Effect of dustfall pollution on chlorophyl content of polyalthea longifolia leaves

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Abstract. Dust has a size of 0.001 - 10000 µm. Dust from motor vehicle exhaust emissions generally has a size of 1 - 150 µm, and flying dust due to vehicle traffic has a size of 100 µm. This dust when it falls on the leaves will cover the stomata. The length of stomata is 80 µm and a maximum width of 50 µm, which is smaller than the size of the dust. As a result, the stomata will be covered by dust, and the leaves cannot absorb CO2, an important ingredient in photosynthesis. The leaf samples used in this study were Polyalthea Longifolia leaves located near the highway, around the cement factory, and in plantations as a control. Then, the leaves were measured for the content of total chlorophyll using the Wintemans and de Mots equation, and mineral content using X-ray Fluorescence (XRF). The results showed that the leaves around the cement factory had a yellow color, small, lower chlorophyll content, and had low absorptivity on minerals than the leaves from near the highway and control.

1. Introduction

Dust is a small particle that enters the air. The dust size varies from 0.001 - 10000 µm. Dust that has a large size of about 100 µm, such as dust from motor vehicle combustion emissions and traffic, quickly falls to the earth due to gravity. Dust that has the same size but comes from a higher source, for example a chimney can fall several km from the source. Dust like this is known as dustfall.

The effects of this dust deposition vary depending on the composition of the dust. Dust from burning oil in motorized vehicles has a size of 1 - 150 µm with the main composition is hydrocarbons, and dust from burning coal in power plants also has the main composition of hydrocarbons [1-2]. On the other hand, dust originating from cement factories has different components. Major constituents of raw material cement dust generated from the first grinding process are CaO (41.77%), SiO2 (11.72%), Al2O3 (3.45%), and Fe2O3 (1.47%), while the cement clinker dust generated from the second grinding process consists mainly CaO (48.09-65.50%), SiO2 (14.02-21.56%), Al2O3 (2.86-3.76%), and Fe2O3 (1.77-2.66%) [3] The main effect that occurs when dust falls on the surface of the leaves is a decrease in the ability of the leaves to carry out photosynthesis due to covering the leaf surface with dust.

Polyalthea Longifolia plant is a plant that can be found on the side of main roads, offices, several industries, and tourism places. This plant has a tall shape and the leaves surrounded the stem. When planted along a straight line at a distance of about 1 m from each other, it produces a beautiful scene. Apart from being used as a plant for aesthetic purposes, the Polyalthea Longifolia plant is also used as
a plant in order to absorb air pollutants [4], especially air pollutants caused by motor vehicle emissions. This plant, can absorb several minerals, and can withstand stress, because this plant contains a lot of water. Although, as a plant to deal with air pollution, Polyalthia Longifolia plants only slightly reduce the concentration of air pollutants, because the area of the plant canopy is very small [5].

Because the Polyalthia Longifolia plant is easy to find in locations contaminated with air pollutants, such as roadsides and industrial areas, this plant can be used as a sample in research on the effects of air pollution on vegetation. Therefore, in this study, Polyalthia Longifolia plants were used as samples to determine the effect of dustfall pollution on vegetation.

2. Materials and methods
The leaf samples were taken from the cement factory silo location so that the dust falling on the leaf surface was assumed to only come from falling or spilled cement. As a comparison, leaf samples were also taken from the roadside of the main road location. It is assumed that the source of dustfall pollutants is traffic activity. The third sample is control, this plant is located on plantations area that are far from the main road or cement factories, so that the source of dust fall pollutants is atmospheric dust.

Then, the leaf samples were taken to the laboratory for characterizing. Characterization sample used X-ray fluorescence (XRF) for mineral content, and UV-VIS Spectrophotometer for calculating the total chlorophyll concentration. The total chlorophyll concentration was calculated using the Wintermans and Mots equation as follows:

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\text{Total chlorophyll (mg/L)} = (20.0 \times A_{649}) + (6.10 \times A_{665})
\]

3. Results and discussion
The Dust pollutants around the road come from the friction between the road surface and the tires, during braking, and from emissions from the combustion of motor vehicle fuels. Dust that comes from motor vehicle exhaust emissions generally has a size smaller than 10 µm, so it is classified into PM$_{10}$ and PM$_{2.5}$. This type of dust can stay longer in the air and can enter human lungs [6,7]. On the other hand, dust originating from tire friction with the road surface has a larger size up to > 50 µm, so the dust can easily and quickly fall on the side of the road which is planted with Polyalthia Longifolia plants [1].

As a result of dust falling on the leaf surface, it will cover the leaf surface, which can be seen in (Figure 1). Figure 1 also shows a large difference in leaf color and leaf size, between leaves that are only covered with atmospheric dust and leaves covered with dustfall.

![Figure 1](image)

**Figure 1.** (a) Control (b) Samples taken from Silo Cement Industry

The leaves which are covered with atmospheric dust look bright green and shiny with a large size. On the other hand, the leaves covered with cement dustfall look brownish yellow, dull, and there is a pile of dustfall on the leaf surface, and they are smaller in size.
Then, the sample is passed on a UV-Vis spectrophotometer to measure its absorbance, which will be used to calculate the total chlorophyll content. The results of the calculation of the sample chlorophyll content can be seen in Table 1.

| Location of the sample                  | Total chlorophyll (mg/L) |
|----------------------------------------|-------------------------|
| Plantations (Control)                  | 28.48                   |
| Roadside of the main road              | 13.41                   |
| Silo cement industry                   | 5.57                    |
| 1 km from cement industry              | 5.72                    |

Table 1 shows that air pollution can reduce the chlorophyll content in leaves, especially dustfall on the leaf surface, such as in samples located on roadsides and around cement factories. The covered leaves will inhibit the photosynthesis process. Reduction in photosynthetic process causes a reduction in number of leaves, which in turn will inhibit plant growth [8,9], as shown in Figure 1.

The samples were also characterized using XRF to find out the minerals contained in the leaves. The results obtained can be seen in Table 2. *Polyalthea longifolia* plants are easy to absorb minerals in particular, in order and starting from the biggest ones are potassium, magnesium, calcium, and iron [10], so these compounds will be detected in the leaves if the soil contains these minerals. In control plants, the dominant mineral compounds in the soil are silica and iron, while in the leaves, calcium and potassium compounds are very dominant according to the natural characteristics of the *Polyalthea longifolia* plant.

| Chemical compound | Control (%) Soil | Roadside of the main road (%) Soil | Roadside of the main road (%) Leaves | Silo cement industry (%) Soil | Silo cement industry (%) Leaves |
|-------------------|------------------|-----------------------------------|-------------------------------------|-------------------------------|--------------------------------|
| K                 | 4.92             | 19.72                             | 4.69                                | 14.78                         | 0.46                           | 19.29                         |
| Cl                | -                | 1.94                              | -                                   | 2.91                          | -                              | 2.24                          |
| Ti                | 2.47             | -                                 | 2.78                                | -                             | 1.55                           | -                             |
| Nb                | 0.21             | 0.18                              | -                                   | 0.38                          | 0.02                           | -                             |
| In                | -                | -                                 | -                                   | 0.17                          | -                              | 0.01                          |
| Ca                | 6.46             | 72.90                             | 14.68                               | 77.99                         | 0.12                           | 30.21                         |
| Px                | 0.94             | 1.19                              | 0.59                                | 3.18                          | 0.26                           | 1.13                          |
| Mg                | -                | -                                 | -                                   | -                             | -                              | 15.76                         |
| Zn                | 0.23             | -                                 | 0.40                                | -                             | -                              | -                             |
| Si                | 34.29            | 3.78                              | 40.65                               | -                             | 34.62                          | 1.53                          |
| Fe                | 46.03            | -                                 | 30.24                               | -                             | 7.00                           | -                             |
| Sr                | 1.59             | -                                 | 0.94                                | -                             | 0.01                           | -                             |
| Mn                | 1.33             | -                                 | 0.75                                | -                             | 0.08                           | -                             |

Now, if the location where the plants grow is polluted by air pollutants, will this condition affect the absorption of leaf minerals? Unfortunately, results showed that the ability of potassium absorption in leaves was decreased; this was seen in leaves originating from the roadside compared to control leaves. As a result, the high potassium content in leaves contaminated by dust from cement factory may come from dustfall of cement which contain potassium. The same result we found for calcium, the high content of calcium in the leaves comes from dustfall because the metabolic ability of the leaves is low shown by the very low chlorophyll content (Table 1).
Table 2 also shows the negative effect of dustfall pollution, apart from disrupting the photosynthesis process due to the closure of the leaf surface, it also decreases the absorption capacity of other minerals by the leaves, such as iron which is undetectable in the leaves, even though it is exist in the soil. Furthermore, some minerals which are not detected in the soil, but are present in the dustfall, can be absorbed into the interior of the leaves, such as Cl, Mg, and Zn. This is because magnesium (Mg) is macronutrient, chlorine (Cl) and Zinc (Zn) are micronutrients which contribute to the photosynthetic process [11].

4. Conclusion
Dustfall is particulate pollution that has a size larger than PM2.5 or PM10 and even the size of leaf stomata. As a result, dust will settle on the leaf surface and cover it, so that the leaves cannot absorb water and carbon dioxide, which are the main elements in the photosynthesis process. The inability to carry out photosynthesis causes the total leaf chlorophyll content to decrease and interferes with the mineral absorption process. In fact, the ability to absorb these minerals is important, because this can be used as an indicator of the ability to reduce material air pollution.

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