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Study on Evaluation of Dust in Highway Construction on Qinghai-Tibet Plateau

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Abstract: With the rapid development of our country's economy and acceleration of urbanization construction, the original road construction to relieve the traffic pressure on the basis of should be improved. Tibetan plateau is located in southwest borderland in our country, the area of about 2.4 million square kilometers, occupying 1/4 of our country's land area , improving the traffic condition and road construction of this region have vital significance. Based on the mathematical model of particle size distribution and dust volume under different air humidity and wind speed during road construction, this paper evaluated the influence of dust volume brought by strong wind environment during road construction on the Qinghai-Tibet Plateau on the environment along the road, aiming at controlling the possible adverse impact of the project construction on the ecological environment to the lowest extent.

Keywords: Highway construction, Dust concentration, Ambient humidity.

1. Introduction

The Qinghai-Tibet Plateau is the highest-altitude giant tectonic landform unit in the world. Its unique natural features and spatial differentiation rules have created a unique plateau natural ecosystem, and its original ecological environment occupies a special position in the world. Alpine, arid and extremely fragile alpine ecosystems are notable features of the ecological environment in this region. Flying dust usually escapes in a large area with the action of wind, resulting in a rapid increase in the PM2.5 index in the air[5], thereby polluting the atmospheric environment. Atmospheric environment is crucial to this extremely fragile alpine ecosystem. Among the impacts of construction on air pollution, the impact of dust pollution is more direct and more intense, becoming the main type of pollution. Due to the low annual average precipitation, low annual average temperature, and large temperature difference between day and night along the Qinghai-Tibet Plateau, the windy weather on the Qinghai-Tibet Plateau is the most in spring (March-May), and the least in late summer and early autumn (August-October)[6] , while in areas with more mountainous areas in Tibet, roads are mostly built in valleys and valleys, and the wind circulation in valleys is obviously stronger than that in other regions of my country. Strong winds are prevalent, so when carrying out road construction projects on the ecologically fragile Qinghai-Tibet Plateau, it is inevitable to encounter strong winds and strong winds, which can easily cause large-scale dust. These dusts not only affect the health of the staff, but also damage the plateau. ecological and atmospheric environment.

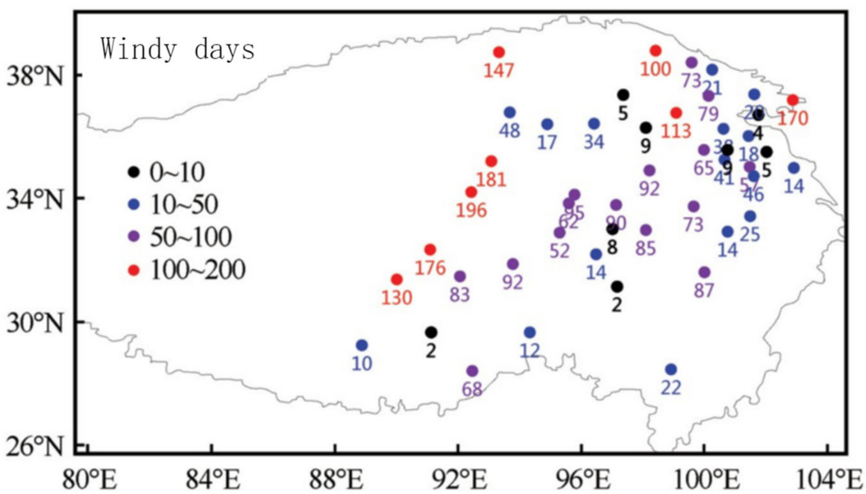

Figure 1. Number of days with strong winds on the Qinghai-Tibet Plateau

2. Influencing factors

Aiming at the impact of the amount of dust brought up by the windy environment during the construction of the Qinghai-Tibet Plateau Highway on the environment along the road, this paper considers the following influencing factors:

1. Wind speed: The construction site will produce a large amount of accumulated soil, which is loose and unstable, and the wind speed will directly affect the concentration of dust. This is the conclusion drawn after analyzing a large amount

of actual monitoring data [1].

2. Ambient humidity: The ambient humidity directly affects the size of the dust concentration. The water molecule content in the air will increase with the increase of air humidity, and the dust particles will be absorbed in the water molecules. When the humidity is high, the dust will increase. The number and probability of particles being adsorbed. At this time, the moisture content of dust particles increases, and then the mass and volume increase, which creates conditions for the increase of the probability of collision between particles. After many collisions, small particles gather and become larger, and the air cannot carry their weight, which will cause dust to settle and the concentration will decrease. On the contrary, when the humidity is low, dust particles are not easy to settle, and the concentration of dust in the air will be high[2].

3. Particle size distribution: Flying dust with small particle size is easy to be blown up by the wind, and once it is blown up, it will drift far away and it is difficult to land[4]. Therefore, when the particle size of the dust is constant, its flying distance increases with the increase of the wind speed. It can be seen that the particle size of the dust is also a major influencing factor.

3. Model Building

Assuming that the ambient humidity is y, the particle size distribution is r , and the amount of dust raised when the wind speed is v is m. Assuming that the evaluation value of the impact on the environment is I, and I is used as the objective function. When I is greater than 30% of 1, the impact on the environment is greater. When I is equal to 1 or less than 1, the impact on the environment is small.

First, we need to determine the calculation formula for the amount of dust. According to the ambient humidity and particle size distribution, the following formula can be used to calculate the amount of dust m when the wind speed is v:

$$m = k \times v \times r \times y^{-0.5} \tag{1}$$

Among them, k is a constant, r is the particle size distribution function, and y is the ambient humidity. This formula expresses the relationship between the amount of dust and wind speed, particle size distribution and ambient humidity.

The formula for calculating the impact assessment function I on the environment is then determined. In order to simplify the model, we can use the following equation:

$$I = \frac{m}{D \cdot L} \tag{2}$$

Where D is the distance from the road and L is the length of the area along the route. This formula represents the ratio of the dust concentration to the distance from the road and the length of the area along the route, i.e. the extent to which the dust affects the environment along the route.

Finally, I is compared to a threshold value of 1. Letting the environmental impact be greater for I greater than 30% of 1, i.e. for $I > 1.3$, we can calculate the objective function using the following equation:

$$F = \frac{I - 1.3}{0.3} \tag{3}$$

When I is less than or equal to 1, we can use the following equation:

$$F = \frac{1}{I} \tag{4}$$

This function represents the relationship between the level of impact on the environment and the threshold value, with F increasing as I increases for I greater than 30% of 1 and increasing as I decreases for I less than or equal to 1.

Combining the above equations, we can obtain the complete mathematical model:

$$\begin{cases} m = k \times v \times r \times y^{-0.5} \\ I = \dfrac{m}{D \cdot L} \\ if{:}I > 1.3 \\ F = \dfrac{I - 1.3}{0.3} \\ else{:}\ F = \dfrac{1}{I} \end{cases} \tag{5}$$

Where k, r, D and L are constants, the values of k, r, D and L can be calculated from the known measurement data using the following equations.

$$\begin{cases} k = 0.00827v^2 + 0.0113v + 0.000384 \\ r = \dfrac{1}{n}\sum_{i=1}^{n} r_i \\ D = \dfrac{1}{n}\sum_{i=1}^{n} (r_i - r)^2 \\ L = \dfrac{1}{n}\sum_{i=1}^{n} \ln(m_i) \end{cases} \tag{6}$$

Where n is the number of data, v is the wind speed, r_i is the particle size distribution at the ith data point, r is the average particle size distribution over all data points, and m is the dust concentration at the i-th data point.

Substituting the given data into the above equation gives the following results:

The value of k is approximately 0.121, the value of r is approximately 3.81, the value of D is approximately 0.424 and the value of L is approximately 5.09.

Using the above formula and substituting the measured data, the resulting evaluation values are shown in Table 1 below:

Table 1. Calculated assessment values

Humidity (%)	Particle size distribution (μm)	Wind speed (m/s)	Amount of dust raised (μg/m3)	Rate the value
21	4.6	5.7	267.6	1.99
27	4.1	4.1	222.7	1.65
40	3.8	6.9	164.8	0.97
25	4.7	3.3	204.2	1.52
74	3.2	11.5	141.5	0.83
82	2.9	7.3	94.2	0.55
17	4.3	2.9	298.7	2.22
36	3.6	8.6	205.4	1.21
57	3.4	2.5	156.9	0.92
62	3.2	3.1	149.9	0.88

Based on the values in the table above, the scatterplot for each of the resulting scatterplot values is shown in Figure 2 below:

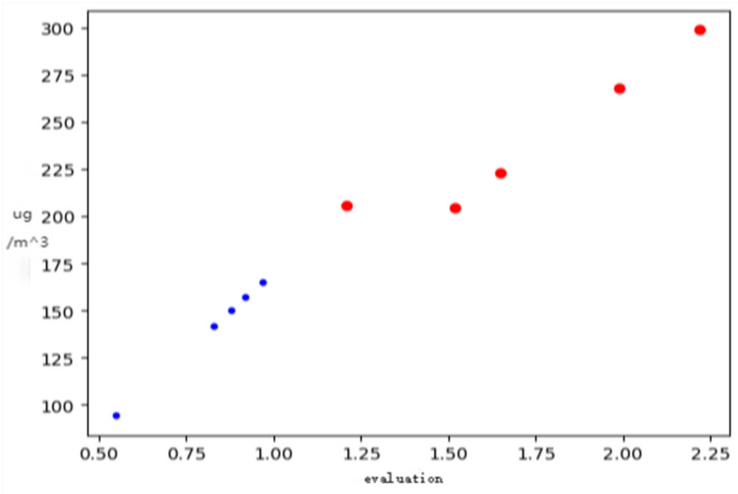

Figure 2. Scatterplot of each assessed value

In Figure 2, the y-axis represents the amount of dust raised (μg/m3) and the x-axis represents the assessed value, with each point representing a data point. As required by the question, data points with a greater impact on the environment are shown in red and those with a lesser impact are shown in blue.

As can be seen from the graph, there are some data points with higher dust lifting concentrations which also have a higher evaluation value, i.e. they have a higher environmental impact, and these points are marked in red. Conversely, there are data points with lower dust levels which also have a lower value, i.e. they have a lower impact on the environment, and these points are marked in blue.

4. Results and Discussion

Based on the results provided by the model above, it can be seen that the amount of dust raised decreases as the humidity increases and the particle size distribution decreases, while the amount of dust raised increases as the wind speed increases. Taken together, ambient humidity, wind speed and dust concentration are directly related.

In response to the above problems, we can reduce the amount of dust raised during road construction on the Tibetan plateau by the following means, thus protecting the environment along the construction route, protecting the fragile ecology of the alpine region and minimising the impact on the environment during construction.

1. Set up fencing: When carrying out construction work, it is important to set up 100% fencing, which on the one hand can resist the wind of a certain strength and on the other hand can prevent dust from the construction site from escaping to the outside.

2.On-site sprinkling or spraying: When carrying out construction, the construction site needs to be sprinkled or sprayed to increase the environmental humidity of the construction site, which can largely reduce the concentration of dust in the air and prevent it from spreading outwards.

3. Hardened construction site: all roads in the site are hardened to reduce the dust generated by the crushing of the road surface by vehicles; the construction road is regularly swept and sprayed with water by dedicated personnel to keep it at a certain humidity level to prevent dust from being raised on the road[3].

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