ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Evaluation of the Severity of Dust Storms and Air Quality Index in Sanandaj in 2010.

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ABSTRACT

In recent years air pollution caused by dust storms is one of the major health problems in the western parts of Iran. World Health Organization has estimated that annually about 800,000 people face premature death because of exposure to airborne particulate matter in ambient air. This study aimed to determine the severity of the dust and air quality index in Sanandaj, Kurdistan, Iran. This is a descriptive cross-sectional study conducted from the beginning of April to the end of March 2010. During the study, daily measurement of air pollutants were conducted using two air quality monitoring stations of department of environment, Kurdistan province. PM_{10} concentrations were measured by beta ray absorption in monitoring stations. High concentrations of PM_{10} occur in summer, spring and autumn with a low concentration in winter. The highest average concentration of 24-hour PM_{10} occurred in July (1396.3 micrograms per cubic meter). And second 24-hour average concentration occurred in June (599.6 micrograms per cubic meter). According to the Air Quality Index, share of the days in Sanandaj in 2010 were as follows: 2 percent more than 500 (was dangerous), 2 percent more than 300 (was very unhealthy), 5 percent more than 200 (was unhealthy), and 15 percent more than 150 (was unhealthy for vulnerable groups. The average annual concentration of PM_{10} in Sanandaj was above the levels set by World Health Organization.
Keywords: dust Storms, Air Quality Index, Sanandaj.

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ISSN: 0975-8585

INTRODUCTION

In recent years, air pollution caused by dust storms is one of the major health problems in Iranian western provinces. Particulate matter is a term that refers to solid or liquid particles in the air [1]. These particles are primary air pollutants which can result from variable sources and in different sizes [2, 3].

Dust storms are natural disasters that occur mainly in dry areas of the world. They reduce air quality and visibility. They can be dangerous for *people with* respiratory problems. Dust storm occurs when the horizontal visibility is reduced to less than 1,000 meters [4].

The Sahara Desert, located in North Africa, is considered to represent the major source of mineral dust in the world, releasing approximately one billion tons of dust annually. Western China and parts of Mongolia are believed to be the second major source of desert dust [5]. Several studies conducted for evaluation of dust including studies at south-eastern states of Washington [6], China [7], Taiwan [8, 9] Japan [10]. Dust storms are natural disasters that occur mainly in dry areas of the world. They reduce air quality and visibility. They can be dangerous for *people with* respiratory problems. Dust storm occurs when the horizontal visibility is reduced to less than 1,000 meters [11]. They contain a variety of pollutants such as ash, carbon monoxide, toxic pollutants such as heavy metals (mercury, cadmium, chromium, lead, arsenic) and other carcinogens, viruses, bacteria, fungi, pesticides, antibiotics, asbestos, combustion products, etc. [12].

World Health Organization estimates that each year, about 800,000 people are dying prematurely due to exposure to airborne particulate matter in ambient air. It also estimates that in Austria, France and Switzerland, annual cost spent on health sector due to air pollution, were about 30 billion pounds [13]. History of standards for particulate matter by international organizations returns to 1971, when the US Environmental Protection Agency (EPA) expressed national standards for air quality as “total suspended particulates.” as a result of a revision in 1987, instead of PM10 measuring and monitoring of total suspended particles were set as standard. Finally in 2006, World Health Organization released revised Air Quality Standards again. It stated the average concentration of 24-hour and annual PM_{10}, as shown in the table 1 [14].

Table 1: 24-hour and annual average PM_{10} standards

PM10 pollutants	WHO Standsards $\mu g / m^3$
Average 24-hour	50
Annual Average	20

PM_{10} particles cause or aggravate a number of diseases and mortalities due to cardiovascular or respiratory conditions. People with cardiovascular or respiratory diseases such as congestive cardiovascular failure, coronary artery disease, asthma or chronic obstructive pulmonary disease and old people are more likely refer to emergency care centers, hospitalized or even die in some cases. Furthermore, cardiac irregularities and cardiovascular attacks were attributed to exposure to particles [15, 16]. In a study conducted in China by Meng et al. reported increasingly frequent hospitalization for pneumonia during dust storms [17]. According to the WHO report, during the late 1990s, exposure to PM_{10} has caused the occurrence of 700 annual deaths due to acute respiratory infections in children under 4 years old in Europe [18]. With the increase of 100 $\mu g/m^3$ in the 24h average concentration of PM_{10}, pneumonia and chronic obstructive pulmonary disease cases increased by 19% and 27%, respectively [19]. Ostro et al. found an association between PM_{10} and daily mortality in the Coachella Valley, a desert resort and retirement area east of Los angles (CA, USA) where coarse particles of geological origin typically comprise approximately 50–60% of PM_{10} and can exceed 90% during wind events [20].

Objectives

Sanandaj as Kurdistan Provincial capital is faced with the problem of dust storms since 2009. Sanandaj had a decline of air quality in 166 days of the year 2008, 233 days of the year 2009, and 239 days of the year 2010. Accordingly, determining the amount of particulate matter and air quality index in Sanandaj is of great importance. Therefore, in this study, PM_{10} concentrations were monitored during the year 2010.

MATERIALS AND METHODS

This is a descriptive cross-sectional study conducted from the beginning of April to the end of March 2010. Sanandaj has 2 stations for measuring pollutants manufactured by ECOTECH, Australia; which is under Environment Office of Kurdistan Province. It is capable of measuring air pollutants including: carbon monoxide (CO), sulfur anhydride (SO_2), particulate matter with a diameter of 10 microns (PM_{10}), nitrogen oxides (NO_X) and ozone (O_3). One of the stations is located in the Department of Environmental Protection and the second station is located in the deputy of Health Department. All data from the above mentioned contaminants is registered on hourly basis automatically.

Tools

Since the purpose of the assessment and evaluation of air pollutants is protecting the health of the society, station at the deputy of health was chosen as the measurement center due to higher pollutant concentrations of the down town. PM_{10} concentrations were measured by beta ray absorption. The air quality index was used to facilitate reporting of air pollution in terms of air quality and its impact on human health and for the purpose of public information by the media. In 1999 this index replaced the air pollution index, which represents the amount of air pollution and its effects. To calculate this indicator, the concentration of main pollutants (carbon monoxide, ozone, particulate matter, sulfur dioxide and ozone dioxide) is converted into air quality index using a formula.

Formula 1 shows calculation of AQI for a sample population.

$$I_p = \frac{I_{Hi} - I_{LO}}{BP_{Hi} - BP_{LO}} (C_P - BP_{LO}) + I_{LO}$$

According to this formula, raw data obtained from the measurement of pollutants changes to AQI using Equation 1(21).

In this regard:

I_p= Air quality index for pollutant P
C_p = concentration of the measured pollutant P
BP_{Hi} = break point which is greater than or equal to Cp
BP_{LO} = break point which is less than or equal to C_P
I_{Hi} = AQI value consistent with BP_{Hi}
I_{Lo} = AQI value consistent with BP_{Lo}

EPA has provided some recommendations based on these ranges to protect public health (21). Currently, AQI is replaced by PSI in most of the world. This change is to be made by the Ministry of Health in Iran as well. Given the importance of air quality index, this index was also calculated in this study.

Table 2: Correlation between level of air quality index and its corresponding colors

Air quality index	Level of health importance	Indicator colors
0 – 50	good	green
51 – 100	moderate	yellow
101- 150	Unhealthy for sensitive groups	Orange
151- 200	unhealthy	red
201 – 300	very unhealthy	violet
301- 500	hazardous	Brown

Ethical Consideration

This study don’t had any ethical consideration.

ISSN: 0975-8585

RESULTS

Figures 1 shows Iran's position in the global dust belt. In this picture western provincial regions including Kurdistan are exposed to dust storms from neighboring countries.

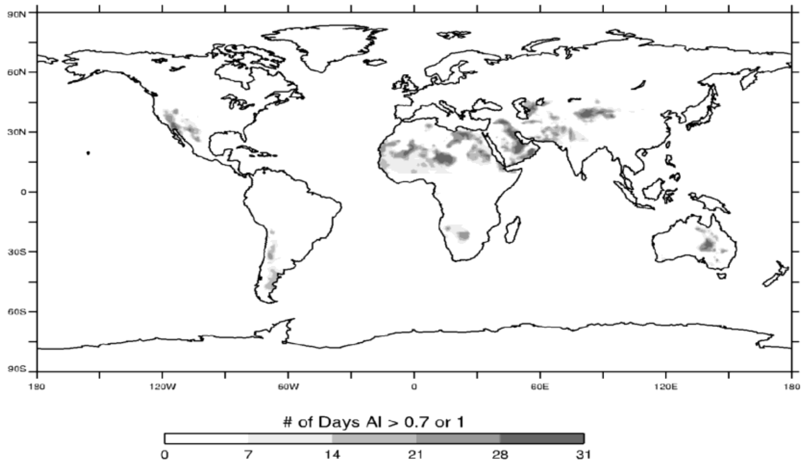

Figure 1: The global dust belt

Figure 2: Location of Sanandaj and Kurdistan province in Iran

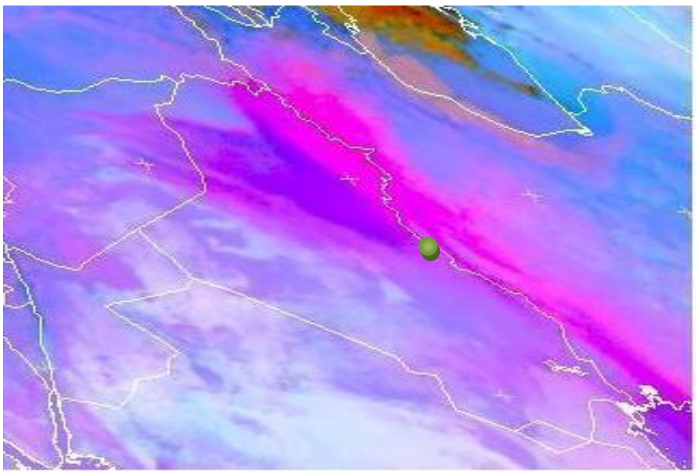

Figure 3: Dust is observed in pink with a tone more intensive the higher the dust content in the atmospheric column of sanandaj: 17 June 2008, 10:30

Minimum, maximum and average PM_{10} concentrations in different seasons are presented in Table 3. Average concentrations of these pollutants in spring, summer, autumn and winter, were 102.53, 113.61, 103.12 and 54.65 micrograms per cubic meter, respectively. According to a survey conducted by World Health Organization in 2006, WHO expressed the average PM_{10} concentration of 24 hour as 50 micrograms per cubic meter. Concentration of pollutants in the spring, summer, and autumn were 73, 81, and 82 times respectively higher than the specified limit.

Table 3: Daily maximum, minimum and average values of PM_{10} in different seasons of 2010

Season	maximum µg/ m^3	minimum µg/ m^3	average µg/ m^3	Standard deviation CI 95%
Spring	599.6	21.5	102.5	9.1
Summer	1396.3	44	113.6	17.6
Autumn	336.8	24.8	103.1	5.2
Winter	130.8	12	54.7	2.5

Minimum 24-hour PM_{10} concentrations during 2010 was 12 micrograms per cubic meter in February and the maximum 24-hour PM_{10} concentrations was 1396.3 micrograms per cubic meter in July which is about 28 times average 24 hour declared by WHO. An annual average PM_{10} concentration was 6.93 micrograms per cubic meter during the year which was above the standard rate and is equivalent to 20 micrograms per cubic meter.

Table 4: Air quality index in different seasons of the year 2010 for PM_{10} pollutant

Number of days based on AQI season	good	average	Unhealthy for sensitive group	unhealthy	Very unhealthy	hazardous
Spring	19	43	16	8	2	5
summer	6	66	11	2	3	2
autumn	8	48	23	7	3	1
winter	36	49	4	-	-	-
total	69	206	54	17	8	8
percent	19	57	15	5	2	2

According to table 4, PM_{10} Index of air quality in different seasons were as follows: having good weather in 69 days of the year, 206 days of average weather, 54 days unhealthy weather for vulnerable groups, 17 days of unhealthy weather, 8 days of very unhealthy weather, and 8 days of dangerous weather. The information was related to 362 days of the year 2010 and due to technical problem of measuring stations; yet, data was not available for the remaining three days.

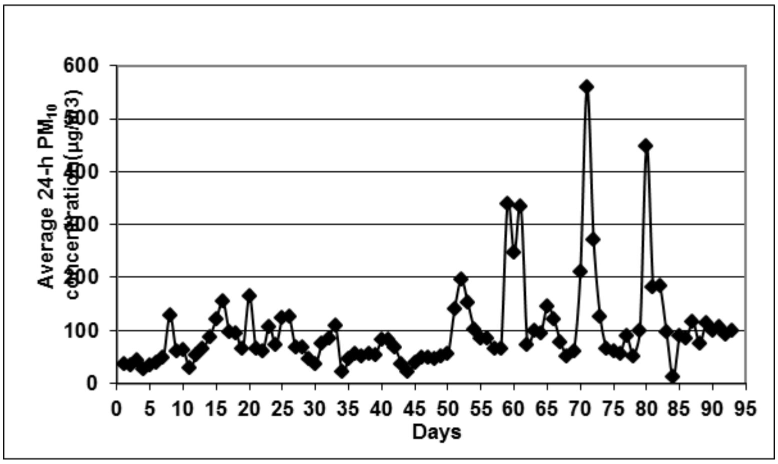

Figure 4: Range of measured concentrations of PM_{10} in spring

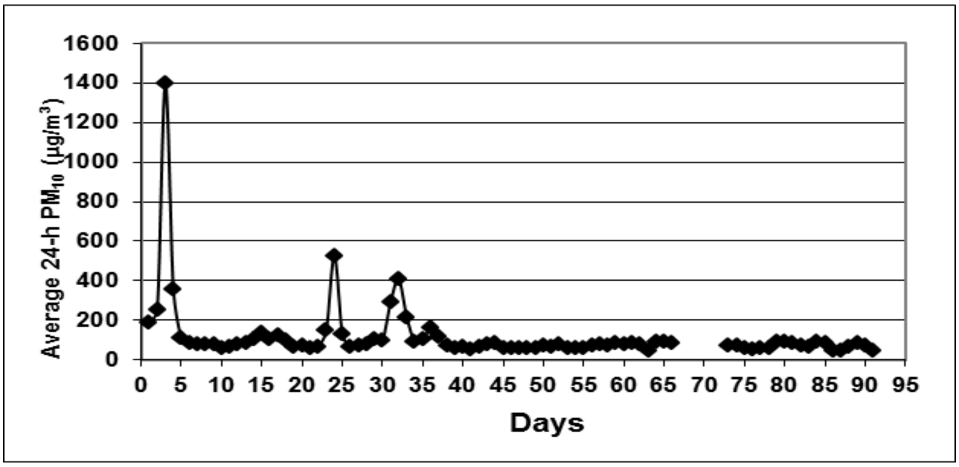

Figure 5: Range of measured concentrations of PM_{10} in summer

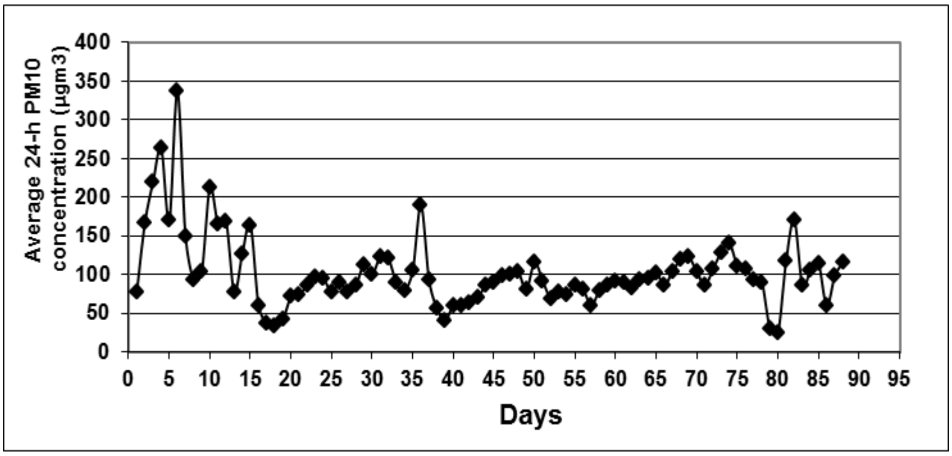

Figure 6: Range of measured concentrations of PM_{10} in autumn

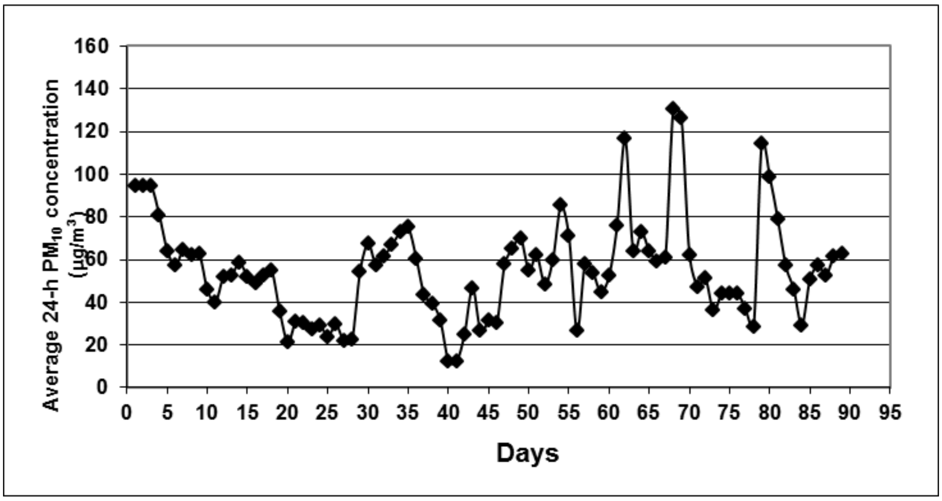

Figure 7: Range of measured concentrations of PM_{10} in winter

Figures 4 to 7 show ranges of PM_{10} measured concentrations in different seasons of the year 2010. According to figure 2, Maximum 24-hour average of PM_{10} concentrations was in July. The difference between the values (1396.3) with other measured values in summer resulted in greater standard deviation compared to other seasons.

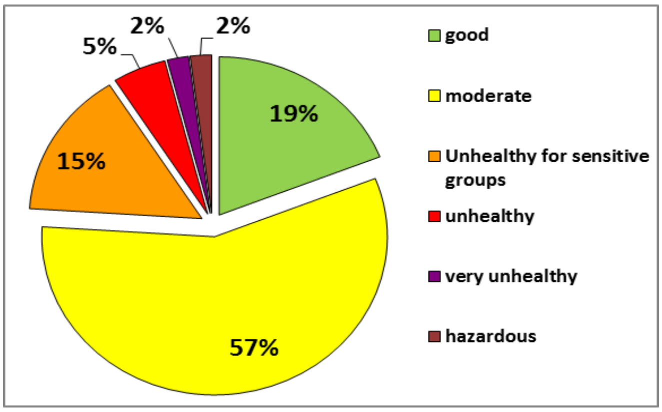

Figure 8: Distribution of air quality status in Sanandaj in 2010

Figure 8 shows the distribution of air quality status in Sanandaj in 2010, Sanandaj is in good condition only in 19 percent of the occasions; 57 percent healthy, and in other cases showed a decline in the air quality due to dust storms.

DISCUSSION

The present study was conducted to evaluate the severity of pollution caused by dust storms, leading to the following results:

Severity of dust storms is different in variety of seasons. The maximum concentration of suspended particles in the summer (3.1396 micrograms per cubic meter), and the second high concentration were (6.599 micrograms per cubic meter) in spring. PM_{10} concentrations in most of the winter days were in the standard range.

Peak 24-hour concentrations level of these pollutants during the year (1396.3), was about 28 times the average 24 hours level declared by the World Health Organization.

Air quality index in Sanandaj during the survey year were: 19% good, 57% healthy, 15% unhealthy for sensitive groups, 5% unhealthy, 2% very unhealthy, and 2% hazardous. PM_{10} pollutant was the responsible pollution factor in 327 days of the year 2010.

According to a study conducted by Alireza Rashki and colleagues, daily PM_{10} concentrations during major dust storms are about 10 to 20 times above the standard levels [22, 23]. Regarding the monthly mean PM_{10} concentrations, the results show extremely large values (>500 µg.m-3) during the period June to October, reaching up to 847 µg.m-3 in July.

Air quality index in Zabol during the survey year were: 5.7% good, 28.6% healthy, 17.8% unhealthy for sensitive groups, 9.7% unhealthy, 3.2% very unhealthy, and 34.9% hazardous.

Mean PM_{10}, $PM_{2.5}$ and PM_{10} concentrations were 319.6, 69.5, and 37.02 µg/m^3. A total of 72 dust days and 711 dust hours occurred over the entire study period. The longest dust storm occurred in July and lasted for five days. The most polluted dust storm occurred in June (max concentration of 5337.6 µg/m^3).

Shahsavani et al conducted their study on PM10, PM2.5, and PM1 concentrations during the Middle Eastern Dust (MED) events in Ahvaz, Iran, from april through september 2010. In their study, overall mean values of 319.6 _ 407.07, 69.5 _ 83.2, and 37.02 _ 34.9 mg/m3 were obtained for PM10, PM2.5, and PM1, respectively, with corresponding maximum values of 5337.6, 910.9, and 495 mg/m3. The presence of the westerly prevailing wind implied that Iraq is the major source of dust events in this area. A total of 72 dust days and 711 dust hours occurred in the study area. The dust events occurred primarily during July. The longest dust event during the study period occurred in July, lasted five days, and had a peak concentration of 2028 mg/m3. These high concentrations produced AQI values of up to 500. A total estimated mortality and morbidity of 1131 and 8157 cases, respectively, can be attributed to these concentrations. The results of this study indicated the importance of dust events in Ahvaz and their possible health impacts [5].

Meanwhile, the average annual concentration of PM_{10} in Sanandaj was above the levels set by World Health Organization.

Limitation

Another limitation is the time and cost of running air quality models, which can be conducted more extensively in the future studies.

Strong Points

Air pollution in Kurdistan is being monitored closely by many international studies and little study has been conducted in Kurdistan, Iran.

ACKNOWLEDGEMENT

This study was conducted in the Kurdistan Province's Health Center, Kurdistan University of Medical Sciences, Sanandaj, Iran. The authors would like to thank all the colleagues who participated in the study. Conflict of Interest None declared. Authors's Contribution.s All authors of this study contributed same in every section.

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