calculations representing the area over which fall-out collection has been made:

= $0.022966 m^2$

- The actual mass collected is derived by subtraction of the mass of the filter ($mass_1$) from the combined mass of the filter and filtrate ($mass_2$):

$Mass_2 - mass_1$ = collected mass of dust sample

- All units should be expressed in milligrams and the value of milligram/square metre/day derived from the formula:

$$\text{Fall-out rate (mg/m}^2\text{/day)} = \frac{\text{collected mass}}{0.022966 \times \text{days}}$$

Understanding how the dust gets into the bucket.

- Generally finer suspended dust (2.5µm > 5µm) will remain airborne almost indefinitely due to the dynamic nature of the air currents and thermal activities on any given day, even if there is no wind at all. A rapid increase in humidity together with an absence of wind will result in precipitation of less than 5 micron particulate.

- Particulate larger than 5µm and up to 100µm will settle on a very still day and this material is collected within the DustWatch buckets.

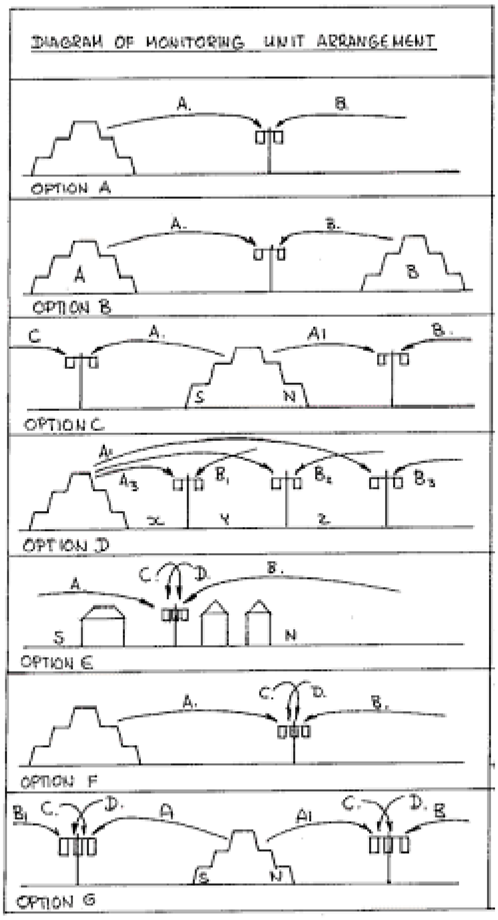
- Particulate of a size 500µm carried by high wind velocities will not be collected within the buckets.

- Once the wind drops to lower levels the particulate starts precipitating and this gets captured in the buckets. We thus note that no dust or very little dust gets captured during very windy conditions but when the wind speed drops then the dust precipitates and is collected in the bucket. Once the wind changes direction, the maximum precipitation rate is reached when the air mass movement is totally arrested and then the air mass starts to move in the other direction.

Filter Paper Selection

- From the above we thus selected filter material with a pore size of ±5μm. The media weave permits capture of 1-2μm particulate and thus the actual collection guarantee is a lot better than 5μm. With the physical dermal layering of the high mass samples, dermal filtration is achieved.

- The filter paper wet strength is important as well as the ash content. When doing filtering the wet strength prevents the filter from breaking and when filters are sent for elemental analysis then the low ash content limits any contamination.



<u>Results Achieved - Linear Function</u>

Source Export Dust and Ambient Import

A. Direct Export from Source
B. Ambient Import

Cross Contamination - Two Stockpiles

A. Direct A Export
B. Direct B Export

Nett Export / Ambient Import

Nett Export North = A1 - C
Nett Export South = A - B
Ambient Import = C and B (S and N)

Fall-out Quantification

Fall-out at x metres = A3
Fall-out at (x+y) metres = A2
Fall-out at (x+y+z) metres = A1

Village Nett Import

Import from North = B
Import from South = A
+ Import from East and West = C and D (4 bucket units)

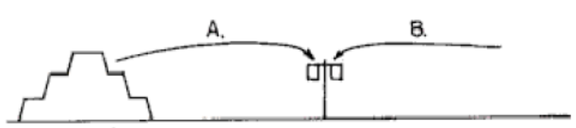
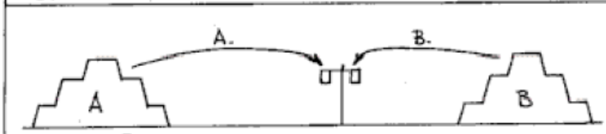
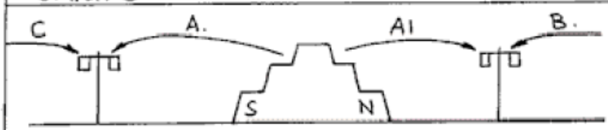
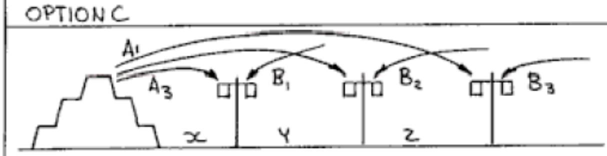
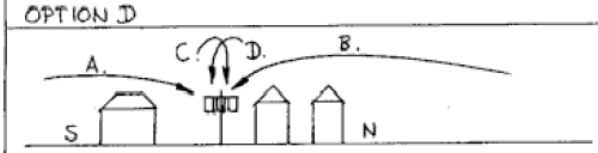
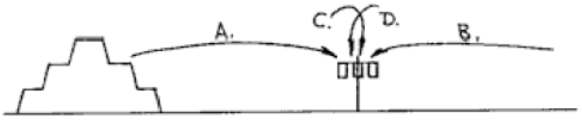
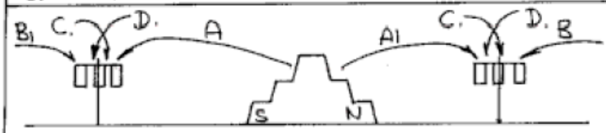
Source Export with Ambient Import From 3 Directions

A. Direct Export From Source
B. Opposing Ambient Import and Import From Other Directions C and D (4 bucket units)

4 Directions – Nett Export / Ambient Import – 4 Directions

Nett Export North - A1 - B1
Nett Export South - A - B
Ambient Import = B1 and B (S & N)
Ambient Import = C Checks C and D Checks D (East and West)

A slightly larger image has been shown on the next page.

DIAGRAM OF MONITORING UNIT ARRANGEMENT	RESULT ACHIEVED LINEAR FUNCTION
 OPTION A	SOURCE EXPORT DUST & AMBIENT IMPORT A. DIRECT EXPORT FROM SOURCE B. AMBIENT IMPORT
 OPTION B	CROSS CONTAMINATION - TWO STOCKPILES A. DIRECT A EXPORT B. DIRECT B EXPORT
 OPTION C	NETT EXPORT / AMBIENT IMPORT NETT EXPORT NORTH = A1 − C NETT EXPORT SOUTH = A − B AMBIENT IMPORT = C AND B (S & N)
 OPTION D	FALL-OUT QUANTIFICATION FALL OUT AT xm = A3 FALL OUT AT $(x+y)$m = A2 FALL OUT AT $(x+y+z)$m = A1
 OPTION E	VILLAGE NETT IMPORT IMPORT FROM NORTH = B IMPORT FROM SOUTH = A + IMPORT FROM EAST & WEST = C AND D (4 BUCKET UNITS)
 OPTION F	SOURCE EXPORT WITH AMBIENT IMPORT FROM 3 DIRECTIONS A. DIRECT EXPORT FROM SOURCE B. OPPOSING AMBIENT IMPORT + IMPORT FROM OTHER DIRECTIONS C AND D (4 BUCKET UNITS)
 OPTION G	NETT EXPORT / AMBIENT IMPORT - 4 DIRECTIONS NETT EXPORT NORTH = A1 − B1 NETT EXPORT SOUTH = A − B AMBIENT IMPORT = B1 AND B (S & N) AMBIENT IMPORT = C CHECKS C & D CHECKS D (E & W) (4 BUCKET UNITS)

5. TRACE ELEMENT ANALYSIS AND FINGERPRINTING

Very often there is a necessity to know more than the mere proportions of various chemical elements within a sample, especially when detailed fingerprinting has to be undertaken.

According to the Technical Report No. 3: Review of Data on Heavy Metals in Ambient Air in Australia (Environment Australia, May 2002, ISBN 0642547815), the metals present in the source fingerprints of fine particulate sources are:

- Motor vehicle emission: Na, Al, K, Ca, Fe, Zn, and Pb
- Coal combustion emissions: Na, Al, K, Ca, and Fe
- Industrial emissions on high sulphur days: V, Cr, Cu, and Pb
- Smoke emissions: K and Ca
- Soil emissions: Al, K, Ca, Ti, Mn, and Fe
- Sea-spray emissions: Na, K, and Ca

6. MicroScanning

The carrying out of a routine microscopic examination offers a valuable continuous check for any sign of fibres of a mineral nature as well as giving an indication of the amount of organics within the sample. While very detailed examinations require specialised knowledge and techniques, the type of examination carried out here can be extremely valuable in offering an insight into the collected dust.

The carrying out of a routine microscopic examination offers a valuable continuous check for any sign of fibres of a mineral nature as well as giving an indication of the amount of organics within the sample.

As a cost-effective assessment of contents, the MicroScan method can estimate the:

- Geological contents of a sample, including organic materials;

- d50 particle size of either the whole sample or specific constituents of the sample;

A sample image can be taken which then indicates the content. Unusual contents and organic insects can be logged for biodiversity purposes and further study.