MCODP: A NEW METHOD FOR ENVIRONMENTAL POLLUTION REDUCTION

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ABSTRACT

In this article, a new method for environmental pollution reduction (dust reduction) in construction sites using Monte Carlo method and a mathematical model is explained and presented. The main carrier of dust is local wind in construction sites. Wind is caused by differences in pressure. When a difference in pressure exists, the air is accelerated from higher to lower pressure and carries the dusts around. Winds and also dust transferring can be defined by an equilibrium of physical terms. Dust is a fact that you can see, taste or smell. The air around us is constantly filled with dust. Most of us would probably say we are surrounded by dust. The dust sources in a construction site should be determined and explained. The findings show that all the operators in a dust mathematical model exhibit nonlinearity. And, dust mathematical model is a deterministic model and supposed to be static model. Results show that it does not account for the element of time.

Key words: Monte Carlo, mathematical model, dust, nonlinear, mobilization.

Introduction

Often when engineers analyze a system to be controlled or optimized, they use a mathematical model [7]. In analysis, engineers can build a descriptive model of the system as a hypothesis of how the system could work, or try to estimate how an unforeseeable event could affect the system. Similarly, in control of a system, engineers can try out different control approaches in simulations [19].

Pollution normally is a general name for solid particles with diameters less than 500 micrometers. Particles in arise from various sources such as soil dust lifted up by wind as an air pollution. Dust contains small amounts of many materials which may be found in the local environment [1,9,6,9,14].

A place dust exist on all surfaces and even in the air. Different mites can be found in the local dust. They excrete enzymes to digest the organic particles, and excrete feces, that together become part of the house dust, and may irritate allergies [5].

Alternately, the hygiene hypothesis posits that the modern obsession with cleanliness is as much a problem as house dust mites. The hygiene hypothesis argues that our lack of prior pathogenic exposure may in fact encourage the development of ailments including hay fever and asthma [8,17].

Dust is widely present in the galaxy. Ambient radiation heats dust and re-emits radiation into the microwave band, which may distort the cosmic microwave background power spectrum. Dust in this regime has a complicated emission spectrum, and includes both thermal dust emission and spinning dust emission [4].

The total dust that can be produced by a project is influenced by its site mobilization; therefore, the use of optimized mobilization helps to keep dust down.

Large projects such as dam construction involve different facilities including batching plants, crushing plants, etc. Moreover, controlling their facilities and choosing the best arrangement of them for dust controlling are extremely complicated. While, there is no simple solution to find the effects of dust in a site mobilization. Thus, in this paper the a mathematical model for dust is achieved and presented.

Materials And Methods

Dust pollution:

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment.

Indoor air pollution and urban air quality are listed as two of the world's worst pollution problems in the 2008 Blacksmith Institute World's Worst
Polluted Places report [18]. An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or manmade [19]. About 4 percent of deaths in the United States can be attributed to air pollution, according to the Environmental Science Engineering Program at the Harvard School of Public Health.

**Mathematical model:**

Mathematical modeling is a method of simulating real situations with mathematical equations to forecast their future behavior. Mathematical modeling uses tools such as decision theory, queuing theory, and linear programming, and requires large amounts of number crunching. It is also called computational model [13].

A mathematical model is an abstract model that uses mathematical language to describe the behavior of a system [16]. Mathematical models are used particularly in the natural sciences and engineering disciplines (such as physics, biology, and electrical engineering) but also in the social sciences (such as economics, sociology and political science); physicists, engineers, computer scientists, and economists use mathematical models most extensively [15].

**Dust mathematical model classifying:**

Dust mathematical model can be classified as follows: It is assumed to be a nonlinear model. Mathematical models are usually composed by variables, which are abstractions of quantities of interest in the described systems, and operators that act on these variables, which can be algebraic operators, functions, differential operators, etc. If all the operators in a mathematical model exhibit nonlinearity, the resulting mathematical model is defined as nonlinear [11].

Dust mathematical model as a deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables [3].

Dust supposed to be static model. A static model does not account for the element of time, while a dynamic model does. Dynamic models typically are represented with difference equations or differential equations [2].

**Mathematical model of dust:**

According to dust mathematical model classification, which is mentioned previously, the mathematical model (%D=dust effect coefficient) were be assumed as equation 1.

\[
%D = \frac{(R - r) (\theta - \phi)}{R \frac{\Pi}{2}}
\]

In which R is the maximum distance between the dust source and site plan border's points. And, r is distance between the dust source and the point which is considered to calculate the dust effect at it. Also, \((\theta - \phi)\) is angle differences between wind direction and a line between source point and target point (Figure 1).

Figure 2 shows a dust mathematical model. In the model the dust source is located at (1,1) and R is assumed to be (2)^1/2.

**Monte Carlo Optimization Of Dust Pollution (Mcodp):**

Monte Carlo methods (or Monte Carlo experiments) are a class of computational algorithms that rely on repeated random sampling to compute their results. Monte Carlo methods are often used in simulating physical and mathematical systems. Because of their reliance on repeated computation of random or pseudo-random numbers, these methods are most suited to calculation by a computer and tend to be used when it is unfeasible or impossible to compute an exact result with a deterministic algorithm.

Monte Carlo simulation methods are especially useful in studying systems with a large number of coupled degrees of freedom, such as fluids, disordered materials, strongly coupled solids, and cellular structures (see cellular Potts model). More broadly, Monte Carlo methods are useful for modeling problems with significant uncertainty in inputs, such as optimization. These methods are also widely used in mathematics: a classic use is for the evaluation of definite integrals, particularly multidimensional integrals with complicated boundary conditions. It is a widely successful method in risk analysis when compared with alternative methods or human intuition. When Monte Carlo simulations have been applied in space exploration and oil exploration, actual observations of failures, cost overruns and schedule overruns are routinely better predicted by the simulations than by human intuition or alternative "soft" methods.

The Monte Carlo Method uses random numbers to determine the answer to problems. The Monte Carlo method usually gives an approximate answer, and we should use a large number of trials to find the exact answer. This method is used to solve complicated problems in many areas of engineering by generating suitable random numbers and observing that fraction of the numbers that obeys some properties. Analyzing using this method has six steps. Generating a parametric model, generating a set of random inputs, evaluating the model and finding inputs that obeys model properties (live
points), repeating step 1 to 3 (trials), and finding the probability which is given by equation 2.

\[
\text{RESULT} = \frac{\text{LIVE POINTS}}{\text{ALL POINTS}}
\]  \hspace{1cm} (2)

Results And Discussion

An example:

In this section a sample site plan and different facilities are assumed. Facilities considered in the site mobilization are presented in Table 1. And, The site plan topography is shown in Figure 3.

Figure 4 shows the changes of dust coefficient in a sample site. As it can be seen from the results, the site mobilization and facilities places are really important and they can have effects on the dust pollution in the construction site.

As it can be seen from results, the quantity of the facilities affect the dust pollution coefficient in a site. Results show that the optimized quantity of the facilities can be achieved by the MCODP method.

It is also clear that using MCODP method the dust pollution can be reduced about 80 percent. While, results show that the dust pollution can even be ZERO using this method.

Table 1: Facilities

<table>
<thead>
<tr>
<th>Facility</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batching plant</td>
<td>3</td>
</tr>
<tr>
<td>Crushing plant</td>
<td>3</td>
</tr>
<tr>
<td>Dormitory</td>
<td>2</td>
</tr>
<tr>
<td>Office</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>Parking</td>
<td>2</td>
</tr>
<tr>
<td>Cement silo</td>
<td>2</td>
</tr>
</tbody>
</table>

Conclusions:

The dust modeling frequently poses challenges in areas of engineering. Dust can effects environment and workers health and dealing with this type of problem is really important. Dust is one of the most important parameters that can be harmful for workers. In this article, main sources of dust production in construction sites and mathematical model of dust are explained and presented. The findings show that:

A. All the operators in a dust mathematical model exhibit nonlinearity, the resulting mathematical model is defined as nonlinear.

B. Dust mathematical model as a deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables.

C. Dust supposed to be static model. and does not account for the element of time.

D. The quantity of the facilities affect the dust pollution coefficient in a site.

E. Optimized quantity of the facilities can be achieved by the MCODP method.

F. Using MCODP method the dust pollution can be reduced about 80 percent.

G. Dust pollution can even be ZERO using MCODP method.

Fig. 1: Wind direction
Fig. 2: Dust mathematical model

Fig. 3: Sample project site plan

Fig. 4: Dust coefficient changes

References


