

PRELIMINARY STUDY ON SAND-DUST STORM DISASTER AND COUNTERMEASURES IN CHINA

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ABSTRACT: As a kind of natural disasters, sand-dust storms frequently occur in deserts and their surrounding areas. The occurrence of this disaster in China's northwest and north China has exerted an extremely adverse effect upon the environment in China. The management of sand-dust storms is of a systematic project closely related with the environment such as agriculture, ecosystem, forestry, water conservancy, meteorology and other aspects. Therefore, studies of the formation, the basic features, causes, temporal-spatial distribution, developing-trend and related disasters of sand-dust storms in China are conducted based on satellite data. The experience of sand-dust storms control and countermeasures in the United States and some other countries are referred. Meanwhile, preliminary countermeasures relating to sand-dust storms in China are proposed.

KEY WORDS: sand-dust storm in China; spatial and temporal distribution; meteorological disaster; countermeasures of sand-dust storms

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Sand-dust storm is a special natural disaster that frequently occurs in deserts and their surrounding areas. In last two years or so, both the frequency of the sand-dust storms occurrence in the northwest and north of China and the intensity have probably not been seen in the same period of China's history. Beijing and more than ten other provinces, cities and autonomous regions were affected and the affected area is equal to about half of China's territory. Therefore, this disastrous phenomenon is one of the most serious environmental problems confronting China in the 21st century, which has been attracted attention to.

1 CHARACTERISTICS OF SAND-DUST STORMS AND THEIR HARM

1.1 Classification of Sand-dust Storm

The phenomenon of sand-dust storm is a combination of both sandstorm and dust storm, which refers to a kind of weather phenomenon that enormous amount of surface sand and dust is blown by strong wind into the air, and made the air turbid, with its horizontal visibility below 1km. The sandstorm refers to a kind of

strong wind with large amount of suspended substances of surface sand, while the dust storm refers to that with large amount of dust and other kind of particles' substances.

The sand-dust storms could be classified into three grades, i. e. suspended dust phenomenon, dust blowing phenomenon and sand-dust storm according to meteorology. The suspended dust phenomenon refers to the suspending dust in the air under non-wind condition or under low wind condition. Under such conditions due to the suspended dust and sand, the horizontal visibility would be below 10km. In general, under such condition large amount of dust and fine sand particles suspending in the air are transported in the upper air from long distance, while the blown-dust phenomenon causes the air turbid and its horizontal visibility below 1 – 10km. Referring to the sand-dust storms, the suspending sand and dust in the air are caused by strong winds and made the air turbid and its horizontal visibility below 1km. As it is known that the severe sand-dust storms (instantaneous wind velocity over 25m/s, wind force over 10 grades) made the air turbid with surface horizontal visibility below 50m, and can cause maximum damage(YIE *et al.*, 2000; ZHANG, 2000).

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1.2 The Temporal-spatial Distribution of China's Sand-dust Storms

In general, sand-dust storms occur in deserts and their surrounding arid and semi-arid areas as well. There are four major sand-dust storm regions all over the world, where storms frequently occur. The four regions are Central Asia, North America, Central Africa and Australia. In China, there are four major sand-dust storms' source regions i. e. the Hexi Corridor in Gansu Province and the Alxa area in Inner Mongolia; the Sandy land areas along the northwest Great Wall in Shaanxi, Inner Mongolia, Ningxia and Shanxi provinces, and their surrounding arid farming areas; the area of north Beijing, and the eastern parts of Hunshandake, Hulun Buir; Sandy land in the Inner Mongolia and the surrounding areas of the Tarim Basin in Xinjiang. In distinguishing a region is whether a sand-dust storm source region or not, there are the following scientific criteria i. e. the number of days and intensity of the sand-dust storms annually, the amount of surface substances of the storms, and the ecological deterioration within the source regions. The occurrence of such storms within the four regions in the past 50 years is over fifteen times, among which at least one was severe sand storm with large amount of surface substances.

In China, sand-blowing weather occurs within a broader area than that of the sand-dust storms, besides the northwest, north, northeast and the Qinghai-Xizang Plateau, such storms may affect Sichuan Basin and the northern parts of the Nanling Mountains.

According to the analysis of the satellite remote sensing images three major tracks of the sand-dust storms affecting China were deduced. The first one is the west track, which passes over the Pamir and then enters into the southern part of Xinjian Basin and then moves eastward, affecting Qinghai and Gansu provinces. The second one is the Northwest route, which travels through northern Xinjian and western region of Mongolia and then enters into China, affecting Xinjiang, Qinghai, Gansu, Ningxia, Inner Mongolia, Shaanxi and other regions. The third one is the northern route, which comes from Lake Baikal or central Mongolia and east Mongolia and then enters into China, mainly affecting Inner Mongolia, Gansu, Ningxia, Shaanxi and North China. The sand-dust storms affecting Beijing mainly originated from Alxa League, Bayannur League, Ulanqab League and Xilingele League of Inner Mongolia, northern Hebei Province and the Loess Plateau. These sand-dust storms affecting Beijing have three routes, as follows:

1) Hunshandake sandy land of the Inner Mongolia → Heihe valley in Hebei Province → Beijing region; 2) Zhurihe of Inner Mongolia → Yanghe valley in Hebei Province → Beijing region, and 3) The eastern part of Shanxi Province → Beijing region(WANG, 2000).

In fact, there have been sandstorms since the ancient times. Studies of the core under the deep sea suggested that there existed sandstorms 2.5 – 3 million years ago, that is the Tertiary period. Historical records of sand-storms in China could seen in the years of 1150 B. C. Statistics show that sandstorms weather in northwest China has become even more serious. A thousand years ago the rate of sandstorm occurrence was one time one hundred years, while in the 1950s there were 5 times, in the 1960s there were 8 times, in the 1970s there were 13 times, in the 1980s there were 19 times, in the 1990s there were 23 times, and in the year of 2000 only there were 12 times.

The occurrence rate of sandstorms in China shows that there is the maximum numbers in spring, which accounts for one half of the whole year round, and the number in summer is less, while in autumn it is minimum. In consideration of monthly rate, April has the maximum, March and May less while in September it has the minimum. In northwest China, the occurrence of sand-dust storms in the afternoon and late afternoon accounts for 65.4%, while in the morning it accounts for 34.6% (QIAN, 1993; LI, 2000; ZHENG, 2001).

1.3 The Harm of Sand-dust Storms

As it is known to all, sand-dust storms, the severe sand-dust storms in particular is a kind of disastrous weather phenomenon which has caused severe disasters in China. Therefore China has been one of the most severest sand-dust storms-stricken countries in the world. For instance, each year China may loses 540 000 million yuan due to the sand-dust storms.

The harm of sand-dust storms can be classified into four forms, such as sand burying, wind erosion, strong wind damage, and severe air pollution.

Sand burying: severe sand storms' movement with their enormous amount of sand and other substances could bury farmland, residential buildings, factory buildings, transportation structures and water sources, waterways and so on.

Wind erosion: severe wind force may bring large amount of sand and dust, therefore damage the fertile farmland and make it no more productive.

Strong wind damage: the combination of sand and strong wind may up-root trees, damage buildings and

other structures, and cost severe losses of both human beings and livestock.

Air pollution: statistics show that each year suspended dust in the air around the world is about 2 – 200 tons due to the sand-dust storms. The sand-dust storms consist of various kinds of harmful and poisonous substances, which are pernicious to human beings, livestock, crops, grasslands and forests (ZHANG, 2000; QIAN, 1993; ZHENG, 2001; JU, 1993; FANG, 1997).

2 CAUSES OF SAND-DUST STORMS' FORMATION

There may be three basic causes for the formation of sand-dust storms. One is strong wind, the second is dry and loose surface sand-dust substances, and the third is unstable air. Combination of the three factors would cause the formation of sand-dust storms. Among the three factors, the second one—the strong wind is a dynamic force which causes suspended and blown sand, while the sand and dust sources provide the storms with substances. Meanwhile, the unstable air with downward and upward convection currents provide important thermodynamic condition. Therefore, it could be said that the combination of specific weather and geographical conditions could produce sand-dust storms.

The specific general circulation patterns over the Qinghai-Xizang Plateau provide the sand-dust storms in northwest China with dynamic conditions.

Coarse sand particles with a diameter of 0.5 – 1.0mm could be blown up in the air with a height of about several ten centimeters when the wind speed is 30m/s. Fine sand particles with a diameter of 0.125 – 0.25mm could be blown up in the air with a height of about 2 meters, and large particles with a diameter of 0.05 – 0.05mm could be blown up even higher.

Sources of sand can provide the sandstorms with a substantial base. In recent years due to impact of global climate change the northern regions in China have become drier and in winter it is warmer. What should be noted are the impact of human activities (such as denudation, unreasonable reclamation, over grazing and misuse of water resources, etc.). Consequently, these sorts of activities have damaged vegetation of large areas, and meanwhile desertification has become even worse. Thus substantial sand sources have been created for sand-dust storms.

Thermodynamic conditions for sand-dust storms are created by unstable air. Our daily life experience may have approved this factor and make it easy to be understood. Besides the three factor mentioned above it is

well known that large-scale mining processes, construction activities and so on could create and produce enormous substances of sand and dust.

There are also other important social factors that cause sand-dust storms. For instance, in some regions there exist certain mistakes in decision-making and incorrect management and coordination and mechanism of development no longer has any effect (YIE, 2000; ZHANG, 2000; ZHENG, 2001; JU, 1993; FANG, 1997; XIA, 1994; JU, 1996; HE, 2000).

3 TENDENCY OF THE FUTURE CHANGE

Analysis of global climate models suggests that in the future several decades with the impact of global warming, precipitation will have no more distinct changes but the temperature will rise distinctively and the surface evaporation will increase at the same time and soil will become arid in the hinterland of the mid-latitudes in the northern hemisphere. This sort of climatic background is beneficial to the formation of sand-dust storms. This together with the unreasonable usage of land resources made the situation even worse, therefore it is difficult to bring about a radical change in the situation. This situation is also closely related to the deterioration of grasslands and water resources shorgatel. Therefore, all of these facts deserve our affection.

Results of the scientific investigation conducted jointly by the State Environment Administration and the Sand-dust Storm Investigation Team of the Chinese Academy of Sciences, suggest that according to the comprehensive situation of resent ecosystem and climate change, in the next few years sand-dust storms in China will increase and will make the situation even worse. Therefore, it is an urgent task for us to prevent and take measures in controlling sandstorms.

4 SAND-DUST STORMS ABROAD AND EXPERIENCE OF PREVENTION

Activities of human beings and the damage of ecosystem have induced the occurrence of sand-dust storms. The well-known sand-dust storms occurred in west America and the former Soviet Union (Kazak, Siberia, and the Urals) were all due to wanton reclamation.

The west region of America used to be a boundless prairie with green grass where the American Indians had been living for generations. However, during the period of 1866 through 1890 about 9000km² of grassland were reclaimed wantonly by the emigrants, thus induced de-

sertification.

The world known 1934 sand-dust storm event was a typical disastrous event. During that period, there existed about 40 tons of sand and dust per cubic meter, and about three hundred million tons of soil was thrown into the Atlantic, about 4500km² of farmland become deserts and 16 000 farmers were forced to leave their houses and migrated from the great plain in west America.

From 1954 to 1963, 6000km² of grassland were reclaimed in the former Soviet Union (i. e. the Kazak region, Siberia, the Ural region, the Volga Valley and parts of the Caucasus region). Because of unreasonable farming and the arid climate the reclaimed farmland was seriously damaged by wind erosion. The loose surface soil in spring each year would produce large amount of substance for the formation of sand-dust storms. For example, only in 1963 in the Kazak region, the area affected by sand-dust storms was about 2000km² accounting for 80% of the reclaimed area.

The Sahara desert is also well known for its severe sand storms. For instance, in the year of 1805, a commercial team consisting of 2000 people and 1800 camels were all engulfed by sand-dust storms there.

The sand-dust storm events mentioned above suggest that human activities not only have certain negative impact upon environment but have also brought great damages to human beings both in life and property. Man should draw lessons from those events. Man should not always demand and extort mother nature only for man's present benefits. We should give our mother nature a change of rehabilitation. Otherwise, man will be surely retaliated by nature.

In dealing with the extra-severe sand-dust storms the American people have become even wiser. The U. S. Congress has adopted a resolution for the long-term investment in dealing with desertification in the west America. Measures adopted are as follows, for example, reclamation activities are forbidden, and farmland into grassland and those areas are protected as national parks of conservation. All kinds of measures have been practised just to reduce the rate of sandstorm occurrence.

The measures adopted in the Kazak region of the former Soviet Union are mainly to grow grass instead of farming in the reclaimed areas. As a result, the impact of sand-dust storms on those areas has been reduced.

Foreign experience from which China should learn is mainly as follows, one is to protect the surrounding grassland around the deserts and adopt measures to prevent the desert from expanding. The second is that

instead of farming grass should be grown and instead of farming livestock grazing should be encouraged. The third is that to the method of soil protection (i. e. less farming, stop faming or crop rotation) . And the fourth is to grow shelter-forests.

5 COUNTERMEASURES IN DEALING WITH THE SAND-DUST STORMS

For years, in dealing with desertification in China great achievements have been obtained. However, it is still far behind the speed of desertification. At present, desertification area in China is about 2 620 000km². Therefore measures of combating desertification should be strengthened while relative laws and regulations should be formulated and implemented. "Law of Grassland Management", "Law of Forests", "Law of Soil Protection" and "Law of Desertification Prevention and Control" should be perfected. At the meantime, the relative leadership, organizations and management should also be improved in order to make the whole situation better. Man induced eco-damages should be forbidden while the relationship between man and nature should scientifically co-ordinate and keep a balance.

The task in dealing with sand-dust storms is a long-term activity with well planned and managed strategy and tactics. At present, the management and control of the sand-dust storms' source effecting Beijing should be the most urgent thing. The desert area of Hunshandake in Inner Mongolia, the desert grassland area in northern Beijing, the Yinshan wind erosion area, the Yianbei area in Shaanxi Province and desert areas in north China should be under well treatment and management. The establishment of the Beijing-Tianjin Green shelter should be accelerated and perfectly managed.

The eco-system in west China is fragile. The strategy of development in the opening up of west China should put the eco-environment protection and improvement in the first place. In dealing with the sand-dust storms in west China the ecological-economic-social benefits should be well combined and coordinated.

The sand-dust storm is a kind of natural phenomenon that man cannot control especially its occurrence and die out.

However, through man's scientific activities the rate of occurrence and intensity of these disastrous events could be reduced. The sand-dust storm is a product of the deteriorated eco-environment. The fun-

damental way in dealing with sandstorms is to reduce or eliminate the sand sources which provide sandstorms with enormous sand and dust substances. Improving environment, protecting vegetation, building shelter forests growing grass, practicing scientific farming and livestock grazing, etc. are effective measures in dealing with the sand-dust storms. The experience in Inner Mongolia suggests that growing grass instead of faming and shelter forests are two effective measures in reducing wind speed. Statistics show that with 70% of vegetation cover the surface wind speed can reduce by 62.8%, therefore the dynamic force of sandstorms can be reduced effectively.

In dealing with the sand-dust storms a method of combination of the earth science, the environmental science and other sciences should adopted. Mechanism of the storm's movement and disasters should be revealed by the studies of the interaction between atmosphere, geosphere, ecosystem and other factors. Researches on feedbacks of population resource, environment disasters should be conducted and improved. Through researches on the coupling relationship between desertification and sand storms and the characteristics of time and space for strong winds, adjusting functions of ecosystem and the eco-environment toward the sandstorms disasters prevention and reduction under the climate condition could be solved step by step. The traditional and passive system of "disaster prevention-disaster relief" should be broken through, therefore a new systems should be then formulated. That new system should be an effective and dynamical "eco-management-disaster control" one which is suitable for sustained development. At present, the key research points should be placed on the environment of the storm's resource and the law of the storm's movement. Researches on the storm's distribution, formation, mechanism, monitoring and forecasting and prevention techniques should be conducted and improved as well, so as to provide the government decision-making with scientific basis.

The management of sand-dust storms is a systematic project, which is closely related with environment, agriculture, meteorology, grassland, ecosystem, forestry, water conservancy and other aspects. Therefore, co-ordination and cooperation should be practised. Meteorological departments concerned should take measures to improve and perfect surface observation system, upper-air sounding system, weather-radar observations, meteorological satellite observation, weather communication and sand-dust storms forecast, monitor-

ing and forecasting system. Timely and accurate information of sandstorms is very helpful to the arrangement of production, communication and the people's daily life, and thus the damage and losses induced by sandstorms may be reduced to the minimum.

Moreover, public education about the management of sand-dust storms should be conducted to cultivate public consciousness and responsibility in order to protect mother nature and the living environment(ZHANG, 2000; WANG, 2000; ZHENG, 2001; ZHAO *et al.*, 2000).

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