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Research Article

Prediction of Dustfall Generation over an Andisol and Entisol Soil and Negatife Impact To Human Health

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Abstract: Dustfall is one of the parameters of air pollution that can cause upper respiratory tract infections diseases. The objective of the research is to analyze the correlation between dustfall, soil moisture content, wind speed, and the percentage of land cover on Andisol and Entisol soil and prediction negative impacts of dustfall generation to human health. Measurement of dustfall was carried out according to national standard, namely SNI 13-4703-1998. Dustfall generation correlated positively with wind speed and correlated negatively with soil moisture content and the percentage of land cover. Effect of wind speed on the dustfall generation Andisol soil was 23.2% on the measurements in the field and 84.3% on the measurements in the laboratory, and Entisol soil was 68.3% on the measurements in the field and 61.7% on the measurements in the laboratory. Effect of soil moisture content on the dustfall generation Andisol soil was 29.4% on the measurements in the field and 59.4% on the measurements in the laboratory, and Entisol soil was 42.8% on the measurements in the field and 42.1% on the measurements in the laboratory. Effect of the land cover percentage on dustfall generation Andisol soil was 84.5% and Entisol soil 87.6%. The negative impact of dustfall generation of Entisol soil on human health allegedly higher than Andisol soil because dustfall on Entisol soil have high fine particles (63.7%) so the particles can be deposited in the alveoli and interfere with the respiratory system, while the Andisol soil allegedly low impact on human health because relatively coarse particles was high (84%).
Keywords: Andisol, dustfall, Entisol, soil moisture content, wind speed

INTRODUCTION

Naturally dustfall can be generated from dry soil which less or without vegetation carried out by the wind[1]. Certain wind speed can lead to the lifting of the fines fractions of the soil surface resulting in dustfall [2-3]. Based on the study Liu *et al*, concentration of dustfall increases with increasing soil erosion due to wind [4]. Judging from the pattern of movement by the wind, dustfall can impact both locally and globally on the ecosystem [5]. Some research has shown that sandy soil is a source of dustfall that can impact to human health [6-8]. Factors affecting soil erosion are: (1) Energy (erosivity), including the potential ability of rain and surface runoff/wind, (2) Sensitivity of land (erodibility), depending on the physical, mechanical and chemical factors, and (3) protection, dealing with land cover [9-12].

According to Akpinar *et al* levels of air pollution including dustfall on certain areas correlated with a combination of local meteorological factors [13]. Dustfall generation is influenced by meteorological conditions, soil surface, and atmospheric stability[14]. The dustfall generation which is influenced by wind speed is a function of surface roughness, soil texture and soil moisture content[7]. On this basis, the objective of the research were: (1) to analyze the correlation between dustfall, soil moisture content, wind speed, and the percentage of land cover on Andisol and Entisol soil which is the major soil types in Java based on Soil Survey Staff [15]; (2) to give an influence of wind speed, soil moisture content, and the percentage of land cover on dustfall generation; and (3) to give an idea about negative impacts of dustfall generation based on particle size distribution of any type of soil.

RESEARCH METHOD

Time and Place

This study was carried out in July to November 2013. Measurements were carried out over an open area of Andisol soil in the Kuningan Municipality, Entisol soil in the Karawang Municipality, and laboratory of Environmental Engineering of the Department of Civil and Environmental Engineering.

Materials and instruments

The materials and instruments used during the field and laboratory experiments were a set of dustfall canister [AS-2011-1], blower [Hercules; Ø 60 cm; 220 V; 170 W], digital anemometer [Lutron AM-4201], digital moisture tester [OGA TA-5], tunnel [7.6 m length; 0.76 m width; 2.4 m height], analytical balance [OHAUS Aventuror Pro], Petri dish [Ø=80 mm], filter paper 10µ [Whatmann #41], universal oven [UNB 400], optical microscope [Trinokuler]; Minitab 14 Portable; and timer.

Measurement of Dustfall Generation in the Field and Laboratory

The placement of Dustfall Canister during direct measurements in the field was done according with SNI 13-4703-1998. Measurements of soil moisture content and wind speed were conducted three times per day. The steps of dustfall concentration measurement in the field are presented in Fig. 1.

The laboratory experiment was conducted in a tunnel where the land surface was covered by Andisol or Entisol soil layer of 3 cm depth (Fig. 2). Wind with 0.8-1.3 m/s speed was mechanically generated by a blower 1.5 m above soil surface in the tunnel, thus forming a dustfall generation in the ambient air and hence the soil moisture content decreases. Generation of the dustfall was measured based on the method as shown in Fig. 1

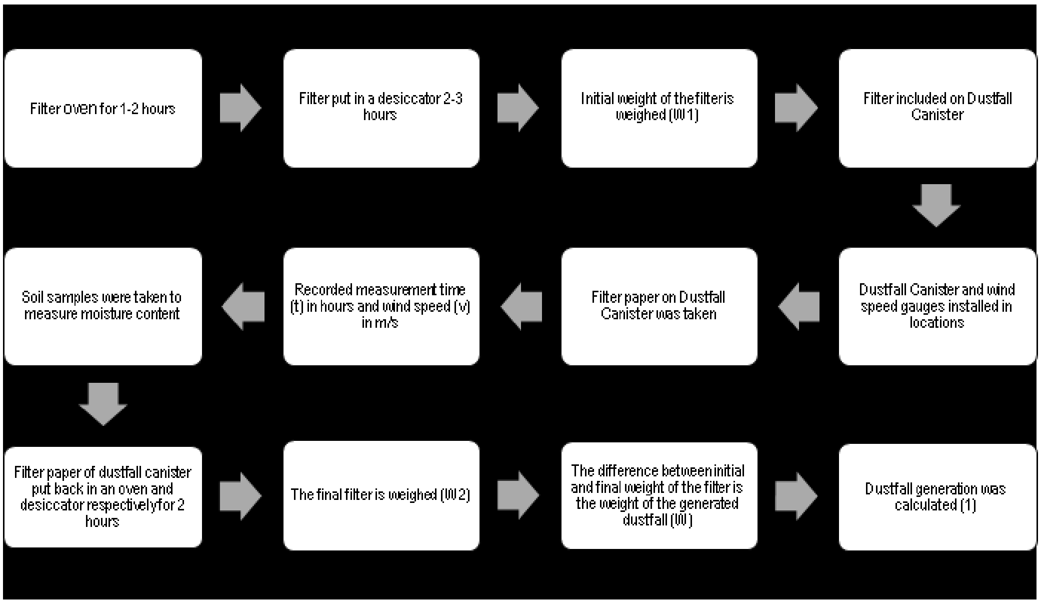


Fig-1: Method of measuring the concentration of dustfall

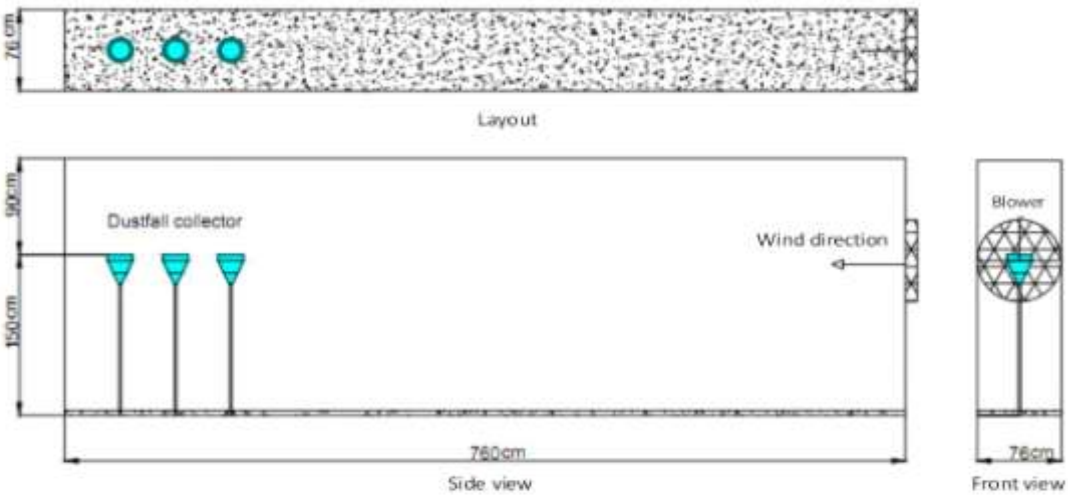


Fig- 2: Tunnel for the measurement of dustfall

$$C = \frac{w}{A \times T} \qquad (1)$$

Remarks:
W : dustfall weight (tons)
A : surface area of canister (km^2)
C : dustfall generation ($ton/km^2.month$)
T : measurement time (months)

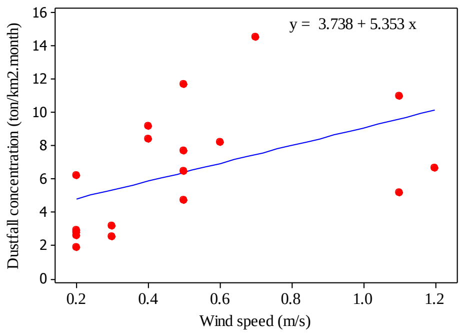
Data Analysis Procedures

Referring to Sugiyono, the data analysis techniques used in this study is Pearson Correlation Technique [16]. Data analysis was performed with the aid of a personal computer using data processing program Minitab. The development of mathematical model was based on those field and laboratory experiments.

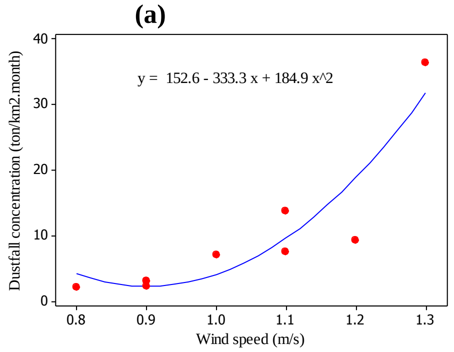
RESULTS AND DISCUSSION

Analysis of Dustfall Generation on Andisol Soil

The result of the correlation analysis showed that there is a linear relationship between dustfall generation of Andisol soil and wind speed on the field measurement and quadratic relationship on the laboratory measurement (Fig. 3). The quadratic relationship obtained on laboratory measurements showed that wind speeds > 1 m/s effect significantly to the generation of dustfall formed from Andisol soil. Effect of wind speed on the dustfall generation of Andisol soil on the field was 23.2% (R-Sq = 23.2%) on wind speed 0.2-1.2 m/s and 84.3% on measurements in the laboratory with wind speeds of 0.2-1.3 m/s.



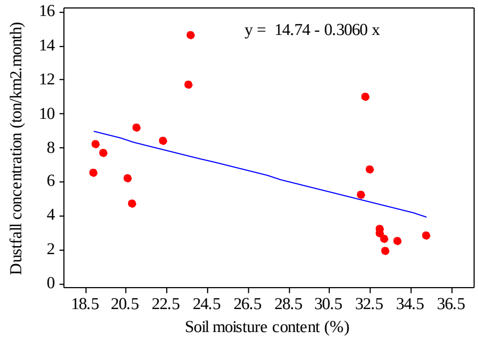
(a)



(b)

Fig-3: Correlation between dustfall vs. wind speed on Andisol soil in the field (*a*); and in the laboratory measurement (*b*)

Andisol soil texture results from laboratory testing consists of 23.26%% clay, 33.71% dust, and 43.02% sand. According to Baskoro [17], Andisol is soil with high organic matter (± 12.2%), so that tend to have a good structure and stable. Correlation between dustfall generation and soil moisture content on Andisol soil can be seen in Fig. 4. Results of measurements in the field showed that soil moisture content 18.9-35.3% affects 29.3% (R-Sq = 29.3%) on generation of dustfall, whereas measurement in the laboratory with a soil moisture content 22.1-27.8% obtained R-Sq 59.4%.



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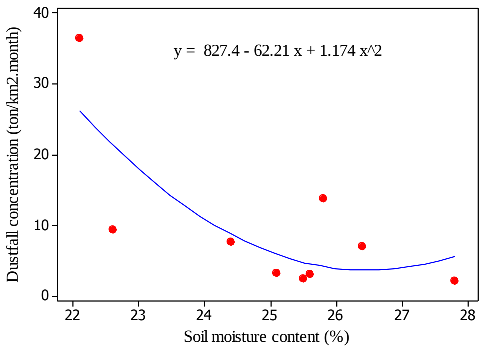


Fig-4: Correlation between dustfall vs. soil moisture content on Andisol soil in the field (*a*); and in the laboratory measurement (*b*)

The result of analysis on Andisol soil indicated that there are negative correlation between dustfall generation and the percentage of land cover. Measurement of dustfall generation on Andisol soil was conducted on soil moisture content 23.3-23.7%. The addition of land cover ≥ 30% on Andisol soil do not affect significantly to decrease dustfall generation formed in the ambient air as shown in Fig. 5.

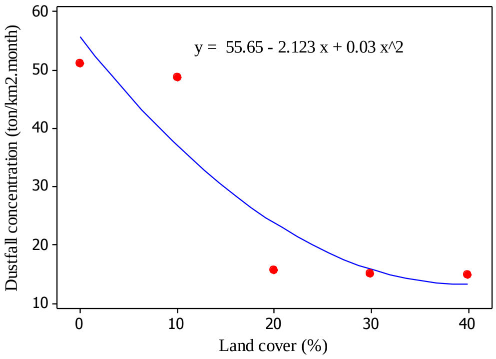
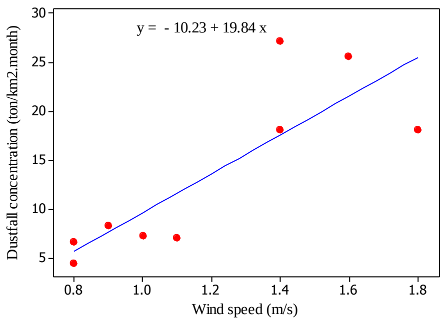


Fig-5: Correlation between dustfall vs. land cover on Andisol soil

Analysis of Dustfall Generation on Entisol Soil

Results of correlation analysis showed that wind speeds of 0.8-1.8 m/s on measurements in the field affects the generation of dustfall 68.3% (R-Sq = 68.3%), while in the laboratory measurement of wind speed of 0.8-1.3 m/s affects dustfall generation 61.7% (Fig. 6). The minor influence of the wind speed on the dustfall generation in the field measurements could be due to other factors that were not taken into account in this research. Besides the wind speed, meteorological factors that could influence the measurement of dustfall directly in the field are temperature, relative humidity and atmospheric pressure[13]. Based on the research Naddafi *et al.* [18], direct influence of relative humidity on dustfall generation formed in the field was as much as 58.1%, whereas influences of wind speed and soil moisture content were 66.9% and 52.8%, respectively.



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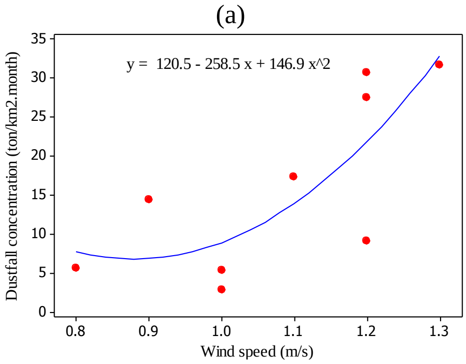
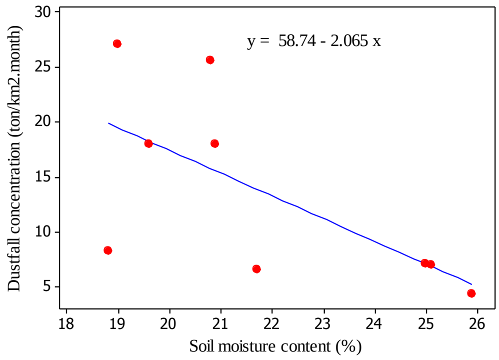


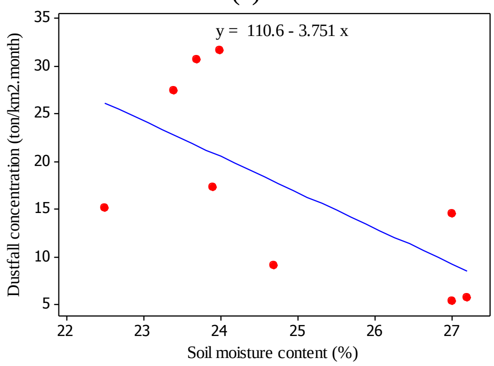
(b)

Fig-6: Correlation between dustfall vs. wind speed on Entisol soil in the field (*a*); and in the laboratory measurement (*b*)

In contrast to the results of measurement on the Andisol soil, dustfall generation on Entisol soil on measurements in the field and in the laboratory did not show a significant difference. Measurement of dustfall generation on Entisol soil conducted in open land for housing development in Karawang Municipality relatively far from the settlement and/or trees, as well as the relatively same weather conditions at the time of measurement (the dry season) resulted in the outside factors that affect measurement in the field becomes lower. The result of analysis correlation on Entisol soil showed that soil moisture content affect 42.8% of dustfall generation on the measurements in the field and 42.1% on the measurements in the laboratory (Fig. 7.)



(a)



(b)

Fig-7: Correlation between dustfall vs. soil moisture content on Entisol soil in the field (*a*); and in the laboratory measurement (*b*)

Dustfall generation and the percentage of land cover also have a negative correlation on Entisol soil as shown in Fig. 8. Measurement of dustfall generation on Entisol soil conducted at the soil moisture content levels of 24.2-29.9%. As in the measurement of Andisol soil, Fig. 8 shows that the percentage of land cover which is effective in reducing the generation of dustfall from the surface of the soil $\leq$ 30%. The addition of land cover greater than 30% not affect significantly to decrease dustfall generation in ambient air.

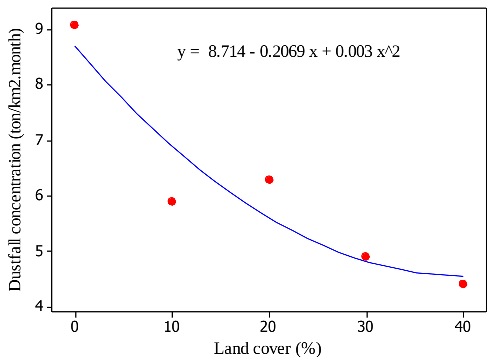


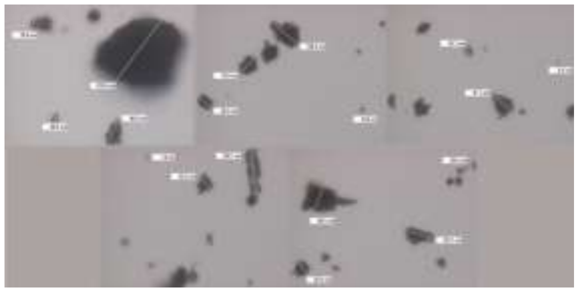
Fig-8: Correlation between dustfall vs. land cover on Entisol soil

Besides wind speed and soil moisture content, the dustfall generation in the field was influenced by soil texture and the C-organic content as well. C-organic content of the soil affects the physical properties of the soil as it serves an adhesive force between the soil particles, and soil texture is an important factor in soil erodibility for determining soil texture consistency, cohesion and soil mobility[19]. Based on the test results of soil texture, soil clay content on Entisol soil is 32.26%, 31.37% dust and 36.37% sand.

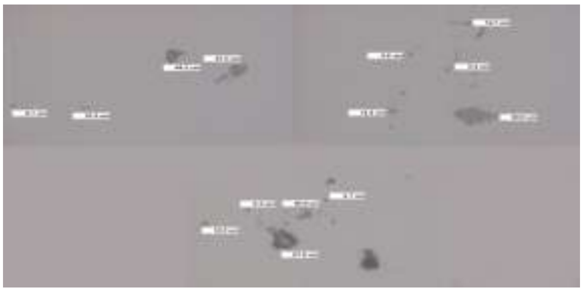
Estimates The Negative Impact of Dustfall Generation

Based on the particle size distribution of dustfall generation on Andisol and Entisol soil as shown in Fig. 9, it can be estimated that the negative impacts of dustfall generation on human health on Entisol soil higher than soil type of Andisol because dustfall of Entisol soil has a high fine particle size (63.7%). According to Laghari *et al.* [20], about 30% of respiratory diseases and 0.5 million deaths a year caused by high concentration of dust fine-sized at ambient air. In addition, according to Portmann [21], particles between 10 and 50 µm deposited in the alveoli, while smaller particles and larger more efficiently stored in the higher regions of the respiratory tract.

The negative impacts of dustfall generation Andisol soil on human health is suspected low because of a particle and its size of coarse relatively high (84%). However, the generation of dustfall with the size of coarse particles relatively high as Andisol soil can be lowered productivity plants and lower value of the property because dustfall that undersized larger will quickly settles and disrupt the process of photosynthesis. Coarse-sized of dustfall can reduce visibility and can interrupt when occurring deposition in plants, building, vehicles, water tank, and disturbing ecosystem [5].



(a)



(b)

Fig-9: Dustfall particle size distribution of Andisol (*a*); and Entisol soil (*b*)

The other factors that affects the negative impacts of dustfall generation from land surface is the composition and chemical structure which plays a role in the differential toxicity of dustfall. Dustfall raised from the land surface may consist of minerals like feldspar, quartz, *phyllosilicates* in various forms of crystals, carbonate, sulphate, phosphate, salt, and heavy minerals such as *pyroxenes* or *amphiboles* [21]. Based on Smith and Lee[1], the main component of the soil surface can be found in the dustfall in ambient air, although not always in equal proportions.

CONCLUSION

The conclusion of this research:

1. Generation of dustfall correlated positively with wind speed and correlated negatively with soil moisture content and the percentage of land cover.
2. a. Effect of wind speed on the dustfall generation Andisol soil in the field measurement was 23.2% and 84.3% in the laboratory measurement, while on Entisol soil was 68.3% in the field measurement and 61.7% in the laboratory measurement.
   b. Effect of soil moisture content on the dustfall generation Andisol soil in the field measurement was 29.4% and 59.4% in the laboratory measurement, while on Entisol soil was 42.8% in the field measurement and 42.1% in the laboratory measurement.
   b. Effect of land cover percentage of dustfall generation on Andisol soil was 84.5% and Entisol soil 87.6%.
3. Negative impact of dustfall generation of Entisol soil on human health allegedly higher than Andisol soil because size fine particles on dustfall Entisol soil are high (63.7%), so that such particles can be

stored in alveoli and disrupt respiratory system. Dustfall of Andisol soil allegedly low impact on human health but the impact of the decrease in visibility, disruption of the process of photosynthesis and ecosystem is high due to particle and its size of coarse relatively high (84%).

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