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Main Industry Stack Emissions Dispersion Over Khoms City in North-Western Libya

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Abstract

Gaseous and particulate emissions from power stations and cement plants are well recognized as environmental hazards. Sulfur dioxide is one of the combustion products of fuel containing sulfur used in power generation. Also it is reported that 70% of NOx are emitted from power stations and 30% are emitted from other industrial stacks. The impact of NOx and SO2 emissions on the surrounding environment can be complicated further as Particulate Matters (PMs) accompanies such emissions. The impact of those pollutants on the wellbeing of man, animals, agricultural crops and human heritage are numerous. The aim of this study is the prediction of dispersion for SO2, NOx and particulate matters from two Portland cement plants and both of Steam and Gas power stations near Khoms city in north-western Libya. Study area is identified by Khoms city and the neighboring ancient Roman city of Leptis Magna on the Mediterranean Coast, (120 km east of Tripoli city), so the significant of study underlays in lack of statistical information and environmental impact assessment studies in relation to the industrial emission in this area. Generally; labels of air quality monitoring facilities across the study area makes computer models a practical approach to assess emission concentration spatial distribution under the effect of the local meteorological conditions and air quality with respect to some international standards. Results shown that the average monthly rates of SO2, NOx and PMs concentrations in study area of high population density exceed the international standard limits of air quality. This investigation highlight the need for improved operational procedures to minimize emissions and avoid any possible adverse environmental effects.

Keywords: Stacks, SO2, NOx, PMs, Hysys, Dispersion.

1. Introduction

Gaseous and particulate emissions produced from chemical reactions of combustions during operation of power stations and cement plants are well recognized as environmental hazards. Sulfur dioxide is one of the combustion products of fuel containing sulfur used in power generation. It is reported that 70% of NOx are emitted from power stations and 30% are emitted from other industrial stacks [Cooper and Alley, 1986].

The impact of NOx, SO2 and PMs emissions is causing human, animals and environmental diseases, as well as decline of agricultural crops. Respiratory illnesses such as asthma are attributed to SO2 at 1000 µg/m3 concentrations over a ten minutes duration [WHO, 2005]. Studies show that exposure of agricultural plants to 1850 µg/m3 of SO2 for 8 hours or 40 µg/m3 throughout the farming seasons can lead to the mortality of such plants [Smith,1981; NAPAP, 1999]. The impact of SO2 on trees varies according to tree species and SO2 concentration. An exposure of pine tree to 44 µg/m3 of SO2 for 10 years leaves a tangible damage on their leaves [Nicholas, 2002; EC,1987]. It is reported that concentrations of about 1880 µg/m3 of NO2 can introduce biochemical changes in animal lungs. Animals subjected to about 990 µg/m3 of NO2 for 6 months tend to suffer from rupture of alveoli and increased vulnerability to bacterial infections [Nicholas, 2002; NAAQS, 2008]. Furthermore, gaseous emissions are blamed for chemical reactions with limestone and marbles of statues and columns of human heritage and hence cause their features to vanish [Roots, 2008]. Inhalable cement dust particles and soot are also linked to lung malfunction, asthma, respiratory infections, cardiovascular, irregularities and early deaths [WHO, 2005]. Air quality monitoring facilities across the study area makes computer models a practical approach to assess emission concentration spatial distribution under the effect of the local meteorological conditions and air quality with respect to some international standards.

This study highlights the environmental impact caused by NOx, SO2 and Cement dust emitted from

the stacks of the surrounding environment of Khoms steam and Gas Power Stations and Mergheb and Libda cement plants.

2. MATERIALS AND METHODS

2.1. Area of Study

The study area is identified by Khoms city [Also, called Al-Khums City] and the neighboring ancient Roman city of Leptis Magna (enlisted human heritage cites by UNESCO) on the Mediterranean Coast, 120 km east of Tripoli, the study location (E 13.975 to 14.525 & N 32.725 to 32.475), and characterized by a rugged topographical land form and bisected by a number of valleys. It is inhibited by over 200,000 residents.

2.2. Data of emission sources

Emission rates from the power stations and the cement plants are obtain from combustion processes simulation reported by Ibrahim et al. [Ibrahim et al. 2012a,b]. Additional data on stack dimensions are listed in Table 1.

TABLE 1. EMISSION RATES, STACK DIMENSIONS AND LOCATIONS

Emission source	Emissions (g/s)			Stack Dimensions (m)		Stack location	
	PMs	NO_2	SO_2	High	Diameter	E	N
Gas P.P.	-	3179.2	-	30	6	14.328025	32.623128
Steam P. P.	-	2130.7	806.2	100	5	14.331181	32.621387
Mergheb C.P.	362.9	258.4	7.8	55	1.8	14.221634	32.633871
Lebda C. P.	2645.2	922.9	30.6	81	4.5	14.325193	32522562

2.3. Meteorological data in the study area

Climate at the study area is a Mediterranean climate of an average temperature 17oC during winter and 26oC during summer. The average precipitation is 17mm/day during the period from September through March. From October through April dominant winds blow from northern and western directions where winds blow from eastern and southern directions dominate the summer months. The meteorological data for simulation represent five years starting from the beginning of January 2005 through the end of December 2010. These data are recorded at station No. 62012 near Khoms city.

2.4. Air pollutants dispersion processing

Estimated NOx, SO2 and PMs emitted from the stacks of Khoms Gas and Steam Power Stations, Mergheb and Lebda Cement Plants in the local atmosphere are achieved by using DISPER V4.0, an air pollution dispersion modeling software produced by Canarina Environmental Software in 2007. In order to assess the effect of each source on the surrounding, each source is simulated independently for all the relevant pollutants. SO2 and NOx are attributed to the steam station, NOx is attributed to the Gas station where SO2, NOx, and dust are attributed to the cement plants. The average speeds and directions of dominant winds in combination with the emission rates are used to calculate the concentration distribution of each pollutant and representing the results by contour maps.

3. RESULTS AND DISCUSSION

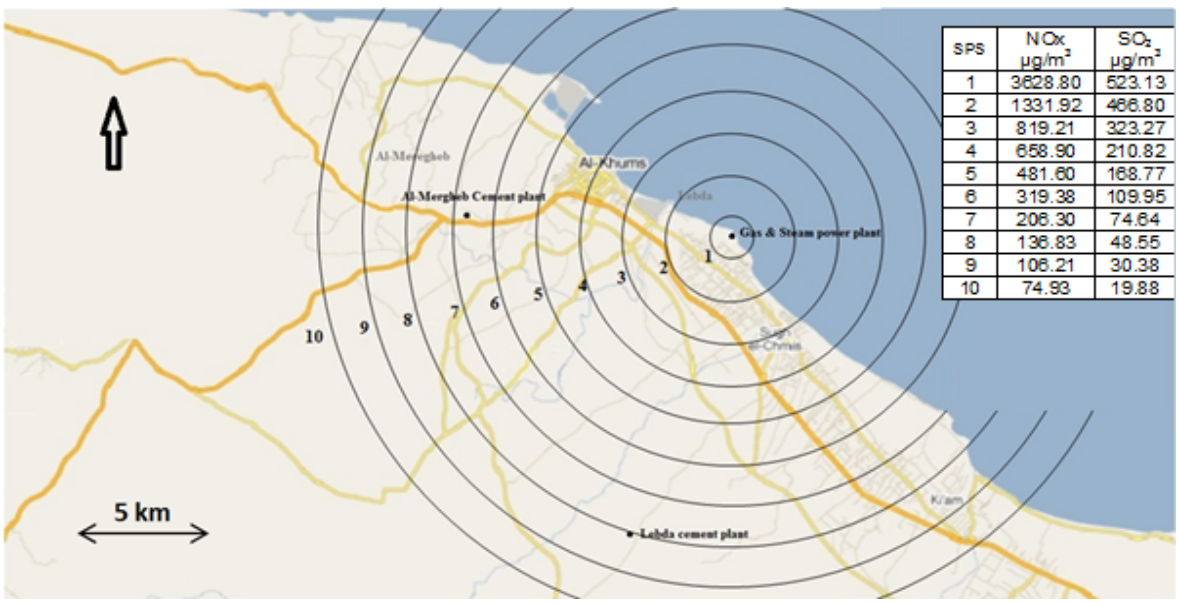
3.1. Steam Power Plant

The simulation results reveal that the steam power station is the main source of sulfur oxides in the area and NOx and SO2 dispersions over the surrounding area (Figure 1) can reach all the populated areas in the vicinity of Khoms city. As an example SO2 over Khoms city under the effect of winds blow from east

can reach high concentrations ranging from 210.82 to 531.1 µg/m3. Such concentration can be blamed for functional changes in human lungs if exposure continues for 10 minutes duration. It is recommended that exposure for SO2 should not exceed 500 µg/m3 over an average duration of 10 minutes [WHO, 2005]. Health impacts attributed to SO2 at 125 µg/m3 concentrations during 24 hrs is also reported [WHO, 2010]. The World Health Organization recommends reducing the emissions of SO2 during 24 hrs to 20 µg/m3 and using the daily limit rather than the annual limit [WHO, 2005].

Gas power station

The results illustrated by Figure (2) show that nitrogen oxides represent the main emissions from the gas station reaching high Figures, in particular, over the most populated area within circle No. 5 corresponding to concentrations ranging from 882.45 µg/m3 to 7893.73 µg/m3. Such concentrations exceed the limits short and long term exposure limits set by the WHO. An exposure to 500 µg/m3 of NOx for an hour time duration has been reported to caused acute health effects on the function of the respiratory system [WHO, 2005]. Other studies suggest that an exposure to a 200 µg/m3 of NOx during short periods can trigger Asthma strokes, hence, a 200 µg/m3 is regarded as a nitrogen indicator by the WHO [WHO, 2010]. Long term exposure can result in lung tissue damage [NAAQS, 2008].



SPS	NOx µg/m³	SO₂ µg/m³
1	3628.80	523.13
2	1331.92	466.80
3	819.21	323.27
4	658.90	210.82
5	481.60	168.77
6	319.38	109.95
7	206.30	74.64
8	136.83	48.55
9	106.21	30.38
10	74.93	19.88

Figure 1. Concentration distribution of pollutants emitted from the steam power plant (SPS)based an annual average wind speeds.

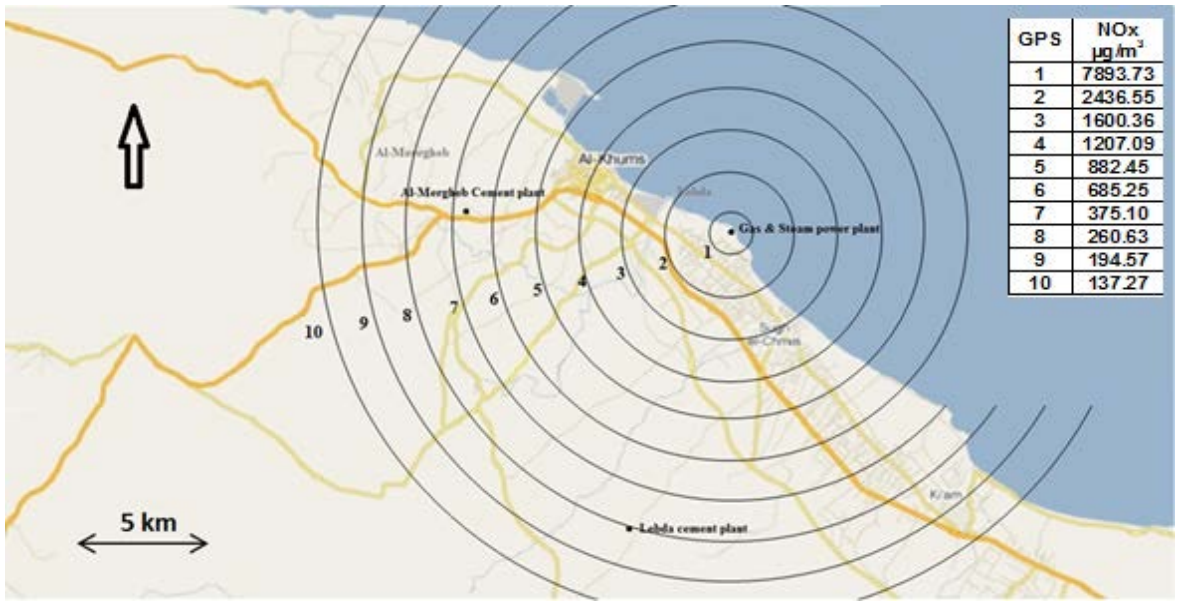


Figure 2. Concentration distribution of pollutants emitted from the gas power plant (GPS)based an annual average wind speeds

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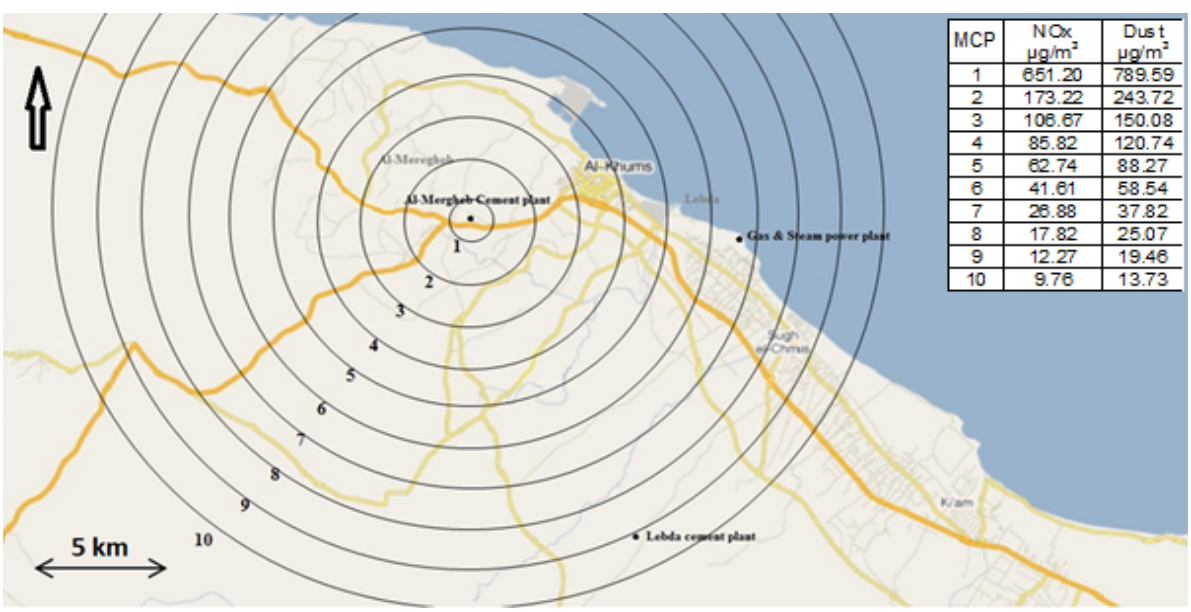
3.2. Cement plants

Lebda and Mergheb cement plants constitute the largest sources PMs sources in the region. Emissions from Lepda plant range between 106.44 µg/m^3 and 1733.8 µg/m^3 (Figure 3) where Mergheb plant range between 13.73 µg/m^3 and 789.59 µg/m^3 (Figure 4). These figures exceed all recognized limits, therefore, such concentrations are most likely to cause impact on public health. This concentrations exceed the international air quality standard limits and most likely to impact the public health in the short term [USEPA, 2010]. Similar studies carried out in 29 European cities and 20 American cities reveal a proportional increase in mortality rates by 0.62% and 0.46% for an increase in concentration by 10 µg/m^3 over a 24 hrs duration [Samet et al. 2000; Katsouyanni et al., 2001], other studies conducted in 29 cities in third world countries indicate that the average increase in mortality rates is 0.5% for an increase in concentration by 10 µg/m^3 [Cohen et al. 2004]. Therefore , the estimated concentrations in the surrounding of both plants targeted by this study are expected to increase mortality rate by 5%. Further impact on the biodiversity and vegetation cover attributed to these plants is reported by Okasha [Okasha et al. 2013].

LCP	NOx µg/m³	Dust µg/m³
1	604.61	1733.8
2	518.98	1490.1
3	340.39	975.45
4	289.16	828.63
5	203.99	584.57
6	151.68	434.66
7	95.60	273.97
8	70.79	201.74
9	47.22	150.64
10	37.14	106.44

Figure 3. Concentration distribution of pollutants emitted from the Lebda Cement Plant (LCP) based an annual average wind speeds.



MCP	NOx µg/m³	Dust µg/m³
1	651.20	789.59
2	173.22	243.72
3	106.67	150.08
4	85.82	120.74
5	62.74	88.27
6	41.61	58.54
7	26.88	37.82
8	17.82	25.07
9	12.27	19.46
10	9.76	13.73

Figure 4. Concentration distribution of pollutants emitted from Mergheb Cement Plant (MCP) based an annual average wind speeds.

4. Conclusions

Results of dispersion of air pollutants concentrations show that atmospheric air of Khoms city region suffers from the presence of contaminants greatly affect the health of the population. These pollutants are primarily result of the major industrialized operations in the region and that of the most important power plants (steam and gas) and Mergheb and Lebda Cement plants. In addition to the pollutants resulting from other sources. This concentrated pollutants show us that the main reason for thoracic and sensitivity in Khoms region are due to poor of air quality that inhaled by population, especially since the presence of cement plants and power plants on the different parts of the city that makes it vulnerable to air pollution from one of these sources whatever wind direction. So it is necessary to tighten emission control over such industrial plants to be reduced to a minimum to meet allowable limits by publication of the International standards air issued by the World Health Organization.

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