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On the influence of sand–wind on atmospheric environment

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Abstract — The authors seek, through tests on simulated sand samples in a wind tunnel and analysis of minerals combination and trace elements, to discover the environmental implications of flying–up, falling–down and concentration variation as a function of natural wind speed and direction, distance of movement, range and extent of influence on the atmospheric environment, of micro–granular components on the ground surface in the Keerqin desert area in northwest Liaoning Province of China.
Keywords: sand–wind; granular grading; wind tunnel simulation; atmospheric environment; dispersion.

INTRODUCTION

There is 1951 km^2 of wind–eroded land in Liaoning Province. Over 80% of it is located in Zhangwu region which is the southern extension of Inner Mongolia Keerqin desert. Wind erosion and sand flying–up cause desertification of soil and degeneration of grassland and badly affect both agricultural and industrial production and transportation; the drifting sandy dusts cause severe air pollution.

This paper reveals the extent, range and principle of variation in a certain time and space of air pollution caused by sand and dust blown from Keerqin desert so as to provide a scientific foundation for preventive and protective measures for the transformation of desert land and the development of production.

METHOD OF RESEARCH

We visited the sandy region twice to investigate the distribution of sand dune and desertized land. We collected samples at fixed sampling points, which were selected in ridge of field, or road which had no obstacles around and thus enabled sand and dust to fall freely onto them and kept unploughed in a relatively long time. One sample of surface soil and one sample of soil at a depth of 10 cm at each sampling point were taken. Altogether 8 fixed sampling points were selected in moving sand dune, semi–permanent and permanent dune, desertized land which was covered by crops during summer and autumn, and Shenyang suburban area at a distance of 140km from Aher township in Keerqin sandy region.

Simulated tests in wind tunnel were carried out to investigate granule grade ratio at each sampling point, starting velocity of wind for land dust of each granule grade, form of movement and principle of falling–down of sand–dust at each grade of strong wind which exceeds the starting velocity of wind. The granule grade ratio analysis was made by means of a timed auto–vibration screen to divide samples into six grades: thick (1.0–0.5mm), medium (0.5–0.25mm), fine (0.25–0.1mm), super fine (0.1–0.045 mm), thick powder (0.045–0.038mm) and

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fine powder (<0.038 mm) and determine their percentage content. Starting, blowing–flying and falling–down tests were made for each grade in the wind tunnel. The test section in the wind tunnel is plane rectangular with a length of 16m and a cross section of 1x0.6 m^2. A side illumination from iodine–tungsten lamp was provided, a thin obstruction was set at several centimetres in front of the inlet of the wind tunnel to observe and determine the heaping–up of the sand. Gradient observation was made by means of a wind–speed tube to determine the starting wind velocity for each grade of sand-dust.

Blowing–flying tests and falling–down tests were made in the same place. With wind at different velocity, the quantity of fallen dust was measured separately for various altitudes and the principle of dispersion and falling–down of sand – wind stream was thus determined.

In addition to the wind tunnel test, we also determined content in samples of trace elements as Ba, Be, Cr, Cu, Ca, Mn, Nb, Ni, P, Sr, Ti, V, Y, Zn, Zr, and oxides as Al_2O_3, Fe_2O_3, MgO, CaO by means of plasma spectrophotometry to investigate the dispersion range of sand–dust at different sampling points and the influence on the atmospheric environment in Shenyang region. The dispersion range of sand–dust in sandy area through analysis and comparisons for sand flying – up and falling–down velocities, mineral combinations and trace element content are also discussed.

RESULT AND DISCUSSION

Granule grade ratio and starting wind velocity of sand–dust

The region investigated is located in the downstream Liaohe plain with its surface covered by loose sediment of the Fourth Period. The zone from Keerqin Zuoyihouqi–Aher township – Zhanggutai – Fengjia is a sandy land distributed region which features mainly medium–fine sand; the zone from Fengjia to Zhangwu is a subsand land distributed region which features serious desertification; the zone from Zhangwu to Xinmin to Shenyang is also a subsand land distributed region but features light desertification. The diameter of sediment granule decreases along the direction from northwest towards southeast.

The movement of sand granules depends on several factors such as wind–force, topography, climate, vegetation, soil feature, stability of atmosphere and roughness beneath layer of sand, and among them, wind force is the major factor. The starting wind velocity for sand granule and logarithm value of mean granule diameter is in a relationship of dual minima. For those granules whose diameter is greater than 0.1mm, the starting wind velocity and logarithm value of mean granule diameter is in a positive correlation, whereas in case of less than 0.1mm, it will be in negative correlation (Fig. 1). The former is the result of gravity function, the latter is that of viscosity function. This is due to the enhancement of viscosity and coagulation between the super–fine sand granules and thus the sarting wind velocity for sand–dust is increased. This situation is basically identical with that of Bagnold.

It is seen that the sand granules in the investigated region would move in great quantity only at a wind velocity of around 5.5m/s.

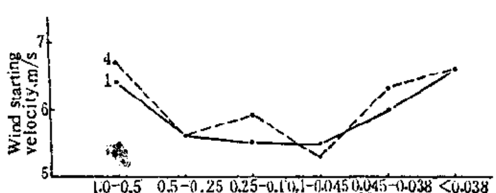

Fig.1 Curve of relationship between wind starting velocity of sand granule and average granule diameter

Characteristics of blowing–flying and dispersion of sand–dust

The movement for those with a granule grade of over 0.25mm is basically bouncing, rolling but not flying–up, whereas those of below 0.25 mm especially below 0.1 mm fly up. The wind tunnel tests shown that the flying–up velocity of sand and dust with a granule grade of below 0.1 mm, especially from 0.1mm to 0.038 mm, has a tendency of slowing down gradually at the action of the same wind velocity along with the gradual reduction of granule diameter; whereas in case of less than 0.038mm, the moving velocity increases gradually as the granule diameter decreases (Fig. 2). This is basically identical to the result of experiments of Chepil (Vanoni, 1975). 0.1mm is the granule diameter with which the dust and sand most easily start their movement. The average flying–up velocity of sand–dust is 75 percent of the wind velocity.

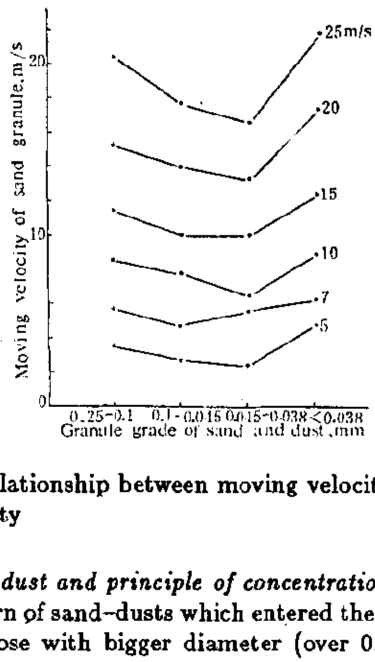

Fig.2 Curve of relationship between moving velocity of sand-dust and indexed wind velocity

Dispersion range of sand-dust and principle of concentration variation

The movement pattern of sand–dusts which entered the wind stream after flying up changes with their diameter. Those with bigger diameter (over 0.25mm) could only roll, wriggle or bounce near the ground surface, those with finer diameter (below 0.10mm) could fly up with the wind. The dispersion range of dust in horizontal and vertical directions, and concentration decrease all have a close relation with the granule diameter and wind velocity.

Table 1 Relationship between granule diameter of sand–dust and Relationship between granule diameter horizontally, vertically dispersed distance

Granule diameter,	Falling–down speed	Time of residence in air, t	Horizontal moving distance, L	Max. moving height, H
0.001	0.0083	0.95-9.5 Year	4.5×10-4.5×10 km	7.75-77.5km
0.01	0.824	0.83-8.3h	4.5-450km	78-775m
0.03	7.416	0.5-5.8h	35-350km	54.6-546m
0.045	16.686	0.46-4.6h	25.5-275km	42.9-429m
0.1	82.4	0.3-3s	4.5-45m	0.78-7.75m

Virtical dispersion range and concentration variation principle of sand–dust: The vertical dispersion range and concentration variation principle discussed in this paper are mainly for those particles with a granule grade of from 0.045 – 0.038mm or less than 0.038mm. Although these two grades of sand and dust account for only a very small part of the total percentage of sand–dust, because they could disperse for a relatively long distance, and affect the atmospheric environment greatly, so the research into them is of importance. The dispersion height of sand – dust relates closely to the granule diameter and wind velocity at different heights: the finer the granule and the greater the wind velocity is, the higher the sand–dust disperses.

Dispersion height of sand – dust: as calculated according to the Von Karman mathematical model, at the action of wind with a velocity of 15m/s, the residence time in air, flying distance and height of sand–dusts differ greatly along with their granule diameter. For those with a diameter of 0.1 mm, the maximum moving height is 0.78 – 7.75m, those of 0.01 mm is 78–778km and those of 0.001 mm is 7.75 – 775km (Table 1). The average maximum height for the two granule grades of 0.045 mm and 0.030mm could reach 48.75 to 487.5 km respectively.

Wind velocity and dispersion speed of sand – dust at each altitude: In a certain range, the wind velocity increases gradually along with the increase of the altitude. In the range from ground level to 1000m altitude the average wind velocity increment coefficient of each altitude varies from 2.2 to 3.6, i.e., wind velocity at each altitude is about 2.2 to 3.6 times of that at the corresponding ground surface (Table 2). Sand–dust at each altitude disperses along with the wind at a speed which is 75 percent of that of the wind. Within the same place, the variation principle of vertical dispersion of sand–dust is the same as that of the wind in same direction (Fig. 3).

Table 2 Average wind velocity at each altitude

Height, m	Ground	100	200	300	500	600	700	900	1000
Increment coefficient		2.2	2.6	3.1	3.3	3.5	3.4	3.6	3.6
Wind	10	22.0	26.0	31.0	33.0	35.0	34.0	36.0	36.0
velocity,	15	33.0	39.0	46.5	49.5	52.5	51.0	54.0	54.0
m/s	20	44.0	52.0	62.0	66.0	70.0	68.0	72.0	72.0

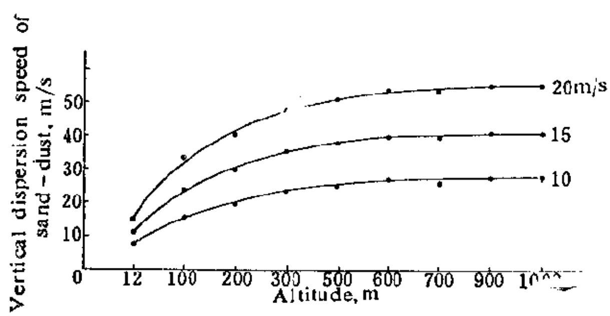

Fig.3 Curve of relationship between vertical moving velocing of sand–dust and altitude

Vertical concentration variation principle of sand–dust: The wind tunnel tests and aerial measurement showed that the vertical concentration of sand–dust reduces gradually along with the increase in altitude; its variation principle can be expressed by the following equation:

$$N = No.e^{(-H/a)},$$

where: N—concentration of sand–dust in air at altitude H (mg/m^3);
No—concentration of sand–dust near ground surface (mg/m^3);
H—height to ground surface (m); a - experimental constant.

For the selection of a value for ' a ', we take 837 for our study and adopt 10.8 mg/m^3 as a maximum and 1.32mg/m as mean concentration which are used as original concentration to calculate the variation principle of sand–dust at different altitude. The calculation shows that concentration at the altitude of 500m corresponds to 55 per cent of that at ground surface, at 1000mm corresponds to 31 percent of that at ground surface. This shows that the concentration of sand–dust is clearly in an inverse relation to its altitude (Fig. 4).

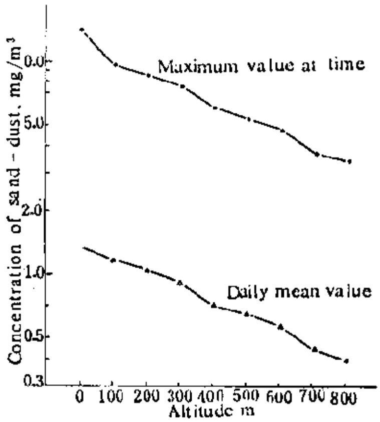

Fig. 4 Curve of variation of mean concentration of sand–dust with altitude

Horizontal dispersion range and concentration variation principle of sand–dust

Sand–dust dispersion range in horizontal direction: In horizontal direction, the dispersion speed, concentration and range of sand–dust in the wind direction have an extremely close relation with many factors such as wind velocity, granule diameter of sand–dust, characteristics and cross angle to wind direction, presence of wind breaks, roughness of soil beneath land surface, topography, and so on. With other conditions unchanged, the dispersion distance of sand – dust is in negative correlation with its granule diameter, i.e., it increases along with the decreasing of granule diameter, the finer the granule is, the further it flies away.

In the leeward of sand–wind stream the closer to the sand source the area is located, the more the sand–dust would accumulate with greater granule diameter, the more severely deserted the land would be and the higher the concentration of sand–dust in the atmosphere would be. A further distance from the sand source would lead to reduction of the problems and the granule diameter of sand–dust would become smaller. The annual wind direction frequency in Keerqin sandy region of S, SSW, WSW, SW is 34, and of N, NNW, WNW is 33, almost the same for the two major wind direction frequencies, i.e., sand and dust in the sandy region generally move towards northeast and southeast. Through analysis of and comparison between practically measured data of Liaoning Provincial Windbreak and Dune Fixation Research Institute, our wind tunnel tests data and experimental data, it has been shown that the dune moves towards northeast and southeast with a speed of 2m per year which results in further desertification of land year by year in these two directions.

Variation principle of concentration in horizontal direction: For the land–dust concentration decreasing rate in the horizontal direction, we took the concentration decreasing rate in vertical direction as a reference, and referred to the results of wind tunnel tests and the relation between granule diameter and flying distance, and deduced an equation for it:

$$C = C_0 \cdot e^{-L/b},$$

where: C—sand–dust concentration in the air at a horizontal distance L from sandy region (mg/m^3); C_0—atmospheric sand–dust concentration near ground surface in sandy region (mg/m^3); L—horizontal distance from sandy region (km); b—experimental coefficient (65 for investigated region).

The mean sand–dust concentration of sand stream in tail wind direction indicates a variation principle of decreasing by index function (Fig. 5). When the sand–dust stream, with an original concentration of 10.8mg/m near ground surface in sandy region, moves to the west boundary of Shenyang at the action of wind with a velocity of 10 m/s, its mean concentration decreases to a level of 1.25 mg/m^3, when it moves a distance of 140km, the concentration decreases to 11.6 per cent of the original value, i.e., 88.4 percent of sand–dust falls down along the way.

Sand–dust flying–up amount in Shenyang urban area: As calculated with its mean velocity, the sand–wind stream needs 0.2 hour to fly across Shenyang. With this and the concentration difference across Shenyang, the total amount of fallen sand–dust can be obtained through calculation. The subsided sand–dust per hour is 111 tons from calculation. If the measurement is made for 4 hours on each sand–wind day and 14 NW–direction sand–wind days per year, there should be 1234 tons sand–dust deposited on Shenyang (Table 3).

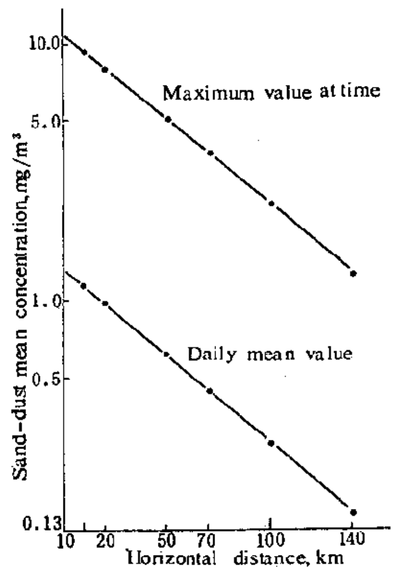

Fig.5 Curve of variation of sand–dust mean concentration in horizontal direction

But the actual amount of deposited sand–dust is far more than this calculated value because of the high buildings, big roughness of ground surface and serious industrial pollution in Shenyang urban region which leads to the reduction of moving speed of sand – wind stream, speed–up of sand–dust deposition and the increase of amount of deposited sand–dust.

Sand–wind which has moved across Shenyang continues to move southeast. Sand–dust at 500 – 600m altitude is forced to slow down and subside at the obstruction of mountains of over 1000m above sea level in Liaodong region. Those with a granule diameter of or below 0.001mm could fly over the mountains and enter the atmosphere above the Pacific Ocean due to their high suspension.

The above–mentioned results of calculation are based on a maximum quantity of 10.8 mg/m^3 of sand – dust at one time near the ground surface in the sandy region as its original concentration and 10 m/s as its original wind velocity. The concentration of sand – dust when entering Shenyang is 1.25 mg/m^3 which equals 57 percent of the peak value of total suspended granules in spring in a control area in Shenyang (2189 mg/m^3), 25 percent of that in communication area (4965 mg/m^3) and 12.8 percent of that in industrial area (9787 mg/m^3) (Table 4). If calculation was based on a mean value, the percentages would decrease greatly and among them that in the control area would be the maximum and that in the industrial area the minimum. This is because the high content of pollutants in the industrial area and big difference as compared with the content of sand–dust entering Shenyang. The pollutant content in the control area is rather low which shows no big difference.

If the sand–dust of the sandy region is picked up by ground wind with a velocity of 15 m/s, it would follow the air stream more quickly (Altena, 1978).

The soil granules in the ground surface become thinner gradually from mid–fine sand to sub–sand soil along the line from Aher township to Shenyang; in particular, the area from Zhangwu to Shenyang is of subsand distributed region. This region features in high content of powder sand and viscous powder, in dry spring season and under a condition of no vegetation on the ground, the land is easily eroded by strong wind. At other times, the land desertizes severely year by year due to the subsiding of sand–dust from upper stream, and also due to the action of wind force, the loose granules of surface layer of land move towards lower stream. As a result, the land is not only affected by subsiding but also eroded by wind, and the subsiding and erosion take place some times simultaneously, some times alternately. Generally speaking, those sand granules to be blown away are finer and those remaining are coarser. There is a vast expanse of desert in the northwestern part of Liaoning Province, the topography of the Shenyang region is flat and soils are loose; each year in this region there are over ten sand–wind days–all these lead to a repeated, long term subsiding and erosion which make the land deserted constantly and the atmosphere be polluted unceasingly. The nibbling' desertification would develop even further as a result of air pollution.

Mineral composition and elements features

We made analysis and measurement for mineral composition and trace elements of sand samples taken from each sampling point along the investigated line by means of plasma spectrophotometry in order to get a better understanding of the range and extent of the reaction of sand–dust from Keerqin sandy region to atmospheric environment, and to verify whether there is a wide regional relation for sand–dust. The result of our analysis is as follows.

Feature of mineral composition

Heavy minerals in sample of particle size 0.5 – 0.25 mm mainly are: amphibole, garnet and magnetite, with some minor ones: pyroxene, spinel, zircon, tourmaline and haematite. The content of amphibole reflecting mineral feature of sand–dust decreases qradually from northwest to southeast.

It is notable that industrial dusts of flake type, thread type, filament type and irregular type, and micro–fine ball type magnetite can be found in thick granule samples and the content of them has a tendency of increasing gradually from Zhangwu to Shenyang, especially that of magnetite which reaches 21 percent in Shenyang region. This is because of the industrial dust diffusion towards northwest following the air stream.

The fact that the content of amphibole and magnetite varies in opposite direction reflects the northwestern sand–wind Shenyang industrial dust influence each other at the action of strong winds from the opposite direction.

Table 3 Amount of subsided sand-dust when sand-wind moves across Shenyang

Atmospheric sand-dust concentration near ground sandy region	Wind velocity near ground	Mean wind velocity of from ground to altitude of 500m	Mean moving velocity of sand-dust of from ground to an altitude of 500m	Mean concentration of sand-wind stream for each altitude (0–500m)	Width of sand wind stream	Time for sand-wind stream to Shenyang urban boundary*	Area of Shenyang urban region
mg/m	m/s	m/s	m/s	mg/m		h	km
10.80 (Max. value)	10	24.4	18.80	8.49	Hundreds, km	2.07	185
	15	36.6	28.20			1.38	
1.32 (Mean value)	10	24.4	18.80	1.04	Hundreds km	2.07	185
	15	36.6	28.20			1.38	

Table 3 (continued)

Amount of subsided sand-dust in Shenyang urban region

Sand-dust concentration as sand-wind stream enters Shenyang urban region C1	Sand-dust concentration as sand-wind stream leaves Shenyang urban region C2	C1-C2	Time for sand-wind stream to fly across Shenyang	Subsided sand-dust ton/hour	Subsided sand-dust ton/year**
mg/m	mg/m	mg/m	h		ton
1.25	1.01	0.24	0.20	22.2	111.0
			0.13		170.8
0.15	0.12	0.03	0.20	2.78	13.8
			0.13		21.4

* Calculated with the distance from Aher township in sandy region to Shenyang of 140km.

** Calculated with 13.9 sand-wind days per year and 4 hours per sand-wind day.

Trace elements features

Form feature of sand-dust (0.1–0.038 mm) is difficult to differentiate under polarization microscope, but through plasma spectrophotometry analysis it is discovered that there are 14 trace elements, such as Ti, Mn, Al, Sr, Ba, V, La, P, Zn, Y and Be, and four oxides, Fe_2O_3, CaO, MgO and Al_2O_3 in the sample. Contents of all these elements tend to increase gradually from northwest towards Shenyang (Table 5). Through further analysis of content variation for each single element it is discovered that the element content differs in different regions: those regions such as Keerqin Zuoyihouqi, Aher township, Zhanggutai and Sihecheng are low value regions where the elements content is low and peak value elements are less; those regions near Xinmin and Zhangwu are mid–value regions where the peak value elements content increases, especially those elements as P, Ti, V, Mn, Ba, Sr; those regions of Yuhong, Masanjiazi in Shenyang are high value regions where both the content and peak value increase. The above mentioned variation shows a gradual increase of trace elements content from northwest towards southeast. Through combination and correlation analysis of these elements, the following pollution sources could be determined preliminarily:

Table 4 Ratio in percentage of sand–dust concentration of sand–wind stream entering Shenyang to practically measured concentration of local suspended granules

Season region	Industrial	Residential	Spring transportation	Cultural	control	Concentration of sand–wind entering Shenyang
5 days average, mg/m^3	1.560	1.025	1.082	0.586	0.704	0.15
Percentage, %	9.6	14.6	13.9	25.6	21.3	
One time Max., mg/m^3	4.787	6.251	4.965	2.894	2.186	1.25
Percentage, %	12.8	20.0	25.0	43.0	57.0	

Table 5 Relative content of abnormal elements in wafted dust in Shenyang region

No. of Sample	Region	Ti+Mn	V+Be+La	Al+Ca+Mg	Sr+Ba	La+Y	Zn	P	Sr	CaO	Ba
1.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2.		0.74	1.30	0.83	0.85	1.22	0.90	2.35	0.85	0.60	0.84
3.	Keerqin	1.24	1.64	0.96	1.02	1.37	1.52	1.80	1.05	1.50	1.02
4.	Zuoyikou-	0.93	1.28	0.96	1.00	1.22	1.03	1.92	0.99	0.90	0.91
5.	qi	1.04	1.36	0.97	1.05	1.20	1.10	1.38	1.09	1.08	1.05
6.	Fengjia	1.00	1.34	1.10	1.39	1.27	2.08	1.81	1.25	1.08	1.40
7.		0.74	1.09	2.06	0.96	1.09	1.04	0.94	0.98	1.00	0.95
8.		0.79	0.92	0.94	1.00	0.98	1.13	0.90	1.02	1.00	1.00
9.	Zhangwu	5.97	4.13	2.99	1.62	3.48	0.92	9.44	3.44	9.17	1.45
10.	Xinmin	5.85	4.83	3.04	1.74	3.74	6.04	4.42	3.76	9.17	3.03
11.		7.45	3.98	2.84	1.55	3.27	1.16	2.81	2.98	7.00	1.42
12.		7.02	3.66	2.05	1.52	2.82	1.41	2.41	2.50	6.25	1.42
13.	Masanjiazi	12.71	8.92	4.68	1.84	6.92	1.40	12.59	4.42	18.33	1.60
14.	Yuhong	15.93	9.64	4.51	3.09	6.36	1.60	7.77	3.23	14.25	1.59
15.		12.54	11.36	4.35	1.65	7.99	1.62	16.54	4.84	24.00	1.35
16.		12.53	12.06	4.61	1.82	9.18	1.59	15.80	4.98	27.83	1.52

Note: Content of sample 1 is taken as basic data for all abnormal elements so as to calculate relative content conveniently, and further with this obtained data to make drawings and carry out discussions

Iron and stell industry: Fig.6 shows that Ti+Mn is in positive correlation with V+Be+La, and increases along the line from Aher township to Shenyang. In Fig. 7 the relationship between Ti +Mn and Al+Ca+Mg reflects an identical feature. Fig. 6 reflects pollution caused by dusts of V, Ti and magnetite from iron and steel industry, Fig. 7 reflects pollution caused by refractory, auxiliary solvent dusts also from iron and steel industry – this is viewed from the relationship of characteristics of elements and combination of elements.

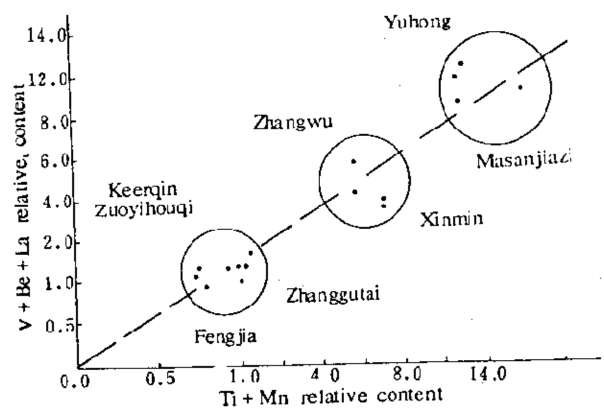

Fig.6 Iron and steel industry minerals dust pollution distribution

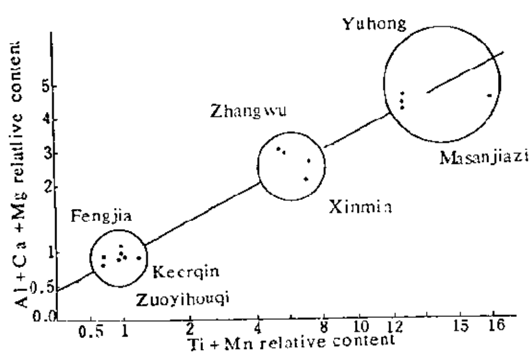

Fig.7 Iron and steel industry refractory materials dust pollution distribution

Rare elements and non-ferrous metal industry: Fig. 8 shows that the abnormal distribution of rare radioactive elements La and Y is closely related to the distribution of Zn. This proves clearly that during the smelting operation of Shenyang Smelter, non-ferrous metal elements and their associated elements dusts diffuse to a mid-distance in the leeward at the action of high chimney as a ' heat pump' .

Chemical industry: Fig. 9 shows that there exists an abnormal distribution of Sr and Ba along the line from Xinmin to Masanjiazi to Yuhong. Fig. 10 indicates the corresponding

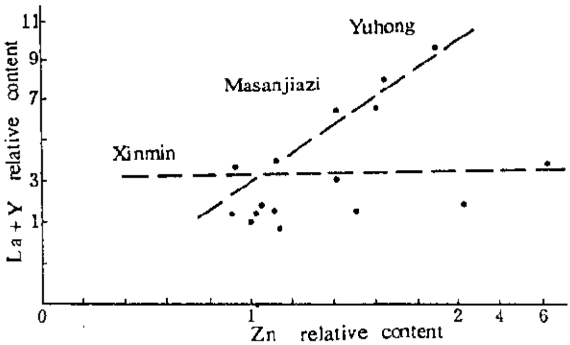

Fig. 8 Radioactive elements and non-ferrous metal industry dust pollution distribution

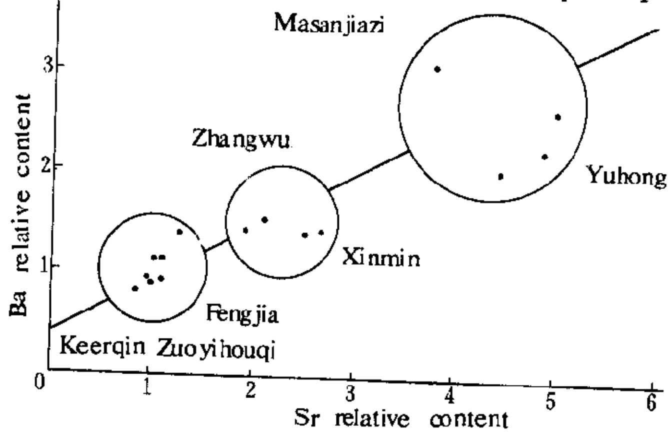

Fig.9 Distribution of dust pollution from chemical industry

relation between the said two elements and Al + Ca + Mg. That is to say, the increase of Sr and Ba is related to the pollution from Shenyang's chemical industry.

The above analysis shows that the dust of iron and steel, non-ferrous metal smelting and chemical industries in Shenyang affects the atmospheric environment in the leeward obviously under southeastern wind. Along with this wind, the pollutants diffuse towards northwest and gradually subside and accumulate onto the surface soil, in the principle of half life period of themselves. The pollutants could reach Zhangwu, resulting in a diffusion range of 100km in radius.

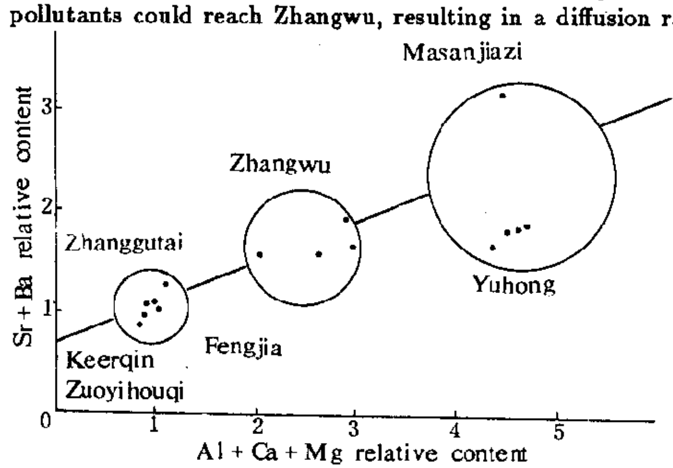

Fig.10 Pollution distribution of chemical industry

The element analysis of industrial dusts, their geographical distribution and the principle of content variation all prove that the industrial dusts affect Zhangwu region in a certain degree, but the sand–dust from desertized regions of Aher township and Zhangwu affect Shenyang region even more seriously at the action of strong wind. Frequency and velocity of wind in north and west directions both in Zhangwu and Shenyang are greater than that of wind in south and east directions, this is the reason why the axial distance of influence of sand–dust from northwest is greater than that of industrial dusts from Shenyang.

CONCLUSIONS

The mechanical composition of surface soil along the line from Keerqin sandy region to Shenyang changes from thick to fine and features in a principle of a gradual decreasing of percentage content of thick granule grade and a gradual increasing of percentage content of fine granule grade of surface soil.

The starting indicating wind velocity and logarithm value of mean granule diameter is generally in a relationship of dual minima, for those with a granule diameter of greater than 0.1mm, is in a positive correlation, and for those less than 0.1mm, a negative correlation.

The diffusion concentration of sand – dust decreases in an index–function relation along with the increasing of altitude and horizontal distance.

The followability of sand – dust to air stream is in a negative correlation with the granule diameter logarithm value.

The movement of sand–dust depends on granule size, sand–dust with a granule diameter of 0.1mm is easy to be eroded by wind, that with a size greater than 0.1mm would wriggle, bounce or slip, that with a size less than 0.1mm would suspend with air stream.

Sand–dusts on ground surface of Keerqin sandy region, which is 140km from Shenyang, affect atmospheric environment of Shenyang at the action of strong wind. The analysis of mineral combination and trace element to sand–dust shows that the industrial dusts from Shenyang also affect in a certain degree to Zhangwu which is 100km away.

Planting trees and fixing sand so as to inhibit sand–dust flying–up and the origination of sand–wind stream to a minimum extent is a most fundamental measure to prevent atmospheric environment from being affected by sand–wind.

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