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Suppression of Soil Dust Emissions from Large-Scale Construction Sites Using Starch and Polyvinyl Alcohol

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ABSTRACT

Soil dust emitted from large-scale construction sites in urban areas impacts air quality and creates a severe health threat to residents. Water spraying is commonly practiced to lower dust emission in construction sites, but its long-term effectiveness is questionable. In this study the utility of starch, polyvinyl alcohol (PVA), and a blend of starch and PVA in various proportions was investigated for the suppression of soil dust emissions at construction sites in Seoul. The efficiency of each dust suppressant was tested with test soil samples in a laboratory-scale wind tunnel box under different concentrations of suppressants and soil textures. Starch and PVA showed superior ability to suppress soil dust emissions compared to moistening bare soil, resulting in PM_{10} lower than the daily limit values of 30 μg/m^3. PVA showed higher soil dust suppression capability for all conditions over starch. Test soils sprayed with dust suppressants significantly improved aggregate stability compared to untreated soils.

KEYWORDS

PM_{10}, Polyvinyl Alcohol (PVA), Soil Dust, Starch, Suppressant

INTRODUCTION

Dust emission is a generic term for dust that is emitted directly into the atmosphere without a certain discharge port (Cohen et al., 2005; Petkova, Jack, Volavka-Close, & Kinney, 2013). In general, dust in the atmosphere is made up of fine suspended particles that are less than 50 μm. These are called total suspended particles (TSP). The TSP includes less than 10 μm of particulate matter-10 (PM_{10}),

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and less than 2.5 μm of particulate matter-2.5 ($PM_{2.5}$). According to the 2015 National Institute of Environmental Science statistical data, TSP and PM_{10} are among the biggest contributors of pollution caused by dust emissions. Most air pollutants are primarily due to dust emissions. Recently, the National Institute of Environmental Science has mandated the forecast and broadcast of fine dust PM_{10} readings for the metropolitan area (Seoul, Incheon, and Gyeonggi) taking into account atmospheric environmental standards and health impacts. As shown in Table 1, based on the daily average, it is divided into four levels (Park, 2018).

In 2017, 97% (1,751) construction site locations, out of a total of 1,805 locations, reported soil particle scattering in Seoul. Most of the related complaints started at the construction site. Currently, there are intermittent water sprays, water-soluble salt sprays, dust covers, and dust nets being used as countermeasures against the emission of soil dust at these construction sites, but the effects are temporary, and more sustainable measures are required (Seo, 2011).

Starch, a water-soluble natural polymer substance, has a polymer structure consisting of several hundred monomer units. Amylose in the polymer is connected through a straight chain, and amylopectin is connected through a branch chain in the form of a tree branch. Amylose shows a tendency to easily retrograde and precipitate upon cooling. These structural features are biodegradable (Priya et al., 2014) and non-toxic (Lu, Wang, Li, & Huang, 2018; Wang, Li, Copeland, Niu, & Wang, 2015).

On the other hand, polyvinyl alcohol (PVA) is a water-soluble surface-active polymer that has excellent film formation, adhesive properties, and it is biodegradable (Priya et al., 2014). PVA, when applied to soil particles, binds the soil surface giving an adhesive effect and also increasing the moisture retention quality of the soil by increasing the capillarity of the dust emissions (Sadhu, Soni, Varmani, & Garg, 2014). Due to these properties, starch and PVA were selected as dust suppressants in this study. The researchers devised a laboratory-scale, small wind, box tunnel and copied various application conditions and field conditions to investigate the dust suppression effect of starch, PVA, and a mixture of starch and PVA. In addition, the correlation between changes in the formation of soil dust due to the action of dust suppressants and dust suppression efficiency was analysed.

EXPERIMENTAL

Soil Sample

Soil samples for the experiment were collected at six construction sites in Seoul, as per the soil pollution process test method outlined by the Ministry of Environment. Soil was collected from a total of five topsoil layers (0-15 cm), one sample was taken at the centre point, and other samplings, 5-10 m away from the surrounding four directions of the centre point sampling, were the targeted areas in the selected construction sites (Adhikari et al., 2016).

The soil texture of the soil samples was analysed using the sieve analysis method, experimental determination of the drag coefficient, and Stokes' Law equation, which was developed by the United States Department of Agriculture (USDA) (Stokes, 1901). Soil collected from the site was stabilized at room temperature after first removing thick gravel and foreign matter of about 4-5 mm or larger. The soil was dried in the oven, cooled at room temperature, and then a soil suppressant was uniformly sprayed on the soil surface with a compressed sprayer. The processed soil was then used for the experiment after a drying period of 8 h or more:

Table 1. Daily limit value for PM_{10}

Dust Concentration ($\mu g/m^3$, day)	Good	Normal	Bad	Very Bad
Fine dust, PM_{10}	0~30	31~80	81~150	151~

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