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ASSESSMENT OF OPEN SOURCES

by

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ABSTRACT

Emissions of particulates and other pollutants from sources such as material transportation, crushing, grinding, screening, blasting, unpaved road use, and agricultural activities are referred to as fugitive emissions, and the sources are called open sources. Although these emissions have been of concern in recent years, they have been difficult to quantify and assess because they sometimes originate over large areas, and often the emissions from more than one open source contaminate a specific site.

This paper describes a method developed for comparing and ranking open sources based on published data and/or estimates of the magnitude and composition of the emissions. A preliminary ranking was used to select sources that are to be analyzed in detail for the purpose of ranking future control technology development projects. Specific methods for sampling open sources which avoid problems are described. Emission factors were developed from an example case for total particulates from crushed granite unit operations such as drilling, blasting, loading, unloading, crushing, screening, and transportation. Measurements and subsequent calculations showed that the mean emission factor for total particulate emission level was 0.13 kilogram per megagram of material processed through the primary crusher. The mean free silica content of the emissions was 27.7% by weight.

ASSESSMENT OF OPEN SOURCES

Open sources, also called Fugitive Sources, do not have a definable point of emission such as a stack or vent. Consequently, source strength of these sources is quite difficult to determine since the emission rate is not a simple function of gas flow rate and pollutant concentration.

Emissions of particulates and other pollutants from open sources have drawn increased attention in recent years because fugitive emission problems are frequently encountered. An investigation of the Open Sources Category was therefore conducted to provide a better understanding of the magnitude and composition of emissions for the purpose of determining needs for developing control technology. An understanding of the extent of emissions from open sources is also necessary to provide a perspective insofar as the benefit to be derived from controlling point sources. If an ambient air quality problem is mostly caused by fugitive emissions then there is little point in controlling a few point sources.

Some typical open sources are dusty material transfer, crushing, sizing, screening, landfill and excavation, blasting, wood processing, unpaved roads, molten metal transfer, and agricultural activities.

A preliminary ranking of the open sources was made based on published data and/or estimates of magnitude and type of emissions. This preliminary ranking was then used to select the source types to be analyzed in detail.

PRELIMINARY RANKING OF OPEN SOURCES

For comparison and ranking purposes, the open sources were investigated on the basis

of their relative impact or hazard potential to "public health". "Public health" in this preliminary ranking was confined to effects on non-employees beyond plant boundaries. The sources were analyzed on the basis of primary emissions; synergistic and secondary effects were not identified nor characterized.

In determining relative values, arbitrary definitions are acceptable if they are applied across-the-board. The first formula postulated to represent the relative hazard potential of a source was as follows:[1]

$$\frac{E}{M \times D^2} = \text{Relative Hazard} \qquad (1)$$

where,

E - Respirable dust emissions from sources; either by estimate, literature, or measurement (preferable). (M/T)

M - Relative toxicity of the emissions. (M/L^3)

D - Distance to population centers. (L)

This simple relationship constituted the initial ranking basis by which the most important open sources were chosen.

The relative toxicity value, M, in the equation was defined as the maximum allowable ambient concentration (MAAC). It was calculated as:

$$\text{MAAC } (\mu g/m^3) = \text{TLV®} \times \frac{40}{168} \times \frac{1}{10} \times 1000 \qquad (2)$$

where,

TLV® is the threshold limit value as defined by the American Conference of Governmental Industrial Hygienists (ACGIH),[2] mg/m^3.

Air quality standards exist for only five pollutants. Therefore, TLVs were used since they represent the only other basis for comparisons among non-criteria pollutants. If more than one pollutant was present, a composite TLV was used.

Composite TLVs were calculated as follows:[2]

$$TLV_c = \frac{1}{\sum_{i=1}^{n} \frac{f_i}{TLV_i}} \qquad (3)$$

where,

TLV_c - composite TLV for complex particulate

f_i - fraction of particulate as substance i

TLV_i - TLV of substance i

n - total number of substances in particulate so that

$$\sum_{i=1}^{n} f_i = 1.0$$

However, due to a lack of quantitative data on the composition of the emissions and also a lack of data on the distance to population centers, another approach was used to estimate the relative impact on public health. From the very simplified model of eq. 1 a more complex "prioritization" model evolved for source assessment and ranking purposes.

The relative impact for a given source type was then defined as follows:

$$I_x = \sum_{j=1}^{K} P_j \sum_{i=1}^{N} \left(\frac{\bar{x}_{ij}}{F_i}\right)^2 \left(\frac{x'_{ij}}{S_i}\right)^{\frac{1}{2}} \qquad (4)$$

where,

P_j = population density in the defined region or affected area (persons/sq km)

x'_{ij} = annual mean concentration of the ith criteria pollutant in the jth region (g/m^3)

S_i = corresponding standard for the ith criteria pollutant (g/m^3)

N = number of hazardous materials emitted by each source

F_i = hazard potential factor (g/m^3)

$\bar{x}_{ij}$ = calculated max. ground level concentration (g/m^3) of the ith material emitted by a source in the jth region

K = number of sources of a given type

I_x = relative impact (persons/sq km)

The relative hazard factor, F, for non-criteria pollutants was defined as follows:

$$F = TLV \times 40/168 \times 1/100 \quad (5)$$

The relative hazard factor for criteria pollutants, F, was defined as the primary national 24-hour ambient air quality standard.

For most of the open sources, particulate is the only criteria pollutant which is emitted.

Equation 4 then simplifies to

$$I_x = \sum_{j=1}^{K} P_j \left(\frac{\bar{X}}{F}\right)\left(\frac{X'}{S}\right)^{\frac{1}{2}} \quad (6)$$

The $\bar{X}$ was calculated using the following equation:

$$\bar{X} = \frac{2Q}{\pi H^2 e \bar{u}} \quad (7)$$

where,

Q = emission rate (g/sec)

$\bar{u}$ = average wind speed (m/sec)

H = effective emission height (m)

e = 2.72

The effective emission height is taken to be equal to a minimum of 10 feet (3.05 meters) for all open sources unless otherwise identified. Elevated open sources were calculated using an estimated height of emission, which did not exceed 30 feet (9.14 meters) in most cases.

SOURCE ASSESSMENT

Based on the preliminary ranking and EPA's recommendations, several sources are presently being studied in detail. An example of a particular source under study is presented below. Particulate emissions from the crushed granite industry were sampled and analyzed. A similar approach is being used for investigating other open sources.

A two-step approach is followed for a rapid source assessment. First, the order of magnitude and composition of emissions is determined by literature survey and/or on-site preliminary sampling. Second, the preliminary sampling results were used to determine the extent of additional sampling required, and a plan to carry it out is designed.

PRELIMINARY SAMPLING OF CRUSHED GRANITE INDUSTRY

Data obtained from preliminary sampling and analysis include the following:

(a) Particulate concentrations derived from Hi-Vol ambient air samples placed in a downwind array;

(b) Particulate concentrations of respirable dust as measured by a GCA dust monitor downwind of source of interest; and

(c) Analytical data consisting of particle sizing and counts, free silica content of particulate dust, trace element analysis, and fiber count.

Hi-Vol Sampling

An array of five General Metal Works high volume air samplers was set up around the major source (Figure 1). Four of these samplers were placed downwind and one was placed upwind to determine background ambient particulate concentrations.

This array method has proved to be very useful because it compensates for fluctuations in wind direction. The ambient air particulate concentrations obtained at the four high volume samples were corrected for the background concentration.

An average mass emission rate was then calculated as an average of the four sample readings using Turner's equation[3] for a ground level source with no effective plume rise.

$$Q = \sum_{i=1}^{N} \frac{x_i \pi \sigma_{Y_i} \sigma_{Z_i} \bar{U}}{N \exp\left[-\frac{1}{2}\left(\frac{Y_i}{\sigma_{Y_i}}\right)^2\right]} \quad (8)$$

where,

Q is the emission rate, g/sec

x_i is the ground level concentration, g/m^3

σ_{Y_i} σ_{Z_i} are standard deviations of plume concentration distributions in the horizontal and vertical direction, respectively, meters

$\bar{U}$ is the average wind speed, m/sec

N is the number of samplers downwind of the source

A meteorological station was employed to monitor the wind speed and direction and the temperature. The wind direction variation was less than ± 45° from the wind center line during sampling.

GCA Dust Monitor

The GCA RDM-101 dust monitor is designed for on-the-spot measurements of mass concentrations of the respirable fraction (<10 μm) or total suspended particulate (<50 μm) and has a minimum sampling time of 4 minutes. It is a portable and fully self-contained monitor with automatic and direct digital readout of mass concentrations of airborne dust.

The versatility of the GCA instrument was realized during the crushed granite presurvey. A "one-man sampling band" was constructed consisting of the GCA instrument, personal samplers, and a lightweight wind speed and direction measuring device - all used by one engineer for a presurvey of all open sources (Figure 2). The one-man effort can cut the presurvey costs by more than a factor of 4 as compared to using Hi-Vol samplers.

SAMPLING RESULTS

Table 1 summarizes results for emissions from crushed granite operations based on the preliminary sampling. The sampling results show that the mean emission factor for total particulate emissions was 0.13 kilogram per megagram of material processed through the primary crusher with a range of 0.08 kilogram per megagram to 0.53 kilogram per megagram at the 95% confidence level. Respirable particulates comprised 3.9% of the total.

The preliminary results also show that primary crushing, conveying, loading, unloading, wind erosion of stockpiles, and drilling together contribute less than 0.4% of the overall plant emissions. Blasting contributes 63% of the overall emissions, vehicular movement on unpaved roads contribute 19.2%, and secondary crushing and screening contribute 17.4%.

Composition

The mean free silica content was 27.7% with a range of 4% to 46% at the 95% confidence level. Trace element and fiber analysis indicated that these constitute levels too low to be of any concern.

The free silica content was determined by infrared spectrometry. Although several procedures can be adapted for silica analysis, the method used has been illustrated by Cares et al.[4,5] The method involves ashing of the filter and sample at 500°C and mixing and pressing the sample ash with KBr to form a solid pellet which is placed in an infrared spectrophotometer for spectral analysis at 800 cm^{-1}.

The fiber count was done at 400X magnification using phase contrast illumination. The elemental analysis was performed by emission spectrography and X-ray fluoroescence.

Conclusion and Discussion

Figure 3 shows the estimated 24 hour average ground level concentration at various distances from the boundaries of an average size crushed granite plant (454 Mg/hr) for emission factors of 0.08 kg/Mg (low), 0.13 kg/Mg (mean), and 0.53 kg/Mg (high). Comparison of the estimated concentrations with the primary and secondary air quality standards shows that there is a possibility that the standards may be exceeded at the plant boundary.

Since there is no air quality standard for free silica in ambient air, ground level con-

centrations were compared with the relative hazard factor F, as defined in equation 5. The threshold limit value for free silica (in total dust) was taken as

$$TLV = \frac{30}{\%\ \text{free silica} + 3}\ mg/m^3$$

We can conclude that ground level concentrations of total dust containing free silica due to emissions from an average size crushed granite plant always exceed the relative hazard factor.

However, the above information is not complete enough to determine the need to develop control technology. For this, the following additional information is necessary:

- Distribution of fibers and free silica content of crushed granite emissions.
- Emissions from blasting and the role of influencing factors on the emissions.
- Emissions from secondary crushing and screening and unpaved roads and the role of influencing factors on the emissions.

The source assessment of crushed granite plants will be addressing the acquisition of this information in present on-going research.

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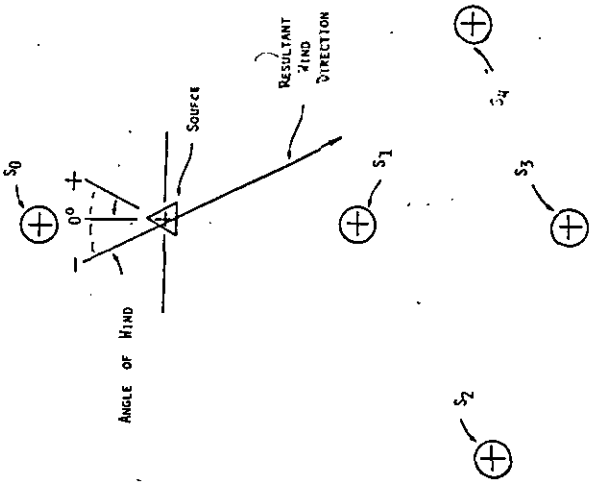

Figure 1. SAMPLER POSITIONS

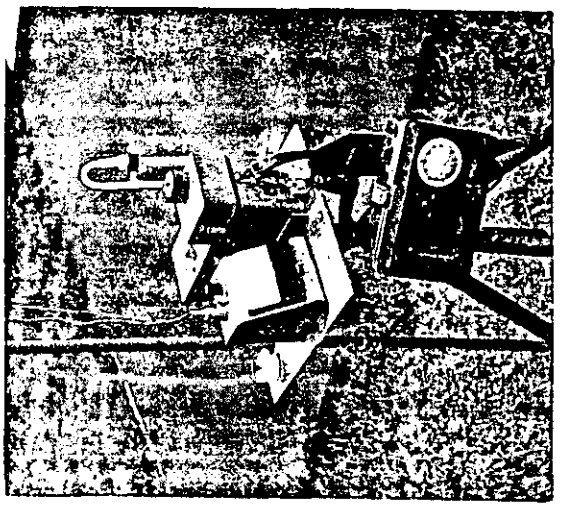

Figure 2. "ONE-MAN SAMPLING BAND"

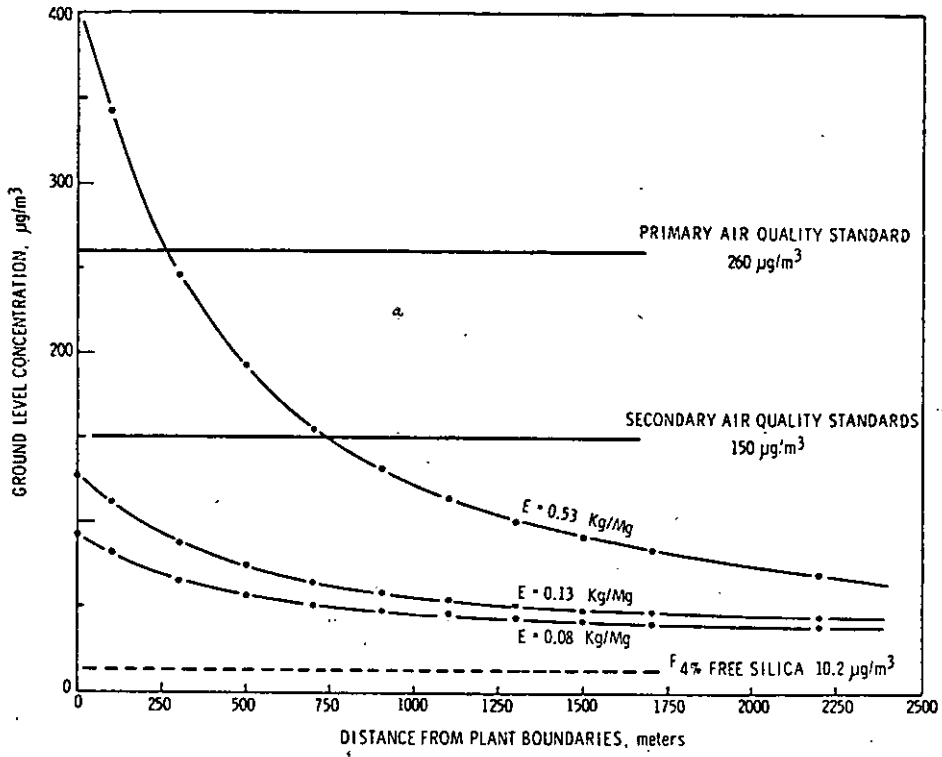

Figure 3. AIR QUALITY AROUND A CRUSHED GRANITE PLANT

Table 1. EMISSION FACTORS FOR CRUSHED GRANITE UNIT OPERATIONS

Unit Operation	Emission Factor for Total Particulates[1]	Contribution, %	Respirable, %
Drilling	4.0×10^{-4}	0.3	11
Blasting	800×10^{-4}	63.0	17
Loading on to Haul Trucks	Negl.	Negl.	
Unloading at Primary Crushing	1.7×10^{-4}	0.1	8.1
Primary Crushing and Screening	Negl.	Negl.	
Secondary Crushing	90×10^{-4}	7.1	3.7
Secondary Screening	130×10^{-4}	10.3	4.2
Conveying	Negl.	Negl.	
Unloading to Stockpiles	Negl.	Negl.	
Vehicular Movement on Unpaved Roads	240×10^{-4}	19.2	3.7
Windblown Emissions	Negl.	Negl.	
TOTAL	1300×10^{-4}	100.0	3.9

[1]Kilograms per megagram of material processed through the primary crusher