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CHARACTERIZATION OF POLLUTANT SOURCES AT 10 STATIONS IN ISTANBUL WITH PM_{10} AND EU DIRECTIVES ON FOCAL POINT

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ABSTRACT

Air pollution is an extremely significant issue that should be focused on all around the globe as it affects human health, ecosystems and the environment, destroys aesthetical conditions, gives harm to matters, buildings, and in turn economy.

In this study it is aimed to show the standing of Turkey under the EU directives. Days that exceed limiting PM_{10} values according to the EU directives PM_{10} restirictions are chosen as episode days (PM10>150 μg/m3. İt can be concluded that in nearly all the stations, between 1998-2003, more than 35 days in a year exceed 50 $\mu g/m^3$. Furthermore, 247 episode days are chosen according to days, which exceed the PM_{10} value of 150 $\mu g/m^3$, of which due to the lack of meteorological data only for 233 days, atmospheric stability conditions are investigated. Furthermore, two test cases representative of summer and winter conditions are investigated in terms of stability conditions and in terms of synoptic fields to capture an approach in defining the source of pollution as local or transport processes. Considering the prevailing synoptic conditions, it is defined either the local sources contribution or the transport processes contribution is the dominant phenomena in generating pollution at the test case days.

Key Words: Air Pollution, PM_{10}, Episode Day, Atmospheric Stability, Istanbul.

1. INTRODUCTION

Air pollution is an extremely significant issue that should be focused on all around the globe as it affects human health, ecosystems and the environment, destroys aesthetical conditions, gives harm to matters, buildings, and in turn economy. European Union's approach to this point is very sensitive. It is important in EU member countries to determine the air pollution sources, the contribution of the sources and to define the effects of local sources, effects of meteorology and transport processes like transport of Saharan dust and ocean sprays, in order to set up policies and regulations. If transport processes are dominant, putting regional standards to industrial sources and limiting anthropogenic activities will not be adequate to prevent pollution because there will be pollutants coming from remote sources. Therefore, contributions of sources are important to effectively establish regulations and protect the desired air quality. Countries like Spain is not meeting

the demands, causing them to pay to the Union for the pollution they generate. Studies are done therefore by Artinano et al. (2003), Salvador et al (2003) and Viana at all (2005)to identify the sources of pollution in Spain. As Turkey is in a series of steps in becoming a EU member, regulations should be accredited considering the EU directives and source characterization should be found out in order to have a better environment and less economic hardness. With this study, it is expected to predict the kind of pollutant activity affecting Istanbul. Moreover, it is the main purpose of this study to examine and highlight the air quality conditions in Turkey and especially Istanbul considering the European Union (EU) directives on particulate matter other than Turkish regulations.

2. DATA

Data used in this study are air pollutant parameters data and meteorological data. Air pollutant parameters data are obtained from 10 stations in Istanbul owned by the Istanbul Metropolitan Municipality Environmental Protection and Control Unit, namely Alibeyköy, Beşiktaş, Sarıyer, Saraçhane, Esenler, Yenibosna, Ümraniye, Üsküdar, Kartal, and Kadıköy. Data is obtained for the period 1998-2003 and pollutant parameters measured are as follows; SO_2, PM_{10}, CO, NO, NO_x, NO_2, CH_4, THC, nMHC, and Ozone. Meteorological data are obtained from the State Meteorological Service of Turkey, which consits of the following: surface wind speed, total solar insolation, solar insolation period, cloudiness, and surface pressure data.

3. PM_{10} ANALYSIS

PM_{10} values from 1998 to 2003 are examined at 10 stations. Number of days that exceeded limiting PM_{10} values of 50, 100,150, 200, 300, and 400$\mu g/m^3$ at these stations on monthly, seasonal and annual basis are obtained (not shown). Table 1 lists number of days that exceed limiting PM_{10} values for the 1998-2003 period in annual base. According to the European Union Directives, daily PM_{10} limit of 50 $\mu g/m^3$ should not be exceeded on more than 35 days in a year for the 2005-2010 periods and in 2010 the limiting value will decrease to 20$\mu g/m^3$ with not more than annual 7 days exceedance permit. Investigating Table 1, it can be concluded that in nearly all the stations, between 1998-2003, more than 35 days in a year exceed 50 $\mu g/m^3$. Furthermore, 247 episode days are chosen according to days, which exceed the PM_{10} value of 150 $\mu g/m^3$, of which due to the lack of meteorological data only for 233 days, atmospheric stability conditions are investigated.

4. ANALYSIS OF ATMOSPHERIC CONDITIONS

4.1 Atmospheric Stability

Atmospheric stability is detected using Pasquill stability classes' method. The chosen episode dates are divided into two parts, summertime dates and wintertime dates. Summertime is defined between April and September, for which stability is detected using solar radiation data, wind speed data and the corresponding section of the Pasquill stability classes' chart. On contrary, wintertime is defined between October

and March, and stability for this period is detected using cloud cover and wind speed data and corresponding section of the Pasquill stability classes' chart. Stability distributions reveal that the most dominant stability is D, which refers to the neutral case. If there were enough data to measure the atmospheric stability in some other means, it is assumed that the atmospheric stability in episode days would be found as stable. In the study by Chen et al. (2003) wind speeds are quite low (below 2m/s) compared with the surface wind speed data measured at episode days in Istanbul. Only at 10 days of the 240-day long episode days period (with available data to determine atmospheric conditions) in Istanbul are wind speed values below 2m/s. As stability classes are defined according to wind speed in Pasquill Stability Classes Method, it is almost impossible to obtain stable atmospheric conditions in Istanbul with this method.

4.2 Surface Atmospheric Pressure and Synoptic Charts

1000 mb pressure level synoptic charts are examined for two representative episode day periods. These periods are chosen for the summer and winter conditions, namely 1-7 April 2000 and 1-12 February 2002.

On the 1-7 April 2000 period, prevailing winds are northerly and the system is coming from the northeastern and eastern Europe. There is low pressure dominant all over Istanbul, and there is promoted vertical mixing as it is the major characteristic of low-pressure systems(Figure 1). As a result, atmospheric stability is neutral and unstable. It is observed at this period that at times of transition to neutral stability the concentrations increase due to less mixing which is meteorological, but at the other times although the atmospheric conditions promote the mixing of air, and vertical motions, particulate matter concentrations are still high (Table 2). For this reason, this pollution can be linked to local sources contribution. Other air pollutant parameters investigated also show the same reflection (Table 3).

In the 1-12 February 2002 period, there is westerly movement of an anticyclone (high pressure system), and the air from the southern Europe and Northern Africa is carried towards Istanbul with southwesterly prevailing winds. On 8th February 2002 there is a cyclone (low pressure system) coming onto Istanbul from north, and air from northeastern Europe and Siberia is carried towards Istanbul. This is not a long lasting situation as on 9th February 2002; the anticyclone again covers Istanbul with southwesterly winds carrying again the air from the southern Europe and Northern Africa until the end of this period, but the high pressure level in Istanbul is not as much as the previous one although it is still the same field corresponding to the same system, at the end of the period again a cyclone is coming from north causing the pressures in Istanbul to lower(Figure 2).

Table 1. Total numbers of days that exceed limiting PM_{10} values($\mu g/m^3$) for the years between 1998-2003.

İstanbul Air Quality Measuruments Stations	Years																	
	1998			**1999**			**2000**			**2001**			**2002**			**2003**		
	TM*	>50	>150	**TM**	>50	>150	**TM**	>50	>150	**TM**	>50	>150	**TM**	>50	>150	**TM**	>50	>150
Alibeyköy	190	159	63	132	61	8	199	85	5	320	86	4	252	180	29	110	79	8
Beşiktaş	210	103	1	200	58	3	-	-	-	93	25	-	218	182	17	110	51	-
Esenler	172	128	23	297	193	8	258	168	22	283	214	17	216	152	24	105	71	6
Kadıköy	-	-	-	-	-	-	-	-	-	-	-	-	179	65	13	112	60	4
Kartal	-	-	-	60	43	5	20	13	-	152	91	-	203	136	9	120	75	3
Saraçhane	150	66	1	283	135	1	167	111	11	242	103	3	236	148	7	118	83	6
Sarıyer	30	5	1	282	93	4	103	54	5	103	68	3	105	61	2	111	43	-
Ümraniye	-	-	-	60	30	2	189	138	9	184	40	-	246	126	10	111	55	1
Üsküdar	-	-	-	-	-	-	-	-	-	48	6	-	301	120	5	110	58	-
Yenibosna	144	129	14	198	159	9	174	105	13	56	19	1	179	119	5	107	74	-

*TM: Total Measurements

Table 2. Variation of PM_{10} concentration ($\mu g/m^3$) for the 1-7 April 2000 period with stability classes.

Days	W.speed, m/s	Stability Class	ALİBEYKÖY	ESENLER	SARAÇHANE	SARIYER	YENİBOSNA	ÜMRANİYE
1	1,1	C-D	126	136	121	-	148	154
2	2,2	D	94	98	91	-	93	105
3	1,0	B-C	108	105	86	68	90	96
4	1,1	D	129	114	104	99	108	109
5	2,9	D	189	192	137	227	-	169
6	3,5	D	55	67	57	72	52	61
7	3,7	C	70	43	37	30	53	35

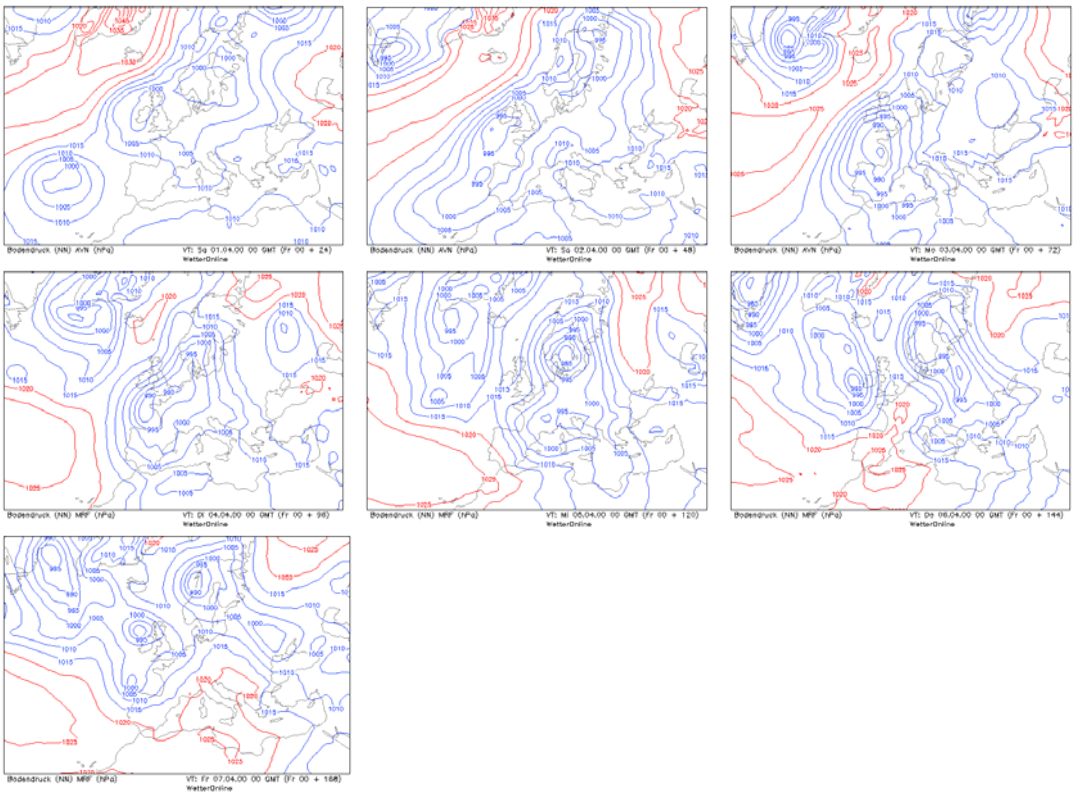

Figure 1. 1000mb Pressure level for 1-7 April 2000 Period

This can be seen as a reflection in PM_{10} concentrations measured at the stations and stability classes in Table 4. There is an increase in PM_{10} levels until 7-8th February, starting with 1020mb and increasing to 1035mb on 5th and decreasing to 1020 again on 7th in Istanbul. After that the cyclone comes from the north and the anticyclone coming for the second time is not as high as the first time, beginning with 1025mb and losing its effect to about 1015 mb with another cyclone coming from the north of Turkey. This in turn causes the PM_{10} concentrations to lower. It can also be observed for other air pollutant parameters, the variation of the other air pollutant parameters in the same period can be seen from the Table 5 in the appendix section.

Anticyclones are high-pressure systems causing a more stable atmosphere by inhibiting vertical motions and as a result increasing the concentrations of pollutant parameters by trapping them in the lower atmosphere. At anticyclonic systems, there is subsidence of air towards the surface; therefore, the pollutants transported from other regions are subsided in the high-pressure centers. What's more, the atmospheric stability coincides with the synoptic chart as expected. It is seen to be neutral and increasing to stable levels as the pressure system gets higher pressure values and becomes neutral on the 8th as there is cyclonic entrance to Istanbul and increasing again to stable atmospheric conditions but not very much as there is another cyclonic entrance at the end of the period.

Table 3. Variation of air pollutant parameters for the 1-7 April 2000 Period

April 2000	BEŞİKTAŞ								ESENLER					ÜMRANİYE						
Days	SO_2	CO	NO	NOx	NO2	THC	CH4	nMHC	SO_2	CO	NO	NOx	NO2	SO_2	CO	NO	NOx	NO2	THC	CH4
1	54	2573	118	175	56	1699	1182	507	59	1099	105	205	100	34	852	12	107	96	2746	2317
2	42	1886	79	121	42	-	-	-	33	483	37	100	63	26	485	5	71	67	1977	1866
3	46	1614	64	113	49	1636	1132	496	43	1210	144	232	88	20	496	10	98	87	2415	2083
4	68	2047	96	156	60	1698	1159	529	55	1211	133	228	95	34	675	4	79	75	2539	1926
5	42	1566	62	103	41	1434	1072	353	32	476	47	101	54	26	368	-	-	-	1967	1830
6	42	1688	81	125	44	1402	1087	306	25	244	14	51	38	14	253	-	-		2396	2210
7	21	1202	65	100	34	1371	1156	207	36	271	28	78	50	12	338	-	-		2349	2304

Table 4. Variation of PM_{10} concentration ($\mu g/m^3$) for the 1-12 February 2002 period with stability classes.

DAYS	W.speed, m/s	Stability Class	Alibeyköy	Beşiktaş	Esenler	Sarıyer	Yenibosna	Ümraniye	Kadıköy	Kartal	Üsküdar
1	1,2	E	136	176	211	93	127	83	81	138	80
2	1,8	D	70	134	139	-	-	84	80	-	48
3	3,6	D	60	99	67	-	--	38	36	-	35
4	4,1	D	54	89	71	56	121	49	50	-	61
5	1,1	F	170	202	298	-	102	145	93	-	128
6	1,1	E	249	164	202	-	71	92	114	-	120
7	0,6	F	257	260	229	99	113	127	166	67	135
8	0,7	None	297	330	464	224	163	205	-	174	185
9	1,4	D	207	173	179	-	40	119	-	-	87
10	0,9	F	182	100	247	-	212	118	-	-	120
11	3,9	D	95	114	77	-	75	62	-	71	81
12	1,3	-	-	112	96	-	37	63	--	60	37

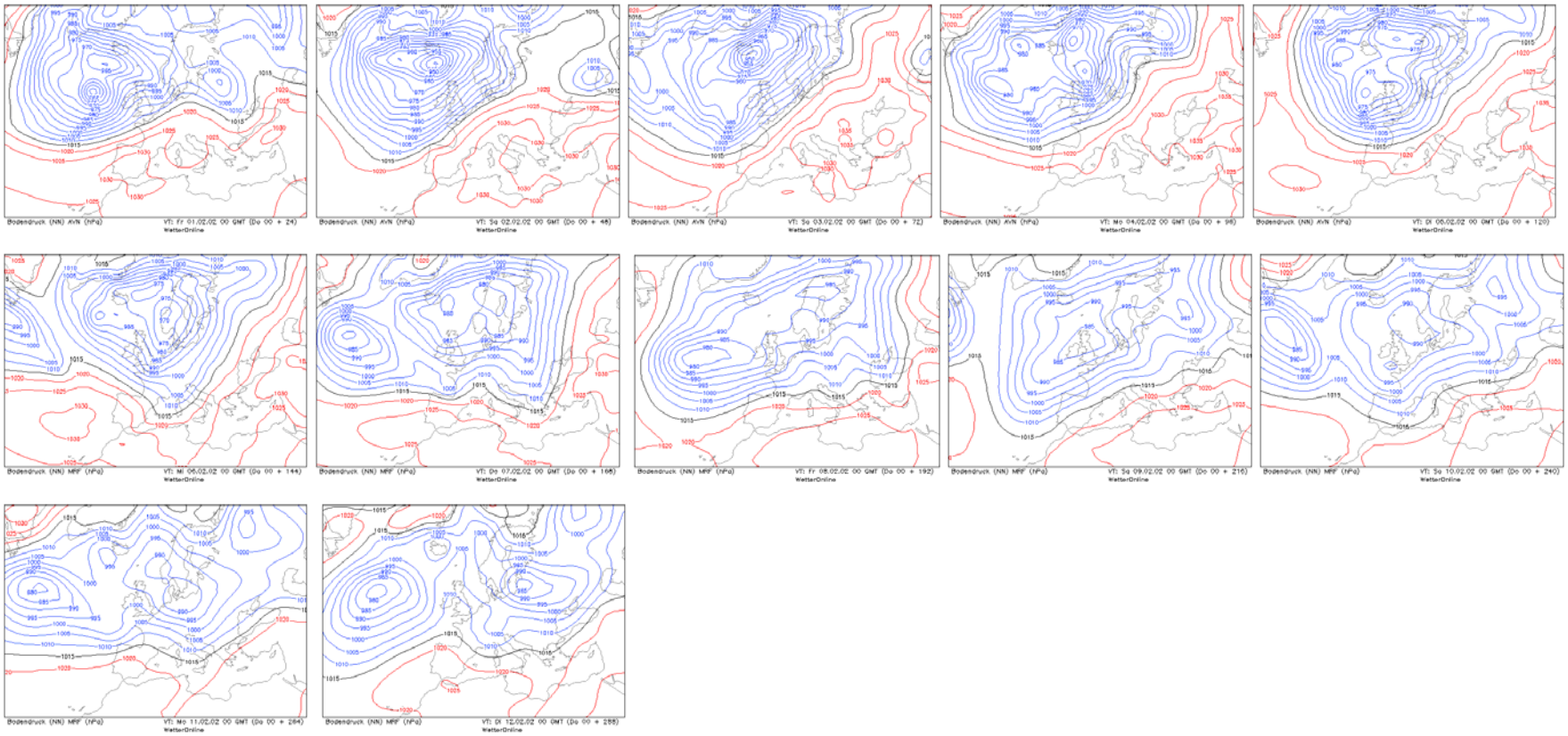

Figure 2. Anticyclone movement for 1-12 February 2002 Period

Table 5. Variation of air pollutant parameters for the 1-12 February 2002 Period

February 2002	BEŞİKTAŞ					ESENLER								**ÜMRANİYE**				
DAYS	SO_2	CO	THC	CH4	nMHC	SO_2	CO	NO	NOx	NO2	THC	CH4	nMHC	SO_2	CO	NO	NOx	NO2
1	78	2642	1484	1186	288	99	1778	104	145	41	1481	1207	266	55	1371	32	59	27
2	44	2438	1693	1428	257	38	-	64	95	32	1349	1249	91	40	1276	24	40	17
3	32	1397	1359	1215	134	23	-	14	36	22	1438	1396	33	15	596	7	17	11
4	23	1740	1351	1214	128	11	567	17	39	22	1537	1503	27	14	533	9	20	12
5	98	2976	1595	1260	326	112	3555	128	186	58	1334	951	373	65	2492	73	109	36
6	104	3149	1580	1199	372	72	2481	105	148	44	1533	1294	230	58	1313	40	64	24
7	73	3593	1615	1191	412	62	3609	216	267	51	1523	1011	505	59	1817	60	85	25
8	135	4658	1910	1288	613	106	7557	453	543	89	2179	1239	931	103	3204	101	149	48
9	58	2059	1372	1169	192	56	2065	115	154	39	1407	1187	210	51	2278	62	95	33
10	68	2915	1325	1210	100	54	4972	265	320	55	1634	1156	469	66	2068	43	70	27
11	66	3356	1271	1106	156	71	2541	118	151	33	1602	1395	140	33	877	11	25	13
12	61	1963	1371	1159	202	48	1311	52	86	34	1189	1002	177	17	771	14	34	19
R^2	0,78	0,79	0,83	0,20	0,94	0,76	0,89	0,89	0,90	0,98	0,67	-0,42	0,94	0,94	0,98	0,98	0,98	0,95

R^2 correlation coefficients are shown the relation levels between PM10 and other parameters for some station.

5. RESULTS

Air pollution is very significant as it affects human health, ecosystems and materials. This is not always a regional phenomenon, with transport processes polluted air can be transported to the region. As a European Union Member candidate, Turkey should monitor the air quality parameters and find ways to control the sources as the parameters are exceeding standards of EU directives. If the pollution is mostly of transport origin, it has to be reported to EU because, even if the regional sources are controlled, pollution can increase to unwanted levels due to transport effects. For these purposes, it is important to find the pollutant fractions of polluted air, and identify whether there is a transport mechanism or not and if there, is the contribution of this mechanism to air pollution.

In this study, using the PM_{10} observations of 1998-2003, it is seen that the number of days exceed limiting values are nearly always exceeding the EU directives. Using meteorological data, atmospheric stability corresponding to the episode days are found and synoptic charts are used to detect the transport mechanisms in two specific periods of the episode days. It is seen that both transport and local sources are contributing to pollution.

In order to be an EU member and most important of all in order to live in a healthy environment with present biodiversity, Turkey must find ways to decrease the amounts of pollutants released into the atmosphere.

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