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IN ALEPPO

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مشروع التحكم المتكامل بالتلوث بحلب

AIR POLLUTION IN ALEPPO

Dr. YOUSEF MESLMANI

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WORK TEAM:

Project Director: Dr. ABDULGHANI CHIHABI

Dr. Eng.: M. FAISAL RIFAI

Dr. MOHAMED ABDRABO

Directorate of Environmental Affairs in Aleppo:

Eng. MUHAMED SAID NAFOUS

Eng. SONIA AFESA

Consultants:

Dr. Eng.: YOUSEF MESLMANI (Atomic Energy Commission, AECS)

Dr. MUHAMED ALOUDAT (AECS)

Abstract

An investigation was carried out of air pollution in Aleppo within the framework of the project of Integrated Pollution Control in Aleppo. This project is financed by the European Union, monitored by the United Nations Development Program (UNDP) and implemented by the Aleppo Directorate of the Environment in the Governorate of Aleppo programs.

Concentrations of air pollutants were measured of total suspended particulate (TSP), of the particulate with diameters less than 10 microns (PM10) and concentrations of some heavy metals such as lead, cadmium, zinc and copper. The measurements were carried out in the industrial areas of Sheikh Said and Shkaief, the solid waste dumping site of Oweija and surroundings.

Also, measurements were made of the concentrations of the polluting gases such as Nitrogen Oxides, Sulfuric Oxides, Hydrogen Sulfide, Ozone and Carbon monoxide (No_x, SO_2, H_2S, O_3 and CO). They were conducted in Sheikh Said area, Shkaief industrial area and Oweija in addition to the residential areas of Medan, Farafra and Mouhafaza-Fourkan quarter.

The study has shown that the hourly concentrations of Nitrogen Oxides (No_x) and Sulfuric Oxides (SO_2) in all areas, except for Oweija were higher than the WHO permissible limits by up to 10 times in some cases. Also, the concentrations of the total suspended particulate (TSP) were higher than the WHO permissible levels in all study areas, with a ratio ranging between 2.6 and 7.8.

The results have indicated that the concentrations of Carbon monoxide, Ozone and Hydrogen Sulfide (H_2S, O_3 and CO) were lower than the WHO permissible levels in all study areas. It was noted furthermore, that the concentrations of Hydrogen Sulfide and Sulfuric Oxides (H_2S, SO_2) were higher in the industrial areas than those of the residential areas.

Immediate intervention measures have to be implemented in factories and vehicles. Filters have to be installed in factories, the use of gasoline should be limited to the unleaded type, the mechanical conditions of the diesel

vehicles have to be strictly controlled to reduce their harmful emissions and improve the properties of diesel and fuel by reducing their sulfur content.

1. Introduction

The atmosphere consists of air which comprises Nitrogen 78.9%, Oxygen 20.95%, Carbon dioxide 0.03%, and rare gases such as Argon 0.093%, Neon 0.0018% …etc in addition to water vapor.

Air pollution in any atmospheric conditions is defined by the presence of harmful materials with concentration in the normal environment. Those concentrations, if higher than the permissible values cause safety hazards to the human beings, animals and to the plants. The pollutants are any natural or chemical materials, industrial or combustible. They are emitted to the atmosphere in three forms: gazes, falling, liquid, or solid particulates.

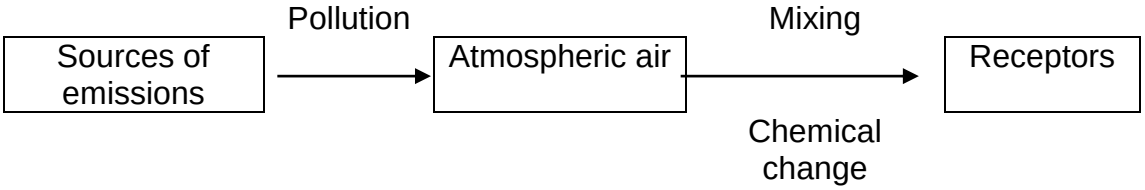
The problem of air pollution is a phenomenon of three components: the emission sources, the mixing and chemical transportation and the recipients.

The main emission sources are traffic and transportation vehicles56%, stationary sources of fuel combustion (industrial and domestic power stations… etc) 22%, industrial processes 15%, solid waste disposal 2% and miscellaneous 5%.

Air pollutants are manifested in the atmosphere as either main or secondary as shown in the schematic representation. The pollutants are either measured by parts per million (PPM), or by Microgram per cubic meter µ g / m3.

Air pollution, which is the presence of high concentration of certain materials in the atmosphere, is seen as one of the main problems of the environment and is mainly associated with human activities, especially the industries, electricity generation, transportation means. It is also associated with waste disposal, particularly if not carried out by sanitary fills, as well as quarrying activities.

The way it works is as follows:



Generally these different sources contribute towards air pollution with varying magnitude[1] (Table 1).

[1] This represents the overall contribution, which is quite different from specific location cases.

Table 2 Sources of emissions by percentage of air pollution

Source	Air pollution %
Industrial processes	15
Transportation	56
Fuel combustion (stationary sources)	22
Solidwaste disposal	2
Miscellaneous	5

The main air polluters include particulate, heavy metals and chemical gases.

2. Study Plan

In the framework of the project of integrated pollution control in Aleppo, investigations on the pollution of water, soil and plants have been carried out. Solid and liquid pollution in Skeikh Said, south of Aleppo, Oweija, north east of Aleppo and Shkaief, north of Aleppo, were investigated and the results were document in the report in (Environmental Study of Sheikh Said Tanneries, Rifai, 1999), (Study of Solidwaste Dumping Site in Oweija, Rifai, 1999), and (Environmental Study of Shkaief Industrial Area, Rifai, 2000).

The operational plan for the study of air pollution for the three areas was planned so that the measurements would be conducted over the same periods. This was hard to achieve because the measuring instruments and equipment are heavy and are available only through central administrations and institutions in Damascus. This meant that sampling and measurements had to be conducted in one operation. Accordingly, the study was divided into two parts: the first part consisted of the investigation of air pollution by particulate and heavy metals, and was conducted during the period July 11, 1999 to July 22, 1999. The second part comprised the investigation of air pollution caused by gases and particulate in Aleppo and its surroundings during the period October, 29,1999 to November 17, 1999.

In the first part, measurements were made of the concentrations of the total suspended particulate (TSP), particulate with diameter less than 10 microns (MP10), in addition to metal elements such as lead, cadmium, zinc and copper. Those measurements were conducted with the use of the equipment of the Syrian Atomic Energy Commission (SAEC) of Damascus. The measurements of the second part comprised monitoring the concentrations of Nitrogen Oxides, sulfuric dioxide, hydrogen sulfide, Ozone, Carbon monoxide in addition to measuring the concentration of total suspended particulate (TSP). The second part measurements were made with the use of the instruments and equipment of the Laboratory of Environment of the Center for Scientific Studies and Research of Damascus.

To make the study of air pollution more comprehensive, commercial and mixed-uses areas were selected with different magnitude of traffic ad transportation circulation. These areas are Medan Triangle (north of Aleppo),

Sijn Street and Farafra Quarter (east inner city) and Mouhafzat-Fourkan Road (west of Aleppo).

3. Pollution

Air pollution with particulate is considered to be the most common type of pollution, especially in semi-arid and arid areas. It is associated with certain types of industrial activities, e.g. cement industries and quarries as well as transportation means. The size of the particulate plays a major role in determining its behavior in the environment and its impacts on human health, living creatures and materials and equipment (Vesilind, 1982).

The most important type of particulate with diameters less than 10 micron (PM10), as it could be inhaled by humans, especially those with less than 2.5 micron diameter (PM2.5). This one can penetrate respiratory defenses and reach the respiratory bronchioles (Ormstad, 1997 and WHO, 1987). The health impacts of PM10, as suggested in many studies include higher frequency and risk of respiratory diseases and the spread of asthma and coughing. They can also decrease the oxygen exchange surface causing of consequently to the impairment the functioning of the respiratory system. This means that the heart has to work more in order to obtain the same quantities of oxygen through the respiratory system. Accordingly, it was found that there is a relationship between particulate pollution and the gross number of death due to heart and respiratory problems.

Particulate also plays a major role in heavy metal pollution, as particulate can act as carriers to heavy metals. Exposure to heavy metals can have serious health effects on humans, particularly children. Lead, for example, penetrates the lungs and through the blood it reaches some enzyme systems, particularly the heme biosynthetic system (Pain, 1989). Similarly, Cadmium, which is used in alloys, batteries and plastic production, can accumulate in the liver and kidneys, impairing the kidney functions (Kjellstrom, 1986), problems in the respiratory system and may lead to cancer (WHO, 1987).

As for copper, inhalation through the mouth, at 15 times its normal level, may lead to vomiting and diarrhea and the presence of copper particulates can lead to respiratory problems and may accumulate in the kidneys, liver and spleen (Sarcar, 1988). Zinc also is considered an air pollutant, when it reaches a concentration of 5 mg/m3 (Bertholf, 1988).

4. Equipment

The equipment used in sampling and analysis include the following:

1. High Volume Air Sampler used for TSP sampling.
2. IP-10 High Volume Air Sampler, with a separation system for
3. Whatman EPM 2000, (with 25x20 dimensions) to measure TSP.

Table 1 Characteristics of the equipment used in this study

Instrument	Model	Measurement Principle	Sensitivity
Oxides of Nitrogen Analyzer	ML 8440	Chemiluminescence	10 ppb
Sulphur Dioxide Analyzer	ML 8850	UV-Fluorescence	10 ppb
Hydrogen Sulphide Analyzer	ML 8770	Catalytic Conversion of H_2S to SO_2	10 ppb
	ML 8850	Detection as SO_2 by UV-Fluorescence	
Ozone Analyzer	ML 8410	Chemiluminescence	5 ppb
Carbon Monoxide Analyzer	ML 8310	Cross-flow Infra-Red	0.1 ppm
Gas Calibration Unit	ML 8500	Preparation of zero air and span gas mixtures	
System Controller	ML 8530	For the control and operation of zero, span, and monitor inlet valves	

These equipment were calibrated using the (Calibration unit, ML 8500).

5. Methods and Techniques

Methods for measuring TSP are by using the weighing of the filters on the Whatman EPM 2000 , for measuring PM10 is by using the IP – 10 Volume Air Sampler and for heavy metals by polarographic analysis using the Anodic Stripping Voltametry.

6. Sampling locations

The sampling of TSP, PM10 and the heavy metals; lead, cadmium, zinc and copper was carried out in seven locations. They include:

1. Medan district: Located in the northeastern part of Aleppo city and accommodates a mix of residential, industrial and commercial activities.
2. Military Housing Company, branch 300: Located one kilometer away to the east of the cement factory.

3. Sheikh Said village: Located to south of Aleppo city, where there are to the southwest Sheikh Said cement factories and a number of non-permitted centers for the reuse of batteries lead.
4. Sheikh Said tanneries: which are located to the west one kilometer, away from the cement factories. There is also to the north of the tanneries Ramousa industrial district.
5. Oweija village: Located to the north of Aleppo city, to the north of it where at some 0.5-1.0 km there is Oweija landfill, and to the west, at some 1.0 km there is Shekeif industrial district.
6. Kendy hospital: located to the north of Oweija village.
7. Shekheif industrial district: Located to the north of Aleppo city to the west of Oweija village and accommodates a variety of industries, the most important of which are batteries and textile industries.

Table 3 Sampling according to type of sampling, sites, codes, dates, characteristics of site.

Location	Name	Code	Date	Site nature	Sampling type
North of Aleppo city	Oweija (south)	A1	18-20/7/99	Village	P
	Oweija (Kendy hospital)	A2	18-20/7/99	Hospital	P
	Oweija (north)	A3	6-9/11/99	Village	P,G
	Shkaeif (center)	S1	19-21/7/99	Industrial	P
	Shkaeif (east)	S2	2-4/11/99	Industrial	P,G
South of Aleppo city	Sheikh Said (south)	C1	16-18/7/99	Village	P
	Sheikh Said (tanneries)	C2	16-17/7/99	Industrial	P
	Sheikh Said (East of the cement factory)	C3	15-17/7/99	Industrial	P
	Sheikh Said (north)	C4	30/10-1/11/99	Village	P,G
Inner Aleppo city	Medan (Police station)	M1	12-14/7/99	Residential-industrial	P
	Medan (Bostan El-Basha	M2	9-12/11/99	Residential-industrial	P,G
	Farafra (Sijn Str.)	F	12-14/11/99	Residential	P,G
	University (University square)	U	14-17/11/99	Residential	P,G

7. Results discussion

Part one : Total Suspended Particulate (TSP), (PM10) and heavy metals (Pb, Cd, Zn, Cu).

Table 4 and 5 show the concentrations of TSP and their averages in the measurement locations.

Table 4 TSP average concentrations, by date and location (μ/m^3)

Location	Date	Concentration($\mu g/m^3$)
Medan (M1)	12/7	328
	13/7	433
	14/7	384
East of cement factory (C3)	15/7	473
	16/7	756
	17/7	431
Sheikh Said village (C1)	16/7	5967 *
	17/7	691**
	18/7	1067
Sheikh Said Tanneries (C2)	16/7	902
	17/7	445
Kendy Hospital (A2)	18/7	160
	19/7	282
	20/7	199
Oweija village (A1)	18/7	234
	19/7	505
	20/7	350
Shekheif (S1)	19/7	597
	20/7	277
	21/7	343

** The presence of southwestern wind means that the dust coming from the chimneys of the cement factory fall directly on the village.*

*** The prevailing wind direction on that date was northern meaning that the village was not affected directly by the dust coming out the cement factory.*

The WHO permissible level, which is similar to the one proposed by the Syrian Ministry of Environment, is 120. As shown in tables 4, 5 and 6, the concentrations of TSP in different locations were found to be high in all locations at different magnitude. For instance, the concentration was found to be highest in Sheikh Said village, with maximum repetition of 21 times over the permitted level and with a maximum concentration that exceeds the permissible limit by 49.7 time in Sheikh Said.

These concentrations compared with the TSP concentration levels (

Table 5: Average concentration of TSP during the measurement period (µ/m^3)

Location	Average	Range
Medan	52± 381	328-433
East of cement factory	177± 553	431-756
Sheikh Said	2943± 2575	691-5967
Tanneries	323± 673	445-902
Kendy hospital	62± 213	160-282
Oweija	136± 363	234-505
Shekheif	169± 406	277-597

The WHO permitted level, which is similar to the one proposed by the Syrian Ministry of Environment, is 120. As shown in table 1, the concentrations of TSP in different locations were found to be considerably high in all locations, yet at different magnitude. For instance, the concentration was found to be highest in Sheikh Said village, more than 21 folds the permitted level, compared with 1.8, 3.0, 3.2, and 3.4 folds in Kendy hospital, Oweija, Medan and Shkaief, respectively.

Table 6: TSP concentrations exceeding the permitted level (times)

Location	Average	Range
Medan (M1)	0.44± 3.18	2.7-3.61
East of cement factory (C3)	1.47± 4.61	3.59-6.3
Sheikh Said village (C1)	24.5± 21.45	5.7-49.7
Tanneries (C2)	2.69± 5.61	3.71-7.52
Kendy Hospital (A2)	0.52± 1.77	1.33-2.35
Oweija village (A1)	1.13± 3.00	1.95-4.21
Shkaief (S1)	1.41± 3.38	2.3-4.97

Table 7: Concentration of TSP in some cities in the world.
Source: UNDP and WHO, 1992

City	Concentration (µ/m^3)	Remarks
New York	60-80	Between 1980-1990
Tokyo	40-80	Between 1980-1990
Canadian Cities	98	90% of measurements
Moscow	100-200	Between 1989-1990
Beijing	400-500	Between 1989-1990
Bangkok	100-300	Between 1989-1990
Calcutta	350-600	Between 1989-1990
Delhi	350-525	Between 1989-1990
Damascus	231±844	Between 1996-1997
Aleppo	303±604	Between 1996-1997
Homos	218±376	Between 1996-1997
Tartos	213±486	Between 1996-1997
Swida	181±393	Between 1996-1997

Table 8: Concentration of MP10 in Aleppo

Location	Date	Concentration (µ/m^3)
Medan (M1)	12/7/99	177
	13/7/99	186
	14/7/99	169
East of the Cement Factory (C3)	15/7/99	245
	16/7/99	387
Sheikh Said (C1)	17/7/99	202
	18/7/99	273
Tanneries (C2)	21/7/99	253
Kandy Hospital (A2)	19/7/99	133
Shkaeif Area (S1)	20/7/99	116

Table 9: Average concentration of MP10 in Aleppo

Location	Average	Range
Medan (M1)	8.5 ± 177	169-186
East of the Cement Factory (C3)	100.4± 316	245-387
Sheikh Said (C1)	50.2± 237.5	202-273
Tanneries (C2)	253	-
Kandy Hospital (A2)	133	-
Shkaeif Area (S1)	116	-

Table 10: Concentration of MP10 in Aleppo in excess of WHO standards (times)

Location	Excess of standards (times)	Range
Medan (M1)	0.12± 2.5	2.41-2.66
East of the Cement Factory (C3)	1.4± 4.5	3.5-5.53
Sheikh Said (C1)	0.72± 3.39	2.88-3.9
Tanneries (C2)	3.6	-
Kandy Hospital (A2)	1.9	-
Shkaeif Area (S1)	1.66	-

Table 11: Percentage of MP10 to TSP in Aleppo

Location	Average TSP	Average PM10	PM10 /TSP
Medan (M1)	381	177	46.4
East of the Cement Factory (C3)	553.3	316	57.1
Sheikh Said (C1)	2575	237.5	9.22
Kandy Hospital (A2)	213	133	62.4
Shkaeif Area (S1)	405.7	116	28.59

Table 12: Concentration of Lead, associated with TSP in Aleppo

Location	**Date**	**Concentration (μ/m^3)**
Medan (M1)	12/7	0.002± 0.187
	13/7	0.006± 0.585
	14/7	0.0078±0.506
East of cement factory (C3)	15/7	0.029± 4.003
	16/7	0.07± 5.646
	17/7	0.106± 4.380
Sheikh Said village (C1)	16/7	0.300± 15.650
	17/7	0.02± 2.19
	18/7	0.03± 2.00
Sheikh Said Tanneries (C2)	16/7	0.072± 4.260
	17/7	0.031± 1.460
Kendy Hospital (A2)	18/7	0.005± 0.413
	19/7	0.010± 0.644
	20/7	0.002± 0.253
Oweija village (A1)	18/7	BDL
	19/7	0.064± 4.920
	20/7	0.002± 0.041
Shekheif (S1)	19/7	0.11± 5.824
	20/7	0.023± 2.164
	21/7	0.056± 3.00

Table 13: Average concentration of Lead, associated with TSP in Aleppo

Location	Average	Range
Medan (M1)	0.211± 0.426	0.187-0.585
East of cement factory (C3)	0.861± 4.676	4.003-5.646
Sheikh Said village (C1)	7.83± 6.613	2.0-15.65
Tanneries (C2)	1.98± 2.86	1.46-4.26
Kendy Hospital (A2)	0.21± 0.404	0.253-0.644
Oweija village (A1)	2.82± 1.65	BDL-4.92
Shekheif (S1)	1.92± 3.66	2.16-5.82

Table 14: Average concentration of Lead, associated with TSP in Aleppo

Location	Date	Concentration (µ/m^3)
Medan (M1)	12/7/99	0.002± 0.166
	13/7/99	0.008± 0.421
	14/7/99	0.0036± 0.324
East of the Cement Factory (C3)	15/7/99	0.036± 1.265
	16/7/99	0.036± 1.802
Sheikh Said (C1)	17/7/99	0.016± 0.664
	18/7/99	0.001± 0.287
Tanneries (C2)	21/7/99	0.002± 0.051
Kandy Hospital (A2)	19/7/99	0.001± 0.096
Shkaeif Area (S1)	20/7/99	0.015± 0.916

Table 15: Average concentration of Lead, associated with MP10 micron in Aleppo

Location	Average	Range	% Lead associated with MP10 to that associated with TSP
Medan (M1)	0.1± 0.304	0.166-0.421	71.3
East of cement factory (C3)	0.268± 1.534	1.265-1.802	32.8
Sheikh Said village (C1)	0.189± 0.476	0.287-0.664	7.2
Tanneries (C2)	0.051	-	1.8
Kendy Hospital (A2)	0.096	-	22.5
Shekheif (S1)	0.916	-	25.0

Table 16: Concentration of Cadmium, associated with TSP in Aleppo

Location	Date	Concentration (nanogram/m^3)
Medan (M1)	12/7	0.1± 4.3
	13/7	1.2± 7.4
	14/7	0.5± 6.5
East of cement factory (C3)	15/7	0.4± 2.7
	16/7	0.1± 3.1
	17/7	BDL
Sheikh Said village (C1)	16/7	BDL
	17/7	BDL
	18/7	BDL
Sheikh Said Tanneries (C2)	16/7	BDL
	17/7	BDL
Kendy Hospital (A2)	18/7	BDL
	19/7	BDL
	20/7	BDL
Oweija village (A1)	18/7	BDL
	19/7	BDL
	20/7	BDL
Shekheif (S1)	19/7	0.2± 1.1
	20/7	BDL
	21/7	BDL

Table 17: Concentration of Zinc, associated with TSP in Aleppo

Location	Date	Concentration (μ/m³)
Medan (M1)	12/7	0.005± 0.377
	13/7	0.005± 0.497
	14/7	0.013± 0.389
East of cement factory (C3)	15/7	0.008± 0.573
	16/7	0.002± 0.163
	17/7	0.003± 0.064
Sheikh Said village (C1)	16/7	0.006± 0.380
	17/7	0.001± 0.047
	18/7	0.001± 0.086
Sheikh Said Tanneries (C2)	16/7	0.001± 0.113
	17/7	0.002± 0.052
Kendy Hospital (A2)	18/7	0.001± 0.042
	19/7	0.001± 0.056
	20/7	0.001± 0.040
Oweija village (A1)	18/7	0.002± 0.061
	19/7	0.005± 0.248
	20/7	0.004± 0.094
Shekheif (S1)	19/7	0.010± 1.017
	20/7	0.010± 0.596
	21/7	0.014± 0.889

Table 18: Average concentration of Cadmium, associated with PM10 in Aleppo

Location	Date	Concentration (nanogram/m³)
Medan (M1)	12/7/99	1.0± 3.9
	13/7/99	BDL
	14/7/99	BDL
East of the Cement Factory (C3)	15/7/99	BDL
	16/7/99	BDL
Sheikh Said (C1)	17/7/99	BDL
	18/7/99	BDL
Tanneries (C2)	21/7/99	BDL
Kandy Hospital (A2)	19/7/99	BDL
Shkaeif Area (S1)	20/7/99	BDL

Table 19: Average concentration of Cadmium, associated with PM10 in Aleppo

Location	Date	Concentration (µ/m^3)
Medan (M1)	12/7/99	0.006± 0.410
	13/7/99	0.006± 0.279
	14/7/99	0.0061± 0.201
East of the Cement Factory (C3)	15/7/99	0.001± 0.037
	16/7/99	0.002± 0.072
Sheikh Said (C1)	17/7/99	0.001± 0.030
	18/7/99	0.001± 0.028
Tanneries (C2)	21/7/99	0.001± 0.045
Kandy Hospital (A2)	19/7/99	0.001± 0.043
Shkaeif Area (S1)	20/7/99	0.004± 0.284

Table 20: Average concentration of Copper, associated with PM10 in Aleppo

Location	Date	Concentration (µ/m^3)
Medan (M1)	12/7/99	0.03± 1.851
	13/7/99	0.063± 1.813
	14/7/99	0.03± 1.604
East of the Cement Factory (C3)	15/7/99	0.029± 0.795
	16/7/99	0.044± 2.493
Sheikh Said (C1)	17/7/99	0.006± 0.421
	18/7/99	0.004± 0.330
Tanneries (C2)	21/7/99	0.006± 0.551
Kandy Hospital (A2)	19/7/99	0.012± 0.775
Shkaeif Area (S1)	20/7/99	0.029± 1.31

Table 21: Frequency of hourly measurements exceeding WHO standards, over 24 hours period

Area	Location and code	Date	Frequency of exceeding standards				
			NO_x	SO_2	H_2S	O_3	CO
South of Aleppo city	Sheikh Said (C1)	29-30/10/99	-	4	-	2	-
		30-31/10/99	-	5	5	-	-
		31/10-1/11/99	-	-	2	5	-
North of Aleppo city	Shkaeif (S2)	2-3/11/99	-	4	-	1	-
		3-4/11/99	-	4	7	-	-
		4-5/11/99	1	-	2	-	-
	Oweija (A3)	6-7/11/99	-	-	6	-	-
		7-8/11/99	1	-	3	-	-
		8-9/11/99	-	-	2	-	-
Inner Aleppo city	Medan (M2)	9-10/11/99	9	5	-	-	-
		10-11/11/99	8	-	-	-	-
		11-12/11/99	9	-	-	-	-
	Farafra (F)	12-13/11/99	17	2		-	-
		13-14/11/99	14	-		-	-
	University (U)	14-15/11/99	15	-		-	-
		15-16/11/99	10	-		-	-
		16-17/11/99	1	-		-	-

Table 22: Permissible levels of different pollutants, according to different agencies

Polluter	Exposure time	WHO	EPA	Canada	USSR
SO_2 (PPM)	Annual	0.015-0.023	0.03	0.023	-
	24 hours	0.047	0.139	0.11	0.06
	One hour	0.134	0.497	0.34	0.19
CO (PPM)	Annual	-	-	-	-
	24 hours	9	9	13	0.9
	One hour	26	35	31	5.2
NO_2 (PPM)	Annual	-	0.053	0.053	-
	24 hours	0.079	-	0.11	0.06
	One hour	0.21	-	0.21	0.19
O_3 (PPM)	Annual	-	-	-	-
	24 hours	0.05-0.06	-	-	-
	One hour	0.076-0.1	-	-	-
H_2S (PPM)	Annual	-	-	-	-
	24 hours	0.1	-	-	-
	One hour	0.047	-	-	-
TSP (PPM)	Annual	60-90	75	70	-
	24 hours	120	260	120	150
	One hour	-	-	-	-
PM10 (μ/m^3)	Annual	-	-	-	-
	24 hours	70	-	-	-
	One hour	-	-	-	-

Table 23: Average daily concentration at different locations

Location	Date	NO_x	SO2	H_2S	O_3	CO
Daily WHO permissible levels		*0.079*	*0.047*	*0.1*	*.05-.06*	*9*
Sheikh Said (C1)	29-30/10/99	0.021	**0.067**	0.007	0.031	2.2
	30-31/10/99	0.031	**0.084**	0.016	0.037	2.5
	31/10-1/11/99	0.012	0.044	0.014	0.040	2.8
Shkaeif (S2)	2-3/11/99	0.071	**0.068**	0.009	0.030	1.8
	3-4/11/99	0.060	**0.082**	0.028	0.032	1.6
	4-5/11/99	0.069	0.041	0.022	0.031	2.4
Oweija (A3)	6-7/11/99	0.055	0.033	0.029	0.027	2.8
	7-8/11/99	**0.079**	0.037	0.019	0.037	2.7
	8-9/11/99	0.043	0.028	0.025	0.040	3.0
Medan (M2)	9-10/11/99	**0.259**	**0.088**	0.025	0.005	7.0
	10-11/11/99	**0.160**	**0.053**	0.0024	0.015	6.2
	11-12/11/99	**0.203**	**0.066**	0.0016	0.012	6.9
Farafra (F)	12-13/11/99	**0.328**	**0.060**	0.0021	0.024	5.0
	13-14/11/99	**0.283**	0.036		0.034	1.7
University (U)	14-15/11/99	**0.263**	0.016		0.012	1.7
	15-16/11/99	**0.208**	**0.054**		0.016	2.6
	16-17/11/99	0.064	0.022		0.023	2.0

Table 24: Days during which the measured levels exceeded WHO permissible levels

Location	Date	NO_x	SO2	H_2S	O_3	CO
Daily WHO permissible levels		*0.079*	*0.047*	*0.1*	*.05-.06*	*9*
Sheikh Said (C1)	29-30/10/99	-	↑	-	-	-
	30-31/10/99	-	↑	-	-	-
	31/10-1/11/99	-	-	-	-	-
Shkaeif (S2)	2-3/11/99	-	↑	-	-	-
	3-4/11/99	-	↑	-	-	-
	4-5/11/99	-	-	-	-	-
Oweija (A3)	6-7/11/99	-	-	-	-	-
	7-8/11/99	↑	-	-	-	-
	8-9/11/99	-	-	-	-	-
Medan (M2)	9-10/11/99	↑	↑	-	-	-
	10-11/11/99	↑	↑	-	-	-
	11-12/11/99	↑	↑	-	-	-
Farafra (F)	12-13/11/99	↑	↑	-	-	-
	13-14/11/99	↑	-	-	-	-
University (U)	14-15/11/99	↑	-	-	-	-
	15-16/11/99	↑	↑	-	-	-
	16-17/11/99	-	-	-	-	-

Table 25: Average daily concentrations of TSP at sampling locations

Area	Location	Date	TSP daily concentration (μ/m^3)	Average daily concentration (μ/m^3)
		WHO average daily permissible level		*120*
South of Aleppo city	Sheikh Said (C1)	30-31/11/99	598	624.5
		30/10-1/11/99	651	
North of Aleppo city	Shkaeif (S2)	2-3/11/99	463	540
		3-4/11/99	617	
	Oweija (A3)	6-7/11/99	363	331
		7-8/11/99	323	
		8-9/11/99	307	
Inner Aleppo city	Medan (M2)	9-10/11/99	930	930
	Farafra (F)	13-14/11/99	658	658
	University (U)	14-15/11/99	701	614.5 *
		15-16/11/99	528	

(*) It should be mentioned that there were large quantities of dust coming during sampling from construction activities nearby.

7. Conclusion and recommendations

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