20 卷 3 期 354 ~ 359 页
2002 年 6 月

山 地 学 报
JOURNAL OF MOUNTAIN SCIENCE

Vol.20, No.3 pp 354 ~ 359
Jun., 2002

文章编号:1008 - 2786(2002)03 - 0354 - 06

Analysis on the Regional Characteristics of Sand-dust Aerosol Over Tarim Basin

GAO Wei-dong[1, 2] and WEI Wen-shou[1]

(1. *Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi* 830011, *China*;
2. *The Graduate School of Chinese Academy of Science, Beijing* 100039, *China*)

Abstract: Aeolian dusts are common in Tarim Basin. The analyzed results show that the concentration of sand-dust aerosol in the atmosphere is much higher during aeolian dusts than that during the periods without aeolian dusts. During aeolian dusts, the percentage by weight of the fine particles in the atmosphere decreases over the Cele station but increases over the Aksu station due to the difference of the geographical locations. This proves that the fine materials are abundant in the sand-dust source regions and they are easy to be carried into the atmosphere to be as the main sources of the sand-dust aerosol during aeolian dusts. The curves of spectrum distribution of Al and other elements in the atmospheric aerosol over the Aksu station are unimodal, and the maximum values of the concentration vary in a range of 4.7 ~ 7.0 μm, which prove that the atmospheric aerosol particles over the locality are mainly from the local sand-dust sources. The analysis on the richly concentrating factors shows that the concentrations of all the crust elements in the atmosphere over the Aksu and Cele stations are higher during the aeolian dusts than that during floating dusts and in the background atmosphere. Moreover, the lower the visibility is, the higher the proportion will be, and the concentrations of the crust elements in the atmosphere are high during all the aeolian dusts.

Key words: Tarim Basin; aerosol; TSP concentration; spectrum analysis; analysis on the richly concentrating factor.
CLC number: P425.5+5; X16 **Document code**: A

Tarim Basin is located in the hinterland of Asia, is far away from the oceans and is surrounded by the high mountains. It is arid with less precipitation and sparse vegetation, and the moving dunes are extensively distributed in Tarim Basin. The area of sand deserts occupies about 60% of the total area of the basin, and Tarim Basin is one of the main source areas of aeolian dusts because of its peculiar climatic conditions and geographical location.

Aeolian dusts are common in Tarim Basin, especially during the period from April to June (Fig. 1). Sand and dust are the main source materials of the atmospheric aerosol over the localities. When an aeolian dust occurs, much sand and dust float in the atmosphere, and can be transported to north China and east China, and even farther.

The much sand and dust in the atmosphere not only impact the local environment, traffic, industrial and agricultural production, but also bring about the disadvantageous influences to people's health because they carry many noxious materials, germs and viruses.[1]

Based on the observed and analyzed results of atmospheric aerosol carried out by the Chinese-Japanese cooperative program of the research on aeolian dusts, this paper analyzes the physi-chemical properties of sand-dust aerosol over Tarim Basin so as to further analyze the

Received date(收稿日期): 2002 - 03 - 25.
Foundation item(基金项目): This work was supported by Chinese Academy of Science(Grant No. Kzcx 2 - 305 and Kzcx 1 - 10 - 07).
Biography(作者简介): GAO Wei-dong, M. A. candidate of Xinjiang Institute of Ecology & Geography CAS and the Graduate School of CAS. Research field: Arid Environment and Climate Change.

impacts of aeolian dusts to the environment.

1 Sampling of the samples of sand-dust aerosol[2]

For the Chinese-Japanese cooperative program of the research on aeolian dusts, the Andersen samplers of atmospheric aerosol are installed at Aksu Station for Water Balance Observation and Cele Desert Research Station, Chinese Academy of Sciences. The granularity of the sampled particles is classified into 9 grades: < 0.43, $0.43 \sim 0.65$, $0.65 \sim 1.01$, $1.01 \sim 2.1$, $2.1 \sim 3.3$, $3.4 \sim 4.7$, $4.7 \sim 7.0$, $7.0 \sim 11.0$ and > 11.0 μm. The samplers are installed on the meteorological observation tower of 34 m in height at the Aksu station. Both big-current air samplers (Sibata HV1000) and small-current Andersen aerosol samplers (Sibata AN200) are installed on the platforms of 7 and 17 m in height of the tower; at the Cele station, the samplers are installed on the top of the two-storey building. During the period from March to August, 2001, the atmospheric aerosols over the western and southern marginal zones of Tarim Basin were sampled twice a month during aeolian dusts and once a month during the periods without aeolian dusts.

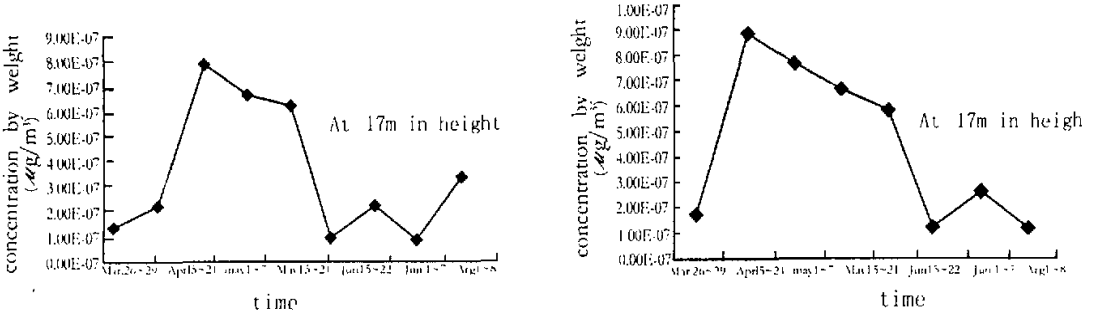

Fig. 1 Distribution of the TSP concentration in sand-dust aerosol at the different height over the Aksu station

2 Analysis on the samples of sand-dust aerosol

The samples are weighted by the precision electron balance made in Japan as soon as they are sampled, then they are put into the polyvinyl bags and sealed so as to avoid the artificial pollution.

The chemical analyses and tests are undertaken in Physical and Chemical Institute, Japan. The analyzing process is as following: one fourth of a sample is put into the ion pure water and oscillated by ultrasonic wave for 20 minutes so as to let the aqua-soluble compositions solve fully. Then the ion concentrations of the aqueous solution are analyzed. The concentration of NH_4^+ is measured by indophenol and that of other positive ions and Cl^-, NO_3^- and SO_4^{2-} are measured by ion chromatographic analysis. After the aqua-soluble ions are eliminated, the aqua-dissoluble compositions are put into acetic acid solution for eliminating carbonate. After that the acid-dissoluble compositions are put into the mixed acid composed of HF-$HCLO_4$-HNO_3 in a polytetrafluoroethylene cauldron and heated to 220℃ so as to let the acid-dissoluble compositions decompose completely. At last the concentrations of the main elements, such as Na, Mg, Al, K, Ca and Fe, are measured by an inductively coupled plasma atomic emission spectrophotometer.

3 The analyzed results and discussion

3.1 Analysis on the TSP characteristics of sand-dust aerosol

According to the analysis on the aerosol samples sampled at the platforms of 7 and 17 m in height at the Aksu station, the concentrations of the atmospheric aerosol particles in all sizes are much higher, about 5

times, during aeolian dusts than that during the periods without aeolian dusts (Fig.1), and about 7 times over the Cele station. The atmospheric TSP concentration during the aeolian dusts is much higher than that during the periods without aeolian dusts. During the aeolian dust on April 15, 2001, the atmospheric TSP concentration was 2044.33 $\mu g/m^3$ over the Aksu station, during the period without aeolian dust (March 23, 2001), however, it was only 332.19 $\mu g/m^3$, the former was 6 times higher than the latter; during the aeolian dust on April 20, 2001, it was 19865.46$\mu g/m^3$ over the Cele station, whereas it was only 212.7$\mu g/m^3$ during the period without aeolian dust (March 24, 2001), the former was about 93 times higher than the latter. During the aeolian dusts, the difference of the TSP concentrations between the two stations was great, that is the TSP concentration over the Cele station was 9.8 times of that over the Aksu station.

3.2 Analysis on the percentage concentrations of aerosol particles in different sizes

The proportion of the coarse particles in aerosol increases evidently during aeolian dusts. For example, the percentage by weight of the coarse particles (> 7.0μm) in aerosol increased for 6% during the aeolian dust on March 23, 2001 than that without aeolian dust (March 20, 2001) over Cele Station, and the peak values varied in a range of 4.7 ~ 7.0 μm. The atmospheric load increased during the aeolian dust, the concentration by weight of the coarse particles was higher than that of the fine ones, the peak values of the particles in different sizes still varied in the range of 4.7 ~ 7.0 μm over the Aksu station (Fig.2), but they changed to > 11.0 μm over the Cele station (Fig.3). Similarly, the percentages of the fine particles are obviously different between the Cele and Aksu stations. During the aeolian dust on March 18, 2001, the percentage by weight of the fine particles (< 1.01 μm) in aerosol over the Cele station was 0.12% less than that without aeolian dust (March 20, 2001); during the aeolian dust on April 15, 2001, the percentage by weight of the fine particles (< 1.01 μm) in aerosol over the Aksu station was 0.8% higher than that without aeolian dust (March 26, 2001) (Fig.4). The increase of the percentage of fine particles in aerosol over the Aksu station during aeolian dusts shows that the local sand and dust materials, especially the fine particles, are abundant and easy to be carried into the atmosphere under strong wind, and the proportion of fine particles can be up to 60% (Table 1). Whereas the percentage of coarse particles in aerosol over the Cele station increases obviously during aeolian dusts because this area is close to a sand desert and the sand-dust sources are abundant. Therefore, during aeolian dusts, the proportion of coarse particles in the atmospheric aerosol over the Cele region increases rapidly, whereas that of fine particles in the atmospheric aerosol over the Aksu region increases rapidly.

3.3 Spectrum distribution of the element concentration of sand-dust aerosol[3,4]

The elements in atmospheric aerosol can reveal their sources to a certain extent. Fig.5 shows the spectrum distribution of Na, Mg, Al, Ca and Fe at the different heights over the Aksu station on June 25, 2001. The curves of the spectrum distribution of these elements in aerosol are unimodal, and the maximum values of the concentrations vary in a range of 4.7 ~ 7.0 μm, which reveal that the atmospheric aerosol particles over the locality are mainly from the local sand sources, the concentrations of all the elements in the aerosol samples collected at the sampling platforms of 7 and 17 m in height respectively are quite similar, that is there is no change with the change of heights, and the total concentration of the aerosol over the Aksu station is much lower than that over the Cele station.

Table 1 The granular composition of sand in Taklamakan Desert (%)

Granularity	coarse sand	mid-sized sand	fine sand	extremely fine sand	silt
Average	0.02	4.54	34.15	41.97	19.32
Maximum	0.4	43.1	77.9	67.7	49.1
Minimum	-	-	4.9	5.9	3.3

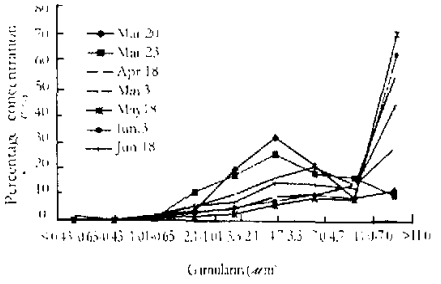

Fig.2 Spectrum distribution of sand-dust aerosol particles in the different size over the Cele station

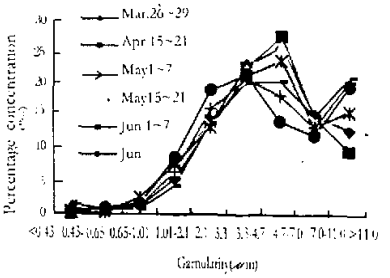

Fig.3 Spectrum distribution of sand-dust aerosol particles in the differe

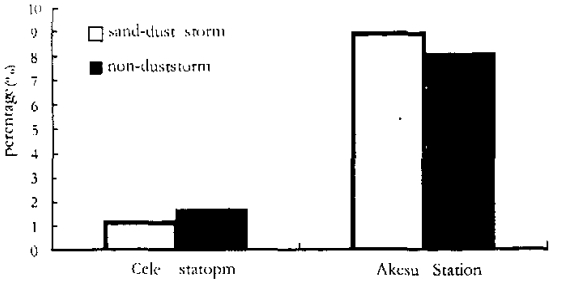

Fig.4 Comparion between the percentage concentrations of fine particals during aerolian dust and the period without aerolian dust

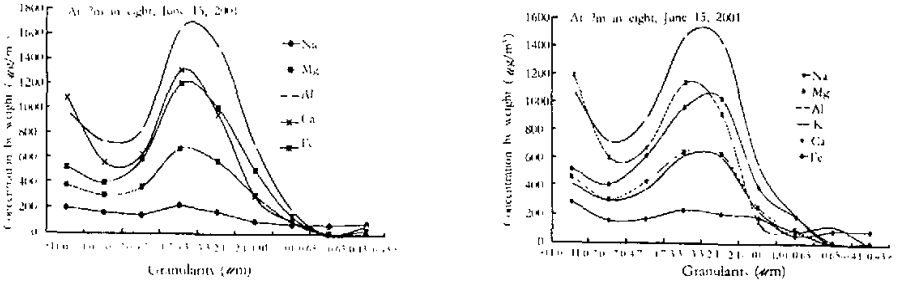

Fig.5 Spectrum distribution of the different elements in sand-dust aerosol particles over the Akesu station

3.4 Analysis on the characteristics of the elements in atmospheric aerosol[5,6]

The ratios of Fe, Na, Ca and K to Al characterize the characteristics of the elements in the atmospheric aerosol over Taklamakan Desert, the purpose is to integrate the differences of the meteorological elements, discharge quantity and transport processes. To take the concentration of Al as the standard is rational because it

does not change so great from the different regions. The results are given in Table. 2, which accord with the results obtained by Zhang Xiaoye, *et al*, and reveal that the desert is one of the main sources of sand-dust aerosol.

Table 2 The characteristics of the elements in the atmospheric aerosol over the Aksu station

Particle size(μm)	Na/Al	Mg/Al	K/Al	Ca/Al	Fe/Al
>11.0	0.21	0.39	0.32	1.11	0.54
11.0 - 7.0	0.22	0.41	0.36	0.77	0.55
7.0 - 4.7	0.17	0.44	0.34	0.75	0.70
4.7 - 3.3	0.136	0.41	0.33	0.794	0.72
3.3 - 2.1	0.12	0.39	0.342	0.64	0.68
2.1 - 1.01	0.14	0.43	0.37	0.42	0.72
1.01 - 0.65	0.39	0.49		0.52	0.72
0.65 - 0.43	14.99				1.90
<0.43	1.26				0.48

3.5 Analysis on the richly concentrating factor

In order to discuss the change characteristics of concentrations of the elements in the aerosol over the different regions, a richly concentrating factor, Ef_x[1-3], can be defined as

$$Ef_x = \frac{\left(\frac{C_x}{C_r}\right)_A}{\left(\frac{C_x}{C_r}\right)_R}$$

Where, C_x is the concentration of the element researched, C_r is the concentration of the element referenced, A is aerosol, and R is the element referenced.

In order to let the richly concentrating factors reflect the proportion of the elements researched in sand-dust aerosol, the elements referenced, such as Al, Ti and Fe, which are abundant in the crust matter and less polluted, are generally selected, and Al is selected as the element referenced in this paper. The richly concentrating factor calculated by taking the crust average as the reference matter is called the relative enrichment in the crust and that calculated by taking soil as the reference matter is called the enrichment in soil. The richly concentrating factors of Na, Mg, K, Ca and Fe over the Aksu station vary in a range of 1 ~ 3 (Table 3). It is proved that these elements are mainly from the regolith. The concentrations of the crust elements in the atmosphere over the Aksu and Cele stations are higher during aeolian dusts than that during floating dusts and in the background atmosphere. Moreover, the lower the visibility is, the higher the proportion will be, and the concentrations of the crust elements are high during all the aeolian dusts.

Table 3 The richly concentrating factors of the main elements in the atmospheric aerosol over the Aksu station

Element	$(C_x/C_r)A$	(C_x/C_r)	E_f
Na	0.49	0.31	1.59
Mg	0.57	0.23	2.50
K	0.38	0.30	1.24
Ca	1.11	0.44	2.51
Fe	0.59	0.57	1.03

4 Conclusions

(1) The concentration of sand-dust aerosol is much higher during aeolian dusts than that during the periods without aeolian dusts; the TSP concentration of sand-dust aerosol over the Cele station is much higher than that over the Aksu station during aeolian dusts.

(2) During aeolian dusts, the atmospheric load increases, the concentration by weight of coarse particles is higher than that of the fine ones, the maximum values of concentration of all the particles in the atmosphere over the Aksu station vary in a range of 4.7 ~ 7.0 μm, but they increase to >11.0μm over the Cele station.

(3) During aeolian dusts, the percentage of fine particles in the atmosphere over the Cele station decreases but increases over the Aksu station due to the different geographical locations.

(4) The curves of the spectrum distribution of Al and other elements in the aerosol over the Aksu station are unimodal, the maximum values of the concentrations vary in a range of 4.7 ~ 7.0 μm, and the concentrations of all the elements in the aerosol samples sampled at the platforms of 7 and 17 m in height are quite similar. Which proves that the particles of the atmospheric aerosol over the locality are mainly from the local surface sand sources.

(5) The analyzed results show that the richly concentrating factors of Na, Mg, K, Ca and Fe in the atmospheric aerosol over the Aksu station vary in a range of 1 ~ 3, which proves that these elements are mainly from the regolith. The concentrations of all the crust elements in the atmospheric aerosol over the two stations are higher during aeolian dusts than that during floating

dusts and in the background atmosphere. Moreover, the lower the visibility is, the higher the proportion will be. The concentrations of the crust elements are high during all the aeolian dusts.

Acknowledgements: This work was supported by Chinese Academy of Sciences (Grant No. kzcx2-305 and kzcx1-10-07)

References:

1. Niu Shengjie, Zhang Chengchang. 2000. Analysis on the chemical composition and the richly concentrating factors of sand-dust aerosol over Helanshan Mountain in spring. *J. China Desert Research*, 20(3): 264 ~ 268.
2. Zhang Chengchang, Zhou Wenxian. 1995. A Course of Atmospheric Aerosol. Beijing: Science Press.
3. Zhang Renjian, Wang Mingxing, Zhang Wen, *et al*. 2000. Study on the chemical composition and the spectrum distribution of aerosol over Beijing in winter and spring. *J. Climatology and Environment Research*, 5(1): 6 ~ 12.
4. Luo Yunfeng, Lu Daren, He Qing, *et al*. 2000. Analysis on the characteristics of the direct solar radiation, visibility and atmospheric aerosol over the coastal regions in south China. *J. Climatology and Environment Research*, 5(1): 36 ~ 44.
5. Zhang Xiaoye, Zhang Guangyu, Zhu Guanghua, *et al*. 1999. Tracer of the elements in the atmospheric dust over the source regions in China. *China Science*, 26(5): 423 ~ 430.
6. Zhuang Guoshun, Guo Jinghua, Yuan Hui, *et al*. 2001. Composition, sources and granular distribution of aeolian dusts over China in 2000 and their impacts to global environment. *Science Bulletin*, 46(2): 191 ~ 195.

塔里木盆地区域沙尘气溶胶特征分析

(摘要)

高卫东[1,2], 魏文寿[1]

(1. 中国科学院新疆生态与地理研究所, 新疆 乌鲁木齐 830011;
2. 中国科学院研究生院, 北京 100039)

摘 要: 沙尘天气是塔里木盆地区常见的天气现象, 对大气沙尘气溶胶的分析表明, 沙尘暴期间, 沙尘气溶胶浓度远大于非沙暴期间。对策勒和阿克苏两地的比较分析表明, 由于两地地理环境的差异, 沙尘暴期间, 策勒站细颗粒质量百分比呈下降趋势; 阿克苏站细颗粒质量百分比呈上升趋势, 说明沙暴期间由于当地沙尘源丰富, 细粒物质较多, 细粒物质迅速被携带到高空, 成为沙尘气溶胶的主要来源。阿克苏站大气气溶胶中 Al 等元素在不同高度的谱分布呈单峰型, 浓度最大值出现在4.7μm ~ 7.0μm范围内, 说明当地大气气溶胶颗粒主要来源于地表沙源。富集因子分析表明, 阿克苏站和策勒站沙尘暴和扬尘天气的各地壳元素含量均高于浮尘和背景大气, 而且能见度能见度愈小, 高出的比例愈大; 各种沙尘天气发生时, 均以亲地元素的浓度为最高。

关键词: 塔里木盆地; 气溶胶; TSP 浓度; 谱分析; 富集因子分析

注: 本文是在中国科学院重大创新项目 (kzcx2-305 和 kzcx1-10-07) 资助下完成。

作者简介: 高卫东, 中国科学院新疆生态与地理研究所、中国科学院研究生院硕士研究生。专业方向: 荒漠环境和气候变化。