Dust Storms Impacts on Air Pollution and Public Health under Hot and Dry Climate

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Abstract- The commencement of drought in the Sistan region, Iran in 1999 created suitable conditions for dust storms to form. They carry clouds of dust in the wind over the region that causes severe air pollution and makes breathing very difficult for local residents, in particular, for those who have respiratory diseases. In such conditions, people use mouth masks even inside their homes. The effects of air pollution arising from dust storms on people in the area of research were studied by completing questionnaires and visiting hospitals in stormy days. The results show that about half of residents have been subject to respiratory diseases due to dust storms during the period of interest. The research indicates that the number of people affected in rural areas is more than in urban areas. Some patients had to call on a doctor during stormy days and approximately 55 percent of them visited a physician more than 20 times per year. About 40 percent called on a doctor a couple of days after a dust storm and 32 percent mentioned that they can not call on a doctor due to financial and economic issues. Also, the results derived from hospital studies show that in stormy days most of the patients were respiratory patients, including those who were affected by Chronic Obstructive Pulmonary Disease (COPD) and asthma. The percentage of these diseases in summer (July and August) is more than other months due to more severe dust storms. The amount of financial losses due to these respiratory diseases has been estimated at over 73.5 million dollars during 1999-2004. Finally, we conclude that dust storms have an important role in spreading respiratory disease in the Sistan region.

Key-Words: Drought, Respiratory diseases, Dust storm, Air pollution, Iran.

1. INTRODUCTION

Dust storms are a kind of severe natural disaster that frequently occurs in the arid and semiarid regions. Are the air-borne coarse crust-originated particles harmful to human health? Kwon et al. (2002) explored the effect of Asian dust events on daily mortality in Seoul, South Korea, during the period of 1995–1998, and showed that the association between the dust events and deaths from cardiovascular and respiratory causes was strong enough to indicate that people with advanced cardiovascular and respiratory disease might be susceptible to Asian dust events [1]. Chen et al. (2004) assessed the possible effects of Asian dust storms on the mortality of the residents of Taipei, Taiwan, during the period 1995– 2000. This study found greater specificity in associating dust effects with respiratory death [2, 3]. Lei et al. (2004) used pulmonary hypertensive rat models to examine inflammation markers in the lung and in the peripheral blood after an exposure to Asian dust storm particles. Their results revealed that an exposure to particulate matters during a dust event could increase lung inflammation and injury in pulmonary hypertensive rats[4]. Clearly, besides the dramatic effects of dust particles on visibility (Kim et al., 2001; Chung et al., 2003), their potential influence on the health risk of the younger generation and allergies of elderly people cannot be ignored. [5]

2. STUDY AREA

The Sistan region in Iran lies between 60°15′ E and 61°50′ E longitude, and 30°5′ N and 31°28′ N latitude; at the end of a closed basin (figure 1). It covers an area of approximately 15,197 square kilometers and has a population of about 400,000. The Sistan region includes 908 villages and two cities, Zabol and Zahak. The economy is strongly dependent on agriculture and the goods and services provided by the wetlands. Three reservoirs called “Chahnimeh” have been constructed for public water supply with a fourth reservoir under preparation. The inflowing rivers from Afghanistan support the irrigated agriculture in the region but are also the source for the Hamoun lake. Unemployment in the area is high.

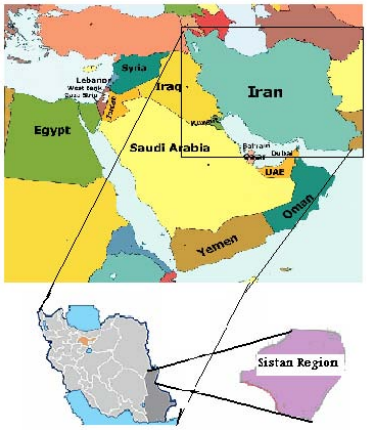

Figure 1. Location of the Sistan Region

Strong winds are one of the main factors affecting weather conditions in the Sistan region. The winds blow alternatively in winter and continuously in spring and summer. The wind is mostly blowing from north and north-west [6]. It blows more strongly during winter and spring than summer and autumn. There are most winds in winter and least winds in autumn. Low pressure which is exerted on Lut Desert in summer is the main reason for the strong winds in this region [7]. In the summer, a phenomenon occurs that is called the '120 days wind' with prevailing wind speeds of nearly 20 knots [6]. The region is subject to severe winds; occasionally wind speeds reach 120 kilometers per hour [6, 8]. After the 1999 drought, owing to land use change (agricultural land to waste land), the drying up of Hamoon Lake, that is located in the north of the region, occurred. And now its soil is sensitive to erosion, a wide portion of the region is subject to soil erosion that, in turn, is a cause of dust storms. Following exposure to a severe dust storm, wind speed increases and a massive amount of dust particles are suspended in the air that can result in respiratory diseases for the residents of the region Dockery et al [10] and Hefflin et al [11]. Figure 2 shows views of Hamoon Lake before and after the drought.

(a) (b)

Figure 2. Views of Hamoon Lake before the drought (a) and after the drought (b).

Since Hamoon Lake Surface has soils susceptible to erosion, as a result of dust storm occurrence, a massive volume of soil particles are removed from the lake surface and fall on the region surface.

The location of Hamoon Lake and the Sistan Region is represented. The view of Zabol city, located in the region of study, for a clear day and a dusty day is shown in Figure 3.

(a) (b)

Figure 3. The situation of Zabol city for a clear day (a) and a dusty day (b)

3. Methodology

In order to analyse impacts of dust storms, wind, horizontal vision, and precipitation data were used that were collected from Zabol synoptic station for 1990-2004 period. For production, the dust storms we assign days that the wind speed was more than 15 m/s and horizontal visibility was less than 1000 m. In addition, to study air pollution caused by dust storm and its impacts on public health in Zabol city, 150 questionnaires were provided. Since population rate of the city to the village is one to three, fifty and hundred pieces of questionnaires have been randomly completed by people living in city and surrounding villages, respectively. It must be mentioned that two-step randomly sampling method has been used in which seven questionnaires distributed in any of fifteen selected villages. Then information extracted from the questionnaires were analysed by the SPSS program. Moreover, for obtaining the statistics of respiratory patients, it was considered that patients should visit the hospital located in the city centre. The data from 2003 to 2004 was collected and considered as representative data that was generalized to the whole region.

4. Results and Discussion

Results show that the dust storms occurred in the region is after the 1999 drought (Figure 4). This is due to presence of local winds that their speed has increased during the drought years. Another reason is suitable soil (clay, silt and loam) for removing by wind.

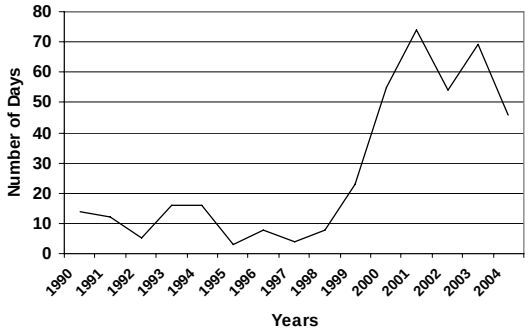

Figure 4. Trend of dust storms in the study over 1990-2004 period

In addition, the results show that most dust storms have occurred during June, July, and August (Figure 5).

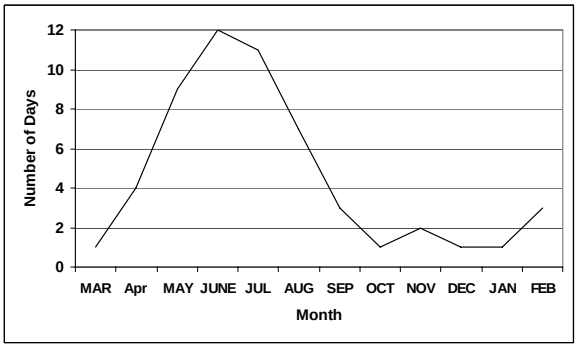

Figure 5. Monthly average number of days with dust Storm in Zabol city over 1990-2004

As can be seen in the figure, months of June, July and August have the most number of dusty days. This is why there was no precipitation during these months as shown in Figure 6, and also local winds occur in these months.

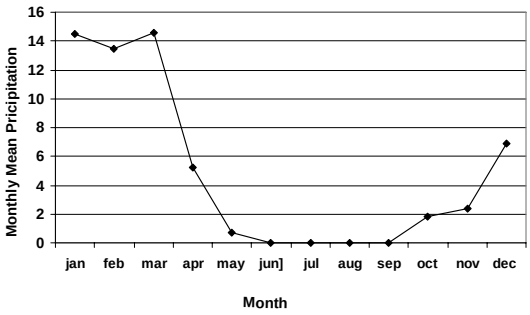

Figure 6. Changes in monthly mean precipitation over 1990-2004

Visual analysis of satellite data and field visits show that the region villages are subject to dust storms more intensive than Zabol city. Transported sediments to villages are more than Zabol city. In Figure 7, dust storms direction is indicated with arrows. As in the figure can be shown, whole study area is represented with yellow color as well as Zabol city limitation with a yellow color cycle and some villages with green color points.

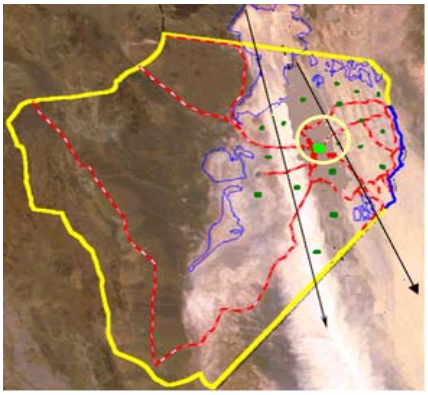

Figure 7. View of Zabol city and its surrounding villages, and dust storms direction

According to Figure 7, almost all the region villages are located in wind corridors' path and most often exposed to severe dust storms. Zabol city is located in the situation that less is affected by dust storms but severe dust storms.

The results of the statistical analysis of the questionnaires show that 63% of the people suffer from respiratory diseases and that more of them reside in the villages than the city. Due to located villages in dust storms' path, the duration that villages are subject to dust storms is more than Zabol city.

64% of these respiratory patients did not call on a physician; more of these patients are from the villages. This is due to the reasons mentioned in Table 1.

Table 1. Reasons for not visiting the hospital.

Reason	Percent (%)
Economic Issues	48
Disease Recovery	15
Going to hospital considered unimportant	26
Lack of access to health centers	11

As the above table indicates, most patients did not go to see a doctor due to economic issues. Since most patients are from villages, and 95% of them are farmers and livestock breeders, the agriculture in the region is impossible owing to the occurrence of drought in recent years and the agricultural land has transformed into wasteland [9]. Hence, villagers live in complete poverty so they are not able to pay remedy costs.

The rest of the resident people, that they visit a doctor's surgery, have an urge to go there immediately after a dust storm. This is due to severe air pollution. Some patients are able to visit a doctor the same day Dockery et al [10] and Hefflin et al [11]. The occasions that patients visited a doctor are given in Table 2.

Table2. Occasions that patients called on doctor.

Visiting Occasion	Percent
Day of dust storm	34
Couple of days after dust storm	40
Three days or more after dust storm	26

As the table above shown, most patients visit a doctor the same day as a dust storm, reside in the city. Most villagers are only able to refer to health centers in the next couple of days and even some of them after three days or more. During the dusty season 55% of participants visited a doctor over 20 times, 33% visited 10-20 times and the remaining 12% only visited a doctor 1-10 times. If each person calls on doctor an average of 15 times a year, and pays 5.6 dollars for each visit, per capita cost for each year will be over 83.3 dollars. The results of the questionnaire show that 63% of the population suffers from respiratory diseases. From this 63%, 12% were considered to have made an error filling out the questionnaire, 18% were considered to have other causes for their diseases such as malnutrition, disregard for health and so on. Thus, 33% of the population (132,000 people) was considered as patients that suffer from respiratory diseases caused by dust storms. The damages to the population were estimated at over 66.7 million dollars during 1999-2004.

The results of the statistical analysis of data and informationS obtained from hospitals indicated that most patients visited hospital suffered from Chronic Obstructive Pulmonary Disease (COPD) and asthmatic diseases [15] (Figure 8)

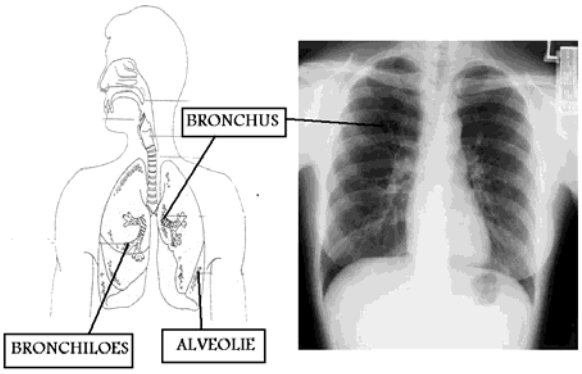

Figure 8. Respiratory system and Chronic Obstructive Pulmonary Disease (COPD) and this is caused by

Most respiratory patients visit Imam-E-Ali hospital during the summer season (Jun, July and August) when the severest dust storms occur (Figure 9).

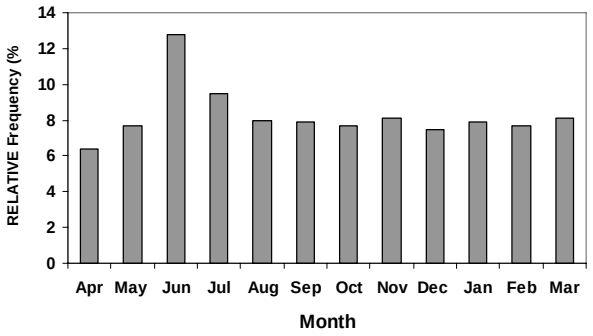

Figure 9. Frequency of respiratory patients visiting the hospital over 2003-2004.

As can be shown in the above figure, most respiratory patients visited the hospital during July and August 2000-2004. A major dust storm took place at the study area on 10th July of 2002 (Figure 10). Commence of the dust storm was midnight and after couple of hours, wind speed and dust concentration in air reached at 20 meter per second and 150 microgram per cubic meter, respectively. Also horizontal sight decreased up to 300 meters. This dust storm took almost five days (110 hours), and visibility was reported less than 1000 meters. It is caused breakthrough of respiratory issues for the public, so that about 90 percent of the patients visiting clinics and hospitals are respiratory patients.

Figure 10. Dust storm of the 10th July of 2002 and situation of the Sistan region

It is estimated that 90% of the population residing in the region suffer from respiratory problems in June, July, August and September. In April and May this figure is believed to drop to 50%, whilst the number is thought to be 20% in other months of the year Bates [12], Hefflin [11] and Williams et al [13]. These figures are heavily influenced by dust storms, which intensify the effects of respiratory diseases. Medical costs for each patient for the period of study were over 166.7 dollars. Table3 shows the number of respiratory patients, along with the corresponding medical costs during 2000 and 2004.

Table3. The number of respiratory patients visiting the hospital and the corresponding medical costs (dollars) during 2003 and 2004.

Year	Number of patients	Medical costs caused by dust storm
2003	293	48888
2004	246	44444
Sum Total	**539**	**93332**

Urban patients go to either hospitals or clinics and rural patients go to rural health centers for medical treatment, therefore 10% of the total population (40,0000 people) was considered as the number of patients referred to hospital [15]. Hence, the total estimated damage to the population based on 40000 adults was 66.7 million dollars. Total damage to the population's health is summarily represented in Table 4.

Table 4: Type and amount of damage to population During 2003-2004.

Damage type	Total cost (million dollars)
Hospital patients	6.7
Damages estimated through questionnaire analysis	66.7
Sum Total	**73.4**

As can be seen in the above table, the sum total of damage to the population caused by dust storm was estimated to be 73.4 million dollars.

5. CONCLUSION

Drought occurrence, climate aridity, Hamoon Lake dryness, lake of vegetation cover and strong winds favor the formation of dust storms during recent years in the Sistan region. The maximal frequency of dust storms has been in summer, especially in June, July and August. These caused air pollution; respiratory diseases have spread in the region. Due to all the villages are located in wind corridors' path and most often exposed to dust storms, therefore the number of patients in villages is more than the city. Also, drought and dust storms caused the agricultural land has transformed into wasteland. Hence, villagers live in complete poverty so they are not able to pay remedy costs. Most respiratory patients visit hospital during the summer season when the dust storms occur. Therefore dust storms have led to widespread damage and loss of life. It seems that the loss of life is more than property damage.

6. AKNOWLEDGMENTS

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References:

[1] Kwon HJ, Cho SH, Chun Y, Lagarde F, Pershagen G. Effects of the Asian dust events on daily mortality in Seoul, Korea. Environ Res Sec A 2002;90:1–5.

[2] Chen YS, Lim JY. The recent characteristics of Asian dust and haze events in Seoul, Korea. Meteorol Atmos Phys 2004;87:143–52.

[3] Chen YS, Sheen PC, Chen ER, Liu YK, Wu TN, Yang CY. Effects of Asian dust storm events on daily mortality in Taipei, Taiwan.Environ Res 2004; 95:151–5.

[4] Lei YC, Chan CC, Wang PY, Lee CT, Cheng TJ. Effects of Asian dust event particles on in ammation markers in peripheral blood and bronchoalveolar lavage in pulmonary hypertensive rats. Environ Res 2004;95:71–6.

[5] Kim YJ, Kim KW, Oh SJ. Seasonal characteristics of haze observed by continuous visibility monitoring in the urban atmosphere of Kwangju, Korea. Environ Monit Assess 2001;70:35–46.

[5] Chung YS, Kima HS, Dulama J, Harris J. On heavy dustfall observed with explosive sandstorms in Chongwon-Chongju, Korea in 2002. Atmos Environ 2003;37:3425–33.

[6] Hossenzadeh, S.R. 1997: One hundred and twenty days winds of Sistan. TheIranian Journal of Research in Geography, 46: 103-127. 12

[7]. Muminov, F.A., Inagamova, S.I. (Eds.), 1995. Variability of the climate of Central Asia. SANIGMI, Tashkent, 215pp. (in Russian).

[8] Weather data of Zabol synoptic station for the statistical period of 1999-2004.

[9] Murray, A.B., Ferguson, A.C., Dust-free bedrooms in the treatment of asthmatic children with house dust or house dust mite allergy: a controlled trial. Pediatrics, March; 71(3): 418-422, 1983.

[10] Dockery, D.W., Pope, C.A., Acute respiratory effects of particulate air pollution, Annul Rev Public Health; 15:107-132, 1994.

[11] Hefflin, B.J., Jalaludin, B., McClure, E., Cobb, N., Johnson, C.A., jecha, L. and Etzel, R.A. , Surveillance for dust storms and respiratory diseases in Washington State, Arech Environ Health, May-June, 49(3): 170-174, 1994.

[12] Bates, D.V., The effects of air pollution on children. Environ Health Perspect. Sep; 103 (Suppl 6):49-53, 1995.

[13] Williams, P. and Young, M., How much dose wind erosion cost the people of South Australia, Policy and economic research unit CSIRO land and water, 1999.

[14]Cullina, P. and Taylor, A.J., Asthma in children: environmental factors. BMJ, Jun; 18; 308 (6944):1585-1586, 1994.

[15] Nursery Offices' Report and patients' files, Imam-E-Ali Hospital of Zabol City

[16]Huszar, P.C. and Piper, S.L., Estimating the off-site costs wind erosion in New Mexico. Journal of soil and water conservation, 41(6): 414-416, 1989.

[17] McMahon, H. (1906). Recent exploration and survey of Seistan. The Geographical Journal, 28: 210-228.

[18] Karetnikova, K.A., 1949. Hot winds, khamsins and afghans in Central Asia (Sukhovei, garmsili I afghantzi v Srednei Asii). Izdatel'stvo Academii Nauk Uzbekskoi SSR, Tashkent, 861pp. (in Russian).