

original article

# Evaluation of SO<sub>2</sub> level in the ambient air of Khark Island

Taghi Aliyan, Mohammad Javad Daryalal, Hamidreza Pourzamani<sup>1</sup>

Department of Health, Safety and Environment,  
Iranian Oil Terminals Company, Khark, Iran,  
<sup>1</sup>Environment Research Center, Isfahan  
University of Medical Sciences, Isfahan, Iran

## ABSTRACT

**Aims:** In this study the concentration of SO<sub>2</sub> in Khark Island was evaluated via passive sampling.

**Materials and Methods:** The climate of the region and SO<sub>2</sub> level were investigated during one year. For SO<sub>2</sub> sampling, sulphatation pages was used and SO<sub>2</sub> was determined by PbO<sub>2</sub> method monthly. The climate data was obtained from Khark airport meteorology station.

**Results:** For SO<sub>2</sub> sampling, the sulphatation pages were installed at six locations in the region for a month. The results indicate the level of this gas is more than air standard. So that, SO<sub>2</sub> concentration in residential Khark area was more than 8.5 µg/cm<sup>2</sup> day.

**Conclusions:** High gas concentrations and climate conditions can cause accelerated corrosion of facilities and can have adverse effects on human and natural resources of the island.

**Key words:** Fuel fossils, Khark Island, SO<sub>2</sub>, sulphatation pages

**Address for correspondence:**

Dr. Hamidreza Pourzamani,  
Isfahan University of Medical Sciences,  
Hezar Jerib Avenue, Isfahan, Iran.  
E-mail: pourzamani@hlth.mui.ac.ir

## INTRODUCTION

Sulfur dioxide gas with chemical formula SO<sub>2</sub>, has molecular weight 120.06, boiling temperature -10°C and freezing point -72.7°C.<sup>[1]</sup> Sulfur dioxide is a colorless, non-flammable and non-explosive gas and is easily detectable in the air at concentration of 0.3-1 ppm. If its concentration in the air reaches over 3 ppm, it will cause scald and inflammation.<sup>[2]</sup> This gas has a very nasty and is heavier than air and is produced in places where use fossil fuels.<sup>[3]</sup> If its concentration in the air reaches 50 ppm, it will cause only severe respiratory effects. But, if its concentration in the air reaches 200 ppm, it will be intolerable, and will cause inflation and obstruction of

larynx. Higher amounts of the gas cause irritation of eyes, respiratory canal, hoarseness and asthma and eventually death.<sup>[4]</sup> Maximum 8 h amount of this gas at work place was determined 5 ppm. Usual range of SO<sub>2</sub> concentration in cities' air is between 0.01-0.2 ppm.<sup>[5]</sup> Some amount of sulfur dioxide is converted to sulfur trioxide or sulfuric acid. Existence of sulfuric acid in the air accelerates corrosion at metals' surface and also leaves many adverse effects on other materials in environment. Due to high gas solubility in water, small quantities of gas in the respiratory air irritate lower and middle parts of larynx, and occasionally produce inflation or acute pulmonary edema and in some cases cause paralysis of respiratory neural control center. Prolonged contact with this gas causes runny nose, scratchy throat, faintness and fatigue.

All fuels consumed by humans have some sulfur. Fuels such as wood have very little amounts of sulfur (0.1% or less) and coals have greater amounts about 0.5 to 3 percent. The amount of sulfur in oil is more than that in wood and lowers than it in coal. Sulfur existing in each of these fuels converts to sulfur dioxide due to combustion. So the main source of SO<sub>2</sub> in the air is the use of coal and industrial processes.<sup>[6]</sup>

Access this article online	
<b>Quick Response Code:</b> 	<b>Website:</b> <a href="http://www.ijehe.org">www.ijehe.org</a>
	<b>DOI:</b> 10.4103/2277-9183.102368

Copyright: © 2012 Aliyan T. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

This article may be cited as:

Aliyan T, Daryalal MJ, Pourzamani H. Evaluation of SO<sub>2</sub> level in the ambient air of Khark Island. *Int J Env Health Eng* 2012;1:39.

There are several SO<sub>2</sub> source such as refused gas combustion and gas and oil sweetening in Khark Island. The island has been considered by National Iranian Oil Company since 1957 and huge oil installations and oil loading jetties were built in it. It includes company, military and local participants, and has a population of about 23,000 people. Oil company employees are employed in Khark Island in both lunar and setting ways. Oil Company in Khark Island includes four companies such as oil company terminals, offshore oil Company, NITC and Petrochemical Company each do special tasks. Due to burning the gases of located factories in the offshore oil company and gases of Khark petrochemical building installations.

So in this study, SO<sub>2</sub> concentration in the air was assessed during one year. In addition to SO<sub>2</sub> concentrations, general climatic conditions (rainfall conditions, temperature, relative humidity, winds and fronts) in Khark Island were investigated.

## MATERIALS AND METHODS

This study was performed in Khark Island for one year, since 21 March 2003 till late March 2004. Khark Island is located in the Persian Gulf and 45 km Southeast of Busher in the range of 29°, 12', 25" to 29°, 16', 45" North latitude and 50°, 16', 45" to 50°, 20', 10" Eastern longitude. The longitude of this island is about 6 km and its average width is 3.5 km. The island has an area about 20 square kilometers. Approximately one third of Khark Island is covered with facilities and the rest with pastures. The pastures have poor vegetation of which about 50% is covered with forage plants with low nutritional value. Deer mammals and hindi crow belonging to birds are the most important species of island's wildlife. Other mammals and birds of the island include mouse, local and regional birds such as gull, lunar, dove, partridge, flamingo, gray goose, balkan etc.

The amount of SO<sub>2</sub> and H<sub>2</sub>S gases during day and night exceeds the licensed limit [Figure 1].

Sulphatation pages were used for sampling to determine SO<sub>2</sub> concentration. These plates were installed at six points



**Figure 1:** Burn extra fuels and smokes caused by imperfect gas combustion

in Khark Island; at the end of each month, these pages were collected from installation sites and sent to Tehran research institute of petroleum industry for testing

and determining SO<sub>2</sub> amount. Lead dioxide (PbO<sub>2</sub>) method (ASTM Book, D2010 part) was used to measure SO<sub>2</sub>.<sup>[7]</sup> Sulphatation page is a paper plate coated with PbO<sub>2</sub> paste and placed in a container made of polystyrene or polycarbonate with a diameter of 50 mm or 60 mm [Figure 2]. This page is installed on a bracket for monthly sampling (passive sampling) of active sulfuric compounds in the air. These pages are installed upside down not to let rainwater into themselves. The bracket is such that protects sulphatation page against the strongest winds. Minimum height of the installation place of sulphatation page with ground level is 1 m [Figure 2].

Meteorological stations information of Khark Island's airport was used to investigate the status of the general climate of the island. Also, the information of Busher environment department was used to evaluate vegetation and wildlife of the area.

## RESULTS

### General climate of Khark Island

The general climatic conditions of Khark Island, the status of air temperature, relative humidity, rainfall, winds and fronts was investigated in this area.

### Temperature

According to the statistics of meteorological stations of Khark Island, annual average temperature in the Island is 24.5°C. In this Island, January with a minimum average temperature of 11.6°C and minimum absolute temperature of 6.9°C, and August with maximum average of 35.24°C and maximum absolute temperature of 38.28°C are the coldest and warmest months of the year, respectively.

### Relative humidity

Khark Island has high humidity during the year, so that the annual average relative humidity is 62% at its maximum is related to month of January with an average of 68%. Summer is drier in the island and its relative humidity is about 60%. Changes in relative humidity is such that it reaches the maximum amount after midnight and then gradually decreases and reaches its minimum at about 9 am. Again, the relative humidity increases in the afternoon.



**Figure 2:** Sulphatation pages used for sampling and the page's bracket

### Rainfall

Annual rainfall in this island is not equally distributed between different months of the year and almost 5 months of the year there is no rainfall in the island. The total amount of annual rainfall occurs in winter and autumn and approximately in 5 months of the year. Most rainfall is related to December and January with average rainfall of 65.97 mm and 95.32 mm, respectively. During the whole year, the average rainfall is 45 days, having been reported up to 62 days. Among the months of the year, January with average of 10.2 days and maximum 17 rainy days has had the most rainy days during statistical period.

### Winds and fronts

According to results obtained from compass-card drawing, the direction of Khark's winds is as follows: northwest winds with frequency of 27.7% and north winds with frequency of 10.6% are the most frequent winds during the year. But, the

south and east winds are also scattered throughout the year and have major changes in the direction of pressure centers. 26.6% of all winds have 4-6 m/s and 22.7% have 7-10 m/s speed. The amount of calm winds and winds with speed of 1-3 m/s is totally 44% and winds with speed over 10 m/s blow with only 6.7% frequency during the year. The prevailing winds direction is northwest with a little change over the year. Sometimes in the summer, humidity increases and the heat becomes intolerable due to weakening of north and northwest winds, domination of south and southwest winds and creation of high-pressure conditions in Persian Gulf.

### Sulfur dioxide

Results obtained from SO<sub>2</sub> measurement and the analysis of sulphatation pages based on sulfur trioxide microgram on square centimeter at day is presented in Figures 3 to 8, and the gas concentration at different sampling sites is compared with standard value.

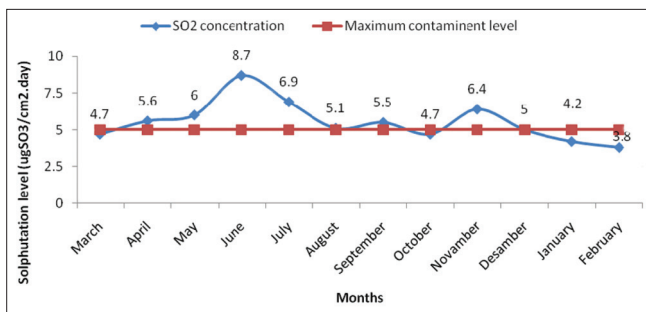


Figure 3: SO<sub>2</sub> changes in different months of the year in Khark residential area

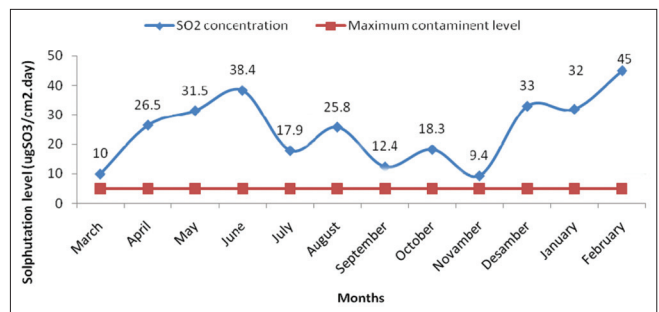


Figure 4: SO<sub>2</sub> changes in different months in front of company central office terminals

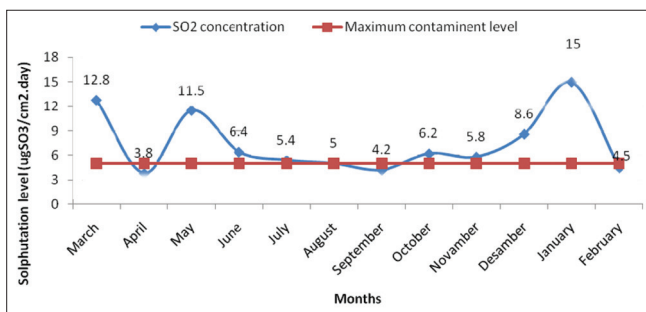


Figure 5: SO<sub>2</sub> changes in different months in residential area of continental plateau

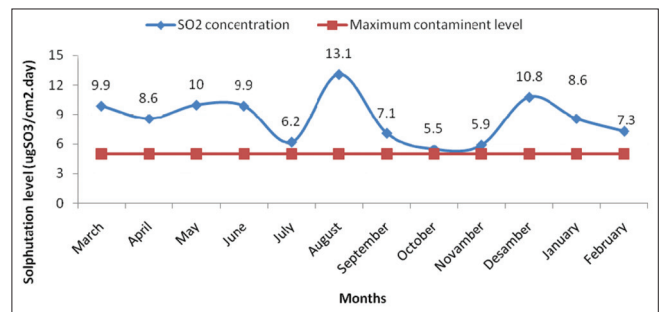


Figure 6: SO<sub>2</sub> changes in different months in front of central office of continental plateau

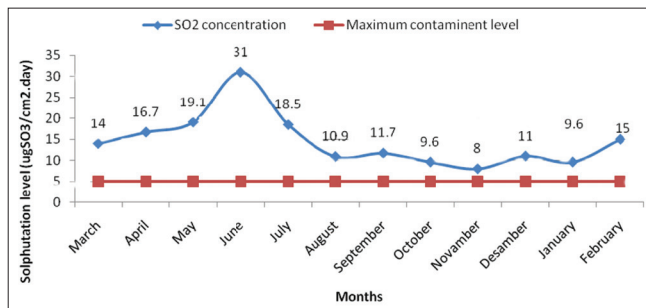


Figure 7: SO<sub>2</sub> changes in different months in eastern oil pool of Terminals Company

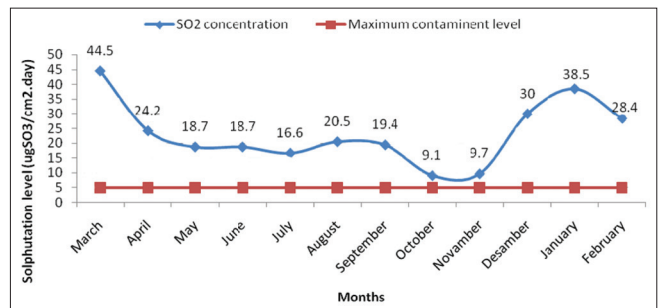


Figure 8: SO<sub>2</sub> changes in different months in front of Dorood's exploitation unit

## DISCUSSION

Khark Island has higher temperature gradient (Laps Rate) compared to oceanic and continental areas of its south because of drier conditions and lower temperature. It has stable high-pressure centers and permanent wind flow over the year. Generally in the winter, cyclone conditions are more than summer and are associated with instability and rapid winds flow, but in the summer, cyclone conditions are less and are associated with stability and tranquility.<sup>[8]</sup>

Regarding the general climate of Khark Island and according to domarten method can say that Khark Island's climate is dry. But based on emberger exponential climate, the island has a very hot climate.<sup>[9]</sup>

As is evident in Figures 3 to 8, the amount of SO<sub>2</sub> gas in residential enclosure of Terminals Company and eastern oil pool of Terminals Company has had an increasing trend since the beginning of the year till approximately July, and has had the highest concentration in July. SO<sub>2</sub> concentration has had a decreasing trend after July. SO<sub>2</sub> concentration in the place of central office of Terminals Company has had an increasing trend at the beginning of the year (till July), then has had irregular changes till January and after January has had a renewed increasing trend, the highest concentration of which has been in March. SO<sub>2</sub> concentration has irregular changes in residential area of continental plateau and in front of central office of continental plateau. In sampling place located in front of Dorood's exploitation unit, two concentrations of SO<sub>2</sub> have decreased at the beginning of the year and this decline has continued till January. But since January, it has had an increasing trend. Generally, except in residential areas of Terminals Company in which SO<sub>2</sub> concentration is lower than permitted threshold since February, in other cases, the gas concentration is higher than the permitted threshold.

Generally, according to the results of samples' analysis and data analysis, it is evident that SO<sub>2</sub> concentration is higher than standards in Khark Island. This is because of the existence of the pollutant-producing resources and also

the Island's climate. High temperature, lack of adequate and regular rainfall,<sup>[10]</sup> and inappropriate location of SO<sub>2</sub>-producing resources in this island are among the most important factors that cause the critical condition of air pollution in terms of the existence of SO<sub>2</sub> gas in this region. So that SO<sub>2</sub> concentration in the samples of sites located in the direction of winds is higher and the condition is more critical. High concentration of this gas in the region affects flora and fauna of the area and creates condition in which only resistant plants are able to live in a very short period of time that this issue also affects the fauna diversity of the region and the limits animals' diversity in the island.

## REFERENCES

1. Yuan Y, Zhang J, Li H, Li Y, Zhao Y, Zheng C. Simultaneous Removal of SO<sub>2</sub>, NO and Mercury using TiO<sub>2</sub>-Aluminum Silicate Fiber by Photocatalysis. *Chem Eng J*.
2. Biswas AK, Farzanegan MR, Thum M. Pollution, shadow economy and corruption: Theory and evidence. *Ecol Econ* 2012;75:114-25.
3. Lin W, Xu X, Ma Z, Zhao H, Liu X, Wang Y. Characteristics and recent trends of sulfur dioxide at urban, rural, and background sites in North China: Effectiveness of control measures. *J Environ Sci* 2012;24:34-49.
4. Fisher JA, Jacob DJ, Wang Q, Bahreini R, Carouge CC, Cubison MJ, *et al.* Sources, distribution, and acidity of sulfate-ammonium aerosol in the Arctic in winter-spring. *Atmos Environ* 2011;45:7301-18.
5. Baodong L, Xiaokun W. Economic structure and intensity influence air pollution model. *Energy Procedia* 2011;5:803-7.
6. Cristóbal J, Guillén-Gosálbez G, Jiménez L, Irabien A. Optimization of global and local pollution control in electricity production from coal burning. *Applied Energy* 2012;92:369-78.
7. Designation A. E399-90. Standard test method for plane-strain fracture toughness of metallic materials. Vol. 90. Philadelphia, Pennsylvania, 1990: American Society for Testing Materials; 1997. p. 1-31
8. Fakhrzadeh H, Batoei M, Faridnia P, Taeb M. Overweight and obesity in oil industry workers on Kharg Island. *Iranian South Medical Journal (ISMJ)* 2002.
9. Rahimi N, Griffin P, Eng P. Potential for acid gas injection at Kharg Island. Doha: SOGAT; 2004. p. E6.
10. Renner M. Oil and Blood. *World Watch* 2003;16:19-21.

**Source of Support:** Iranian Oil Terminal Company, Khark, Iran, **Conflict of Interest:** None declared.