Estimation of Sand Dunes Movement in the Northern Part of Shaanxi Province, China

Mushtak Talib Jabbar Al-Temimi[1], YUAN Lin[2], SUN Dong-ying[2]
(1. *Faculty of Earth Resources, China University of Geosciences, Wuhan* 430074, *Hubei Province, China*;
2. *Department of Public Relations and Tourism, Jiujiang University, Jiujiang* 332005, *Jiangxi Province, China*)

Abstract: This investigation was conducted to estimate sand dune movement in Yulin and Jinbian areas of northern Shaanxi Province, China. Results indicate that total sand movement has been 24.433, 21.147 metric tons for Yulin and Jinbian, respectively. The mean sand dune movement equates to a rate of 4.61 and 3.99m per year, but average monthly sand dune movement rates were 1.152 and 0.997m for the two locations respectively. The rates of movement occurred in Jul. followed by Jun., Aug. and Sep.. Rates of movement depend on wind velocity, dune height, and dune length and slope ratio. The study reveals that cultivated lands extended obliquely to the direction of sand dune movement are extremely affected severely by the movement, while cultivated land segments extending parallel to the direction of movement are not affected.

Keywords: **sand dunes movement**; **wind erosion**; **desertification**; **North Shaanxi Province of China**

中国陕西省北部地区沙丘运动评估

穆斯塔克·达力伯·贾巴·阿-特米米[1], **袁林**[2], **孙冬英**[2]
(1. 中国地质大学 资源学院, 湖北 武汉 430074; 2. 九江学院 公关旅游系, 江西 九江, 332005)

摘 要: 对中国陕西省北部地区的榆林和靖边地区沙丘运动进行了评估。结果表明榆林和靖边地区总移动沙堆分别达 24.433 和 21.147 t。平均沙丘移动速率分别为 4.61m 和 3.99m, 而每月沙丘在榆林和靖边分别前进 1.152 m 和 0.997 m。受影响最大的月份是 6 月份, 接下来的是 7—9 月份。沙丘运动依赖于风速、沙丘高度、沙丘长度以及坡度。研究表明开垦地与沙丘方向相交时, 受到极大影响, 而与沙丘平行时, 不受影响。

关键词: 沙丘运动; 土壤风蚀; 沙漠化; 中国陕北
文献标识码: A **文章编号**: 1000—288X(2004)03—0005—04 **中图分类号**: S288

Sand dune movement has become an almost universal and extremely disastrous problem in most of the arid and semi-arid regions of the world. Bagnold[1] has defined sand dunes are mounds, hill or ridges of windblown sand and stated that the threshold wind speed is 12～19 km/h. However, the mechanical effect of transported sand will increase 10 times when it rises from 24 to 34m/h, and 100 times when it rises from 24 to 56 km/h. This phenomenon has been studied in different parts of the world (table 1). This shows that high speed sand storm is important for the formation and movement of sand dunes. However, local topography should be considered to expect dune movement direction[2]. The area of desertification caused by wind erosion is 1.607 million km^2, accounting for 61.3% of total area of desertification affected land area, and is mainly distributed in the arid and the semi-arid areas[3]. Soil wind erosion also is a very severe kind of land degradation. According to Agenda 21, referring to a remote sensing survey in 1990, China's soil erosion area corresponding to 3 670 000 square kilometers, covering about 38% of the total land area. Annual soil loss is said to account for 5 billion tons; 70 000 hectares of arable land are lost every year by soil erosion. According to the State Science & Technology Commission (referred to by UNDP) between 1985 and 1994, about 360 000 hectares of farm land annually have been affected by top-soil loss. north In Shaanxi Province, soil erosion extremely serious,

收稿日期: 2004-01-29 **修回日期**: 2004-04-16
作者简介: Mushtak T. J. Al-Temimi(1967—), 男(伊拉克), 马士拉市出生, 博士后。主要从事土壤环境研究。E-mail: mushtak123@hotmail.com。

affects 130 000 km^2 (67% of Shaanxi Province). Soil loss estimated, 850 million t/year, average erosion rate, 6 500 t/km^2 a year in the Loess Plateau of Shaanxi Province and sediment concentrations in the middle reaches of the Yellow River in China (the loess plateau) approach 700 kg/m^3 (about 50% by weight)[4]. The purpose of this study is to estimate sand dunes movement in the whole territory of north Shaanxi Province in order to conclude their relation with the cultivated areas.

Table 1 Commonly used theoretical methods for calculation of sand dunes movement

Researcher	Amount of sand expected to move (q)	Total sand expected to move (Q)	The advance rates of the dunes/m
Bagnold, 1941	$q = C\ (d/D)^{1/2} V_*^3 p/g$	$Q = q * N$	$C = Q / \gamma H$
Kawamura, 1951	$q = K\ (p/g)\ (V_* + V_{t*})\ (V_* - V_{t*})^2$	$Q = q * N$	$C = Q / \gamma H$
Williams, 1964	$q = a\ (p/g)\ V_* b$	$Q = q * N$	$C = Q / \gamma H$
Kadiba, 1965	$q = \{ [\gamma/g\ (\gamma - p)/p]^{1/2} (gd) \} * 10^{-5}$	$Q = q * N$	$C = Q / \gamma H$
Hsu, 1971	$q = K_w * 10^{-5} [10V_* / (gd/10)^{1/2}]^3$	$Q = q * N$	$C = Q / \gamma H$
White, 1979	$q = 2.61 V_*^3 (1 V_{t*}) (1 + V_{t*}^2) (V_*^2) (p/g)$	$Q = q * N$	$C = Q / \gamma H$
Borowka, 1980	$q = 2.5 * 10^{-6} (V)^{4.55}$	$Q = q * N$	$C = Q / \gamma H$
Al- Sheak, 1984	$q = 0.87090637 + 0.5085891 (V)$	$M = [(1.6)(200)(q)/106/H](100)$	
Abdulla, 1990	$q = 1.5 * 10^{-9} (V - V_t)^3$	$Q = q * N$	$C = Q / \gamma H$
AL - Malki, 1995	$E = I.C.K.L.V$	$Q = I * C$	$C = Q / \gamma H$

K_w, a, k, C —constant; d —mean grain diameter; D —standard mean grain diameter; p —air specific weight; $g = 22/7$; V_*, V_t —threshold wind velocity; V —local wind velocity; H —dune height (m); N —number of hours net wind (average mean of the dry period); I —soil erodibility factor; C —climatic factor; γ—particle density, being taken to be 2.65 (gm/cm^3) for the quartz.

1 Description of study area

The study area, located in the northern part of Shaanxi Province, lies within longitude 109°00′ to 110°00′E and from latitude 38°40′ to 37°20′N. The area is 158 km long (from north to south) and 87 km wide (from east to west) and has a total area of 13 746 km^2. The area is located at a typical transitional zone between the Mao Wusu desert area, which is suitable for livestock farming and an agriculture area, concerns about the desert moving southeastwards. The landform is gentle in location area, with elevation ranging from 897.0 to 1 600m. The land surface is mainly sandy sediments of alluvium and lacustrine deposits. Sand dunes extend in the area with sheet, lakes, river valleys and ravine floors. The landform of the sandy land with great ecological activity is seldom among the sand area of China. The area fall in arid and semi-arid continental monsoon climate zone. The mean annual precipitation is 250～433mm, the mean annual wind velocity is 2.4～3.3m/s, and the days with gale wind are 15～33 days with a maximum of 77 days.

2 Methodology

2.1 Preparation and sampling

Representative dune sand samples were collected from Yulin and Jinbian areas. Some physical and chemical properties of the investigated sand dune are presented in table 2 by the procedures of Black et al.[5]. The dry sieving analysis has been done to obtain the common grain sizes. Value for average wind velocity and rainfall data were obtained for the investigated location according to information recorded during the period 1987- 1999 from Yulin climatic station, months start from June to September each year.

2.2 Calculation of data

Calculation of sand dunes movement was done according to the method from Bagnold equation[6] as follows:

(1) Threshold wind velocity (V_t) for dune sand was calculated as by Bagnold's equation[7]:

$$V_t = 680\sqrt{d}\ \lg\frac{30}{d} \qquad (1)$$

where: V_t —the threshold wind velocity ($cm \cdot s^{-1}$); d —the mean grain diameter (cm).

(2) The amount of sand expected to move (q) [ton/(m · h)] is obtained by the following equation of Bagnold[7]:

$$q = 1.5 \times 10^{-9} (V - V_t)^3 \quad (2)$$

Where: V —the local wind velocity ($cm \cdot s^{-1}$) for the study period.

(3) Total sand expected to move in the considered period (Q, metric ton) was calculated as follow:

$$Q = q \times N \quad (3)$$

Where: N —the number of hours net wind (average mean of the study period).

(4) The advance rates of the dunes were calculated as follows:

$$C = Q / \gamma H \quad (4)$$

Where: γ—the particle density which has been taken to be 2.65 (gm/cm^3) for the quartz; H —the dune height (m).

Table 2　Some physical and chemical properties of the investigated dune sand

Properties	Yulin	Jinbian
Sand/%	92.49	90.13
Silt/%	3.37	3.21
Clay/%	4.14	6.66
Grain mean diameter/mm	0.28	0.21
O. M/($gm \cdot kg^{-1}$)	0.84	0.95
$CaCO_3$/($gm \cdot kg^{-1}$)	215.0	176.0
EC/($cmole \cdot kg^{-1}$)	3.20	2.10
pH	7.87	7.34

3　Discussion of Results

At this stage of study, north-westerly wind can dry out the soil surface very fast, causing wind erosion and drifting sand over the country from a wide source. This is a cold wind blowing from northern Europe penetrating into the Mongolia desert. The air in the desert becomes very unstable, stirring up strong winds (as a result of the mentioned cold air) at some places such as northern desert, so the dust is brought over hundreds of kilometers[3]. The threshold wind velocity, required to move the common dune sand grains (diameter 0.26 mm), found to be 3.33 m/s (see equation 1); therefore, the rate of movement of an average sand dune in metric tons per meter width of lane per hour (q) was 0, 0.006, 0.126 and 0.429 ton/(m · h) of 0, 4, 6 and 8 m/s wind velocity, respectively (see equation 2). Then the values of total dune sand movement, metric ton (Q) were calculated with respect to occurrence of north-westerly wind and q (table 3). From the result of theoretical sand dunes movement calculated by Bagnold method were 1.32, 1.94, 0.79 and 0.56 m in June, July, August and September respectively for Yulin, and 0.95, 1.89, 0.72 and 0.43 m in June, July, August and September respectively for Jinbian (table 4). This result depends on wind velocity, dunes height, length and slope ratio. Figure 1, 2, 3, and 4) shows the relationships between advance rate of sand dune and wind velocity, dunes height, and length and slope ratio respectively. This indicated that Yulin area is more affected by wind erosion than Jinbian. This is attributed to the climatic factor which has main effect to move the common dune sand grains, whereas, wind velocity has the same effect in calculation the results. In addition, sand dunes advance and sand drift were greatest for July followed by June, August and September (Figure 5) due to wind velocity. Because no vegetation in this period which are required to slow down wind velocity near soil surface and their shades help to keep the soil sand dune surface moist, so, soil erosion was enhanced and sand dunes advance rate as a result was increased (Figure 2—5)[8].

Table 3　The amount of sand movement (Q) of sand dunes at the investigated locations

Location	Sand movement, Q (metric ton)					
	Jun.	Jul.	Aug.	Sep.	Total	Mean
Yulin	6.996	10.282	4.187	2.968	24.433	6.108
Jinbian	5.035	10.017	3.816	2.279	21.147	5.286
Total	12.03	20.299	8.003	5.247	45.579	11.39
Mean	6.015	10.149	4.001	2.623	22.788	5.697

Table 4　The advance rate (C) of sand dunes at investigated locations

Location	Sand movement, Q (metric ton)					
	Jun.	Jul.	Aug.	Sep.	Total	Mean
Yulin	1.32	1.94	0.79	0.56	4.61	1.152
Jinbian	0.95	1.89	0.72	0.43	3.99	0.997
Total	2.27	3.83	1.51	0.99	8.60	2.150
Mean	1.13	1.91	0.75	0.49	4.30	1.075

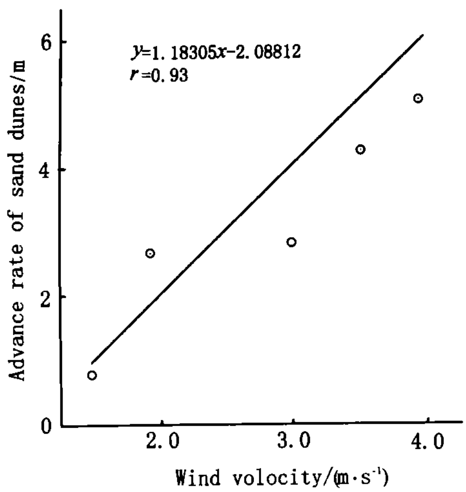

Figure 1 Relationships between sand dune movement and wind velocity for investigated locations in northern Shaanxi Province

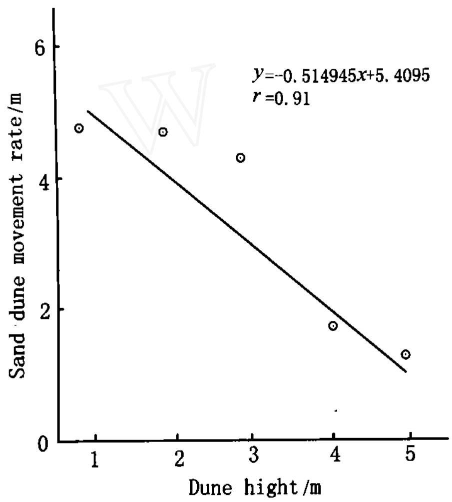

Figure 2 Relationships between advance rate of sand dune and dunes height for investigated location in northern Shaanxi Province

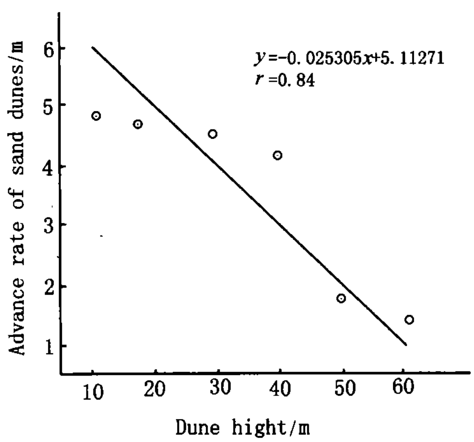

Figure 3 Relationships between advance rate of sand dune and dunes lenght for investigated locations in northern Shaanxi Province

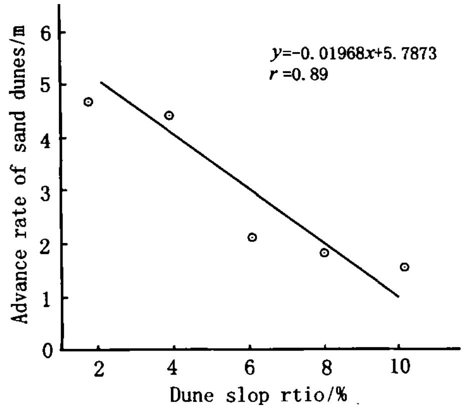

Figure 4 Relationships between advance rate of sand dune and dunes slope ratio for investigated locations in northern Shaanxi Province

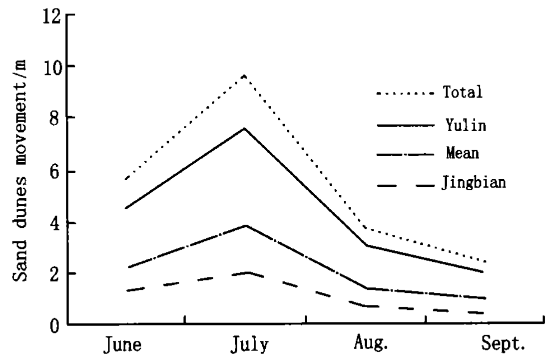

Figure 5 Sand dunes movement in the north Shaanxi Province

Yulin areas more affected by sand dunes movement have trend oblique to the direction of the prevailing wind than Jinbian. There are plains between the desert area and river such as cultivated lands in west Yulin and north Jinbian. These areas are oblique to the northwest trending wind direction. Also obtained from sand dunes movement result, these areas are affected by aeolian sand that moves from north to south over the bordering agriculture areas, this result agreement with CCICCD, 1997a, and Yang Zhongxin, 1984[3,9].

4 Conclusion

In this study the north part from Shaanxi Province desert includes 90% of these sandy deposits which threatens the cultivated land in the borders of the Yulin and Jinbian areas

(下转第 20 页)

侵蚀研究应以地块为基本监测单元; 由于前期系统观测资料较少, 但是池塘、坝库分布广泛, 沉积在池塘和坝库中泥沙沉积物储藏着大量的信息, 如矿物组成、粒径分布、孢粉组合、碳同位素比值、养分和各种核示踪元素等对流域内不同时空尺度上的土壤侵蚀特征都有反映, 特别是核素示踪技术由于廉价、省时又易掌握, 应用的时空尺度范围较广泛, 且前景广阔。

[参 考 文 献]

[1] 史立人. 长江流域水土流失特征、防治对策及实施成效[J]. 人民长江, 1998, 29(1): 40—42.

[2] 徐茂其, 张大泉. 川中丘陵土壤水力侵蚀及防治对策[J]. 水土保持学报, 1992, 6(4): 35—42.

[3] 刘刚才, 朱波. 四川低山丘陵区紫色土不同土地利用类型的水蚀特征[J]. 水土保持学报, 2001(2): 39—32.

[4] 史德明. 长江流域土壤侵蚀的特点及其潜在危险[J]. 中国水土保持, 1983(3): 43—46.

[5] 朱波. 紫色母岩风化侵蚀及其环境效应[J]. 土壤侵蚀与水土保持学报, 1999(5): 16—19.

[6] 文安邦, 刘淑珍, 范建容, 等. 雅鲁藏布江中游地区土壤侵蚀的 Cs—137 示踪法研究[J]. 水土保持学报, 2000, 14(4): 47—50.

[7] 张信宝, D. E. Walling, 冯明义, 等. Pb—210 在土壤中的深度分布和通过 Pb—210 法求算土壤侵蚀速率模型[J]. 科学通报, 2003, 48(5): 502—506.

[8] 文安邦, 张信宝, 王玉宽, 等. 长江上游 Cs—137 法土壤侵蚀量研究[J]. 水土保持学报, 2002, 16(6): 1—3.

[9] 史立人. 水土保持是治理江河的根本[J]. 中国水土保持, 1998(11): 13—17.

[10] 杨艳生, 梁音, 刘佳桂. 长江三峡土壤坡面流失及重力侵蚀[J]. 水土保持学报, 1991, 5(3): 29—35.

[11] 景可. 长江上游泥沙输移比初探[J]. 泥沙研究, 2002(1): 53—59.

[12] 冯明汉. 长江流域土壤侵蚀研究现状及存在问题[J]. 长江水土保持, 2003(1): 14—16.

[13] 史立人, 魏特. 岩矿分析法及其在河流泥沙调查中的应用[J]. 水土保持学报, 1988, 2(2): 80—88.

[14] Dearing J A, Alstronm K, Bergman A, et al. Past and present erosion in southern Sweden[M]. In: Boardman, Foster, Dearing, (Eds), Soil Erosion on Agricultural Land. Wiley, Chichester, 1990. 687.

[15] Nearing M A, Bradford J M. Single waterdrop splash detachment and mechanical properties of soils [J]. Soil Sci Soc Am. J. 1985, 49: 547—552.

[16] 窦葆璋, 周佩华. 雨滴的观测和计算方法[J]. 水土保持通报, 1982, 2(1): 44—47.

[17] 高学田, 包忠谟. 降雨特性和土壤结构对溅蚀的影响[J]. 水土保持学报, 2001, 15(3): 24—27.

[18] 唐克丽, 张科利, 郑粉莉, 等. 子午岭区自然侵蚀与人为加速侵蚀剖析[J]. 西北水土保持研究所集刊, 1993, 17: 17—28.

[19] 郑粉莉, 康绍忠. 黄土坡面不同侵蚀带侵蚀产沙关系及其机理[J]. 地理学报, 1998, 53(5): 422—428.

(上接第 8 页)

The study reveals that cultivated lands extended obliquely to the direction of sand dune movement are extremely affected, while other segments which extend parallel to the direction of the movement are not affected. Accordingly the north Shaanxi Province were divided into areas of different classes of potential risk moreover, the area of western desert are also affected by blown sands and sand movement from neighboring highlands.

[**References**]

[1] Bagnold R A. The physics of blown sand desert dunes. London: Metheun Baret. F. and G. Guyot. (1991) Potentials and Limits of Vegetation Indices For LAI and APAR Assessment Remote Sensing of the Environment, 1954. 35: 161—173.

[2] Muhs D R, Bush C A, Cowherd S D, Mahan S. Source of Sand for the Algodones Dunes[M]. In Tchakerian, V. P., ed., Desert aeolian processes; New York, Chapman and Hall, 1995. 37—74. Cliffs, N. J.

[3] CCICCD. China Country Paper to Combat Desertification[M]. Beijing: China Forestry Publishing House, 1997a. 18—31.

[4] Jiao Juren. Integrated Techniques and Practices of Sands Rebuilding by Hydraulic Power[M]. Shaanxi Science and Technology Press, June 1996.

[5] Black C A, Evans D D, White J L, et al. Methods of Soil Analysis[M]. Part 1. Am Soc Agron Inc, 1965.

[6] Abdulla H J. Rate of sand dune movement during the dry season in the lower Mesopotamian plain- Basrah [J]. J. Agric. Sci. 1990(1, 2): 99—107.

[7] Bagnold R A. The physics of blown sand and desert dunes[M]. Methues and Co. ltd., London, 1971. 7—12.

[8] Chepil W S. Soil condition that influence wind erosion [J]. U. S. D. A. Tech. Bull., 1958. 1185.

[9] Yang Zhongxin. Afforestation Investigation in Yulin Prefecture[M]. Shaanxi Province Publishing House, China, 1984.