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Evaluation of Air Quality in the City of Istanbul during the Years 2013 and 2015

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Abstract: Air pollution has been the most important health issue in recent years. In this study, the aim was to evaluate the results of regular measurements of air pollutants PM10 (Particulate Matter of 10 Microns in Diameter) and SO_2 (Sulfur Dioxide) concentrations in the city of Istanbul by taking the years 2013 and 2015 as a sample. The data were obtained through the website http://www.havaizleme.gov.tr, which was published by the Administration of Marmara Clean Air Center of Ministry of Environment and Urbanization in Turkey. For the years 2013 and 2015, the mean SO_2 concentration was 8.35 ± 6.04 and 10.60 ± 7.16 μg/m^3. The mean PM10 concentration was 73.06 ± 30.63 μg/m^3 for 2013 and 51.57 ± 18.84 μg/m^3 for 2015. The acceptable upper limit values by WHO (World Health Organization) for daily mean SO_2 and PM10 concentrations respectively are 20 μg/m^3 and 50 μg/m^3. In Istanbul, SO_2 concentrations were above the upper limit values recommended by WHO, but PM10 concentrations during 2013 and 2015 were over the recommended limit values by WHO. As the particulate matter pollution is at high concentrations during these two years, it has shown that air pollution emerges as a problem awaiting solutions in Istanbul, where is industrially intense, highly populated and also with high traffic density.

Key words: Istanbul, air pollution, PM10 (Particulate Matter of 10 Microns in Diameter), SO_2 (Sulfur Dioxide).

1. Introduction

Air is one of the most indispensable and essential substance for human life. A human-being can survive only for up to 4 minutes without breathing air. Clean air consists of 78% N_2 (Nitrogen), 20% O_2 (Oxygen), 0.9% Ar (Argon), 0.04% CO_2 (Carbon Dioxide) and very small amounts of Ne (Neon), CH_4 (Methane), He (Helium), H_2 (Hydrogen) and Kr (Krypton). About 0.25% of the atmospheric mass is water vapor. Today, pollutants originating mainly from heating, industry and traffic disrupt air quality and so cause air pollution.

Air pollution has been the most important health issue in recent years. EPA (Environmental Protection Agency) determined 6 criteria air pollutants for outdoor air. These pollutants are PM10 (Particulate Matter of 10 Microns in Diameter), CO (Carbon Monoxide), Pb (Lead), SO_2 (Sulfur Dioxide), NO_2 (Nitrogen Dioxide) and O_3 (Ozone) [1]. Nowadays, it is a well-known fact that these pollutants increase the incidence of asthma and chronic obstructive pulmonary disease [2-4].

In addition, myocardial infarction, angina pectoris and hypertension among cardiovascular diseases, also cerebrovascular diseases and associated paralyses have increased due to air pollution [5, 6]. Air pollution leads to damages in the nervous system and so causes headache and anxiety; moreover, air pollution is held responsible for the increase in some neurological diseases such as Alzheimer's and Parkinson's diseases. Air pollution has unfavorable effects on fertility and child's health, too. It gives rise to low birth weight and premature birth [7]. Besides, air pollution has been held responsible for the etiology of some cancers like breast and prostate cancer, which have been increasingly incident over the recent years [8].

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Air pollution affects the environment, human health and thus life negatively. Climate change, depletion of the ozone layer and acid rains stem from air pollution. For this reason, air pollution must be monitored with AQI (Air Quality Index). This index, which was identified by EPA (Environmental Protection Agency), has been adapted and used as "National AQI" for Turkey. AQI is calculated for five main pollutants. These pollutants are PM10, CO, SO_2, NO_2 and O_3. The AQI is calculated by using these five parameters and this index is expressed in colors: We refer the values between 0-50 green as "good"; between 51-100 yellow as "moderate"; between 101-150 orange as "sensitive"; between 151-200 red as "unhealthy". The values between 201-300 are referred as "bad" (purple), whereas the ones between 301-500 are considered "dangerous" (brown) [9]. These pollutants are measured daily at monitoring stations and their concentrations are published at the website of Turkish Ministry of Environment and Urbanization [10]. But, to make comments on results and so to benefit from them in the field of health require knowing this basic information.

In Turkey, the Ministry of Environment and Urbanization have measured all the criteria air pollutants except Pb daily in each city and in each district up to today since 2005. In Istanbul, there are 31 Air Quality Monitoring Stations at 39 districts; at some districts, more than one monitoring stations exist. Yet, there are losses at some parameters for several districts. The parameters, which are obtained most regularly, are PM10 and SO_2. In this study, our aim was to evaluate the measurement results of PM10 and SO_2 concentrations, which are regularly measured pollutants in the city of Istanbul, by sampling from the years 2013 and 2015.

2. Materials and Methods

Between the years 2013 and 2015, the air quality was audited by the Administration of MTHM (Marmara Clean Air Center). The data of Istanbul were obtained through the website acceced January 13, 2016, http://www.havaizleme.gov.tr, which was published by the Administration of Marmara Clean Air Center. The acceptable upper limits by WHO (World Health Organization) for daily average, for SO_2 and PM10 respectively are 20 μg/m^3 and 50 μg/m^3 [11]. For evaluation, the months of January, April, June and September in 2013 and 2015 were chosen since these are the months that the data were either complete or included the highest numbers of days with measurement.

Among the data of these months, the measurement results of PM10 and SO_2 were entered into SPSS (Statistical Package for the Social Sciences) for Windows, Version 21.0 registered in the name of Istanbul University and then evaluated as mean, standard deviation. The monthly mean values with each other for the same year and with the other year's equivalent monthly mean values were compared statistically. The suitability of variables for the normal distribution was examined by Kolmogorov-Smirnov test. For the variables, which are distributed normally, independent samples t test was used. For the statistical comparison of the means of more than two groups, one-way ANOVA (Analysis of Variance) test was used. $p < 0.05$ was considered significant at 95% confidence level in statistical evaluations.

3. Results and Discussion

For the years 2013 and 2015, the mean SO_2 concentration was 8.35 ± 6.04 μg/m^3 and 10.60 ± 7.16 μg/m^3. The mean PM10 concentration was 73.06 ± 30.63 μg/m^3 for 2013 and 51.57 ± 18.84 μg/m^3 for 2015. The mean concentration of PM10 was above the recommended limit values determined by WHO for both years.

For the city of Istanbul, the measurement results of mean SO_2 and PM10 concentrations in January 2013 and January 2015 was shown in Table 1, whereas the ones in April for the same years in Table 2, the ones in June for the same years in Table 3 and

the ones in September for the same years in Table 4 can be seen.

Except the mean PM10 concentration during April 2015, all of its concentrations were above the upper limit values recommended by WHO; whereas the mean SO_2 concentrations were under the upper limit values recommended by WHO throughout all of these months within these two years. Among the chosen months, SO_2 concentration was detected as the highest in 2013 during April and in 2015 during January; on the other hand, PM10 concentration was detected as the highest in 2013 during April and the highest in 2015 during September.

Table 5 shows the statistical comparison of mean concentration of SO_2 measurements during the four months observed for the year 2013 by one-way ANOVA test. Among the four months' means, there is a statistical significance at high level. The comparison of mean concentration of PM10 measurements for the year 2013 during January, April, June and September by using one-way ANOVA test can be seen in Table 6. It was detected that the measurements of mean PM10 concentrations showed a statistical significance between different months.

The statistical comparison of mean concentration of SO_2 measurements for the year 2015 during January, April, June and September by using one way ANOVA test can be seen in Table 7; there is a statistical significance at high level among the means. The statistical comparison of mean concentration of PM10 measurements for the year 2015 during January, April, June and September by using one way ANOVA test was shown in Table 8; there exists a statistical significance at high level among the means.

Table 1 The measurement results of SO_2 and PM10 concentrations among air quality criteria pollutants in Istanbul in January 2013 and January 2015 (μg/m^3).

	n	Minimum	Maximum	Mean	Std. deviation
SO_2 (2013)	31	2.0	28.0	7.32	5.71
PM10 (2013)	31	5.0	138.0	61.90	35.70
SO_2 (2015)	31	6.0	51.0	16.94	9.84
PM10 (2015)	29	25.0	104.0	53.38	23.95

Table 2 The measurement results of SO_2 and PM10 concentrations among air quality criteria pollutants in Istanbul in April 2013 and April 2015 (μg/m^3).

	n	Minimum	Maximum	Mean	Std. deviation
SO_2 (2013)	30	8.0	27.0	15.10	5.02
PM10 (2013)	30	29.0	189.0	86.63	37.41
SO_2 (2015)	30	3.0	15.0	7.43	2.76
PM10 (2015)	28	18.0	67.0	38.86	15.93

Table 3 The measurement results of SO_2 and PM10 concentrations among air quality criteria pollutants in Istanbul in June 2013 and June 2015 (μg/m^3).

	n	Minimum	Maximum	Mean	Std. deviation
SO_2 (2013)	30	1.0	16.0	7.70	4.00
PM10 (2013)	27	40.0	139.0	73.26	24.19
SO_2 (2015)	30	5.0	23.0	12.17	3.71
PM10 (2015)	30	33.0	76.0	55.70	12.45

Table 4 The measurement results of SO_2 and PM10 concentrations among air quality criteria pollutants in Istanbul in September 2013 and September 2015 (μg/m^3).

	n	Minimum	Maximum	Mean	Std. deviation
SO_2 (2013)	30	2.0	6.0	3.30	0.84
PM10 (2013)	30	50.0	105.0	70.83	14.67
SO_2 (2015)	27	2.0	9.0	5.11	1.34
PM10 (2015)	27	26.0	91.0	58.22	15.68

Table 5 The comparison of mean concentration of SO_2 measurements for the year 2013 during January, April, June and September by one way ANOVA test.

SO_2	Sum of squares	df	Mean square	F	Sig.
Between groups	2,177.4	3	725.78	38.703	.000
Within groups	2,194.1	117	18.75		
Total	4,371.4	120			

Table 6 The comparison of mean concentration of PM10 measurements for the year 2013 during January, April, June and September by one way ANOVA test.

PM10	Sum of squares	df	Mean square	F	Sig.
Between groups	9,535.6	3	3,178.52	3.614	.015
Within groups	100,253.0	114	879.41		
Total	109,788.6	117			

Table 7 The comparison of mean concentration of SO_2 measurements for the year 2015 during January, April, June and September by one way ANOVA test.

SO_2	Sum of squares	df	Mean square	F	Sig.
Between groups	2,432.2	3	810.74	25.889	.000
Within groups	3,570.1	114	31.32		
Total	6,002.3	117			

Table 8 The comparison of mean concentration of PM10 measurements for the year 2015 during January, April, June and September by one way ANOVA test.

PM 10	Sum of squares	df	Mean square	F	Sig.
Between groups	6,326.7	3	2,108.91	6.863	.000
Within groups	33,801.2	110	307.28		
Total	40,127.9	113			

Taking the results in January and September as one group called "cold seasons" and the results in April and June as another group called "hot seasons", for SO_2 concentration, a statistical significance at high level was detected in 2013 between both seasons (*t*: -6.361; *p*: 0.000); on the contrary, the same statistical difference wasn't detected for the year 2015 (*t*: 1.239; *p*: 0.218). For PM10 concentration, these values were calculated as (*t*: -2.539; *p*: 0.012) for the year 2013 and (*t*: 2.353; *p*: 0.020) for the year 2015. There was a statistical significance between summer and winter seasons in terms of air pollution. In winter, the level of air pollution was more severe than summer. PM10 seemed to play an important role in air pollution. When PM10 and SO_2 results were compared according to the districts, Uskudar was ranked first among the districts with the highest mean PM10 concentration measured 89.57 ± 64.48 μg/m^3. The district of Uskudar was followed by Aksaray (PM10 concentration measured 62.80 ± 28.66 μg/m^3), Maslak (PM10 concentration measured 59.89 ± 37.93 μg/m^3) and Alibeykoy (PM10 concentration measured 54.68 ± 28.36 μg/m^3). As seen among SO_2 measurements, it was detected that mean SO_2 measurements were even above the WHO recommended limit values in Uskudar (SO_2 concentration measured 55.91 ± 28.19 μg/m^3) and in Sultanbeyli (SO_2 concentration measured 42.87 ± 29.60 μg/m^3); on the other hand, the mean SO_2 measurements were under the limit values in other districts.

According to EEA (European Environment Agency)'s data, over 90 % of the urban population in Turkey has been exposed to PM10 at unhealthy levels [12]. Air pollution within cities is also known to have negative effects on health [13]. Among different Turkish cities, there are limited number of studies indicating the status of air pollution. The annual mean PM10 concentrations recommended are 58 μg/m^3 in

Turkey, 40 μg/m^3 in EU (European Union) and 20 μg/m^3 by WHO. According to WHO's data, the annual mean PM10 concentrations between the years 2008-2015 are 85 μg/m^3 for the world, 235 μg/m^3 for Eastern Mediterranean countries with high income, 158 μg/m^3 for Eastern Mediterranean countries with low income, 123 μg/m^3 for Southeastern Asia, 119 μg/m^3 for Africa and 104 μg/m^3 for Western Pacific Mediterranean countries with low-middle income. This value for European countries with low-middle income is 55 μg/m^3, thus the city of Istanbul is shown as "moderately polluted" on WHO's maps in terms of air quality (AQI—Yellow: between 51-100). Eastern Mediterranean and Southeastern Anatolian cities of Turkey are demonstrated as "sensitive" (AQI—Orange: between 101-150) [14]. In this study, the levels of PM10 concentrations were found to be above the recommended limit values by WHO in Istanbul during the years 2013 and 2015. No research made in Istanbul about this subject was found during literature survey. In a doctoral thesis research conducted in Kirklareli, air pollution and meteorological parameters were detected to increase the number of hospital admissions due to cardiovascular and respiratory diseases [15]. In a study conducted by Bolu, F., et al. [16] in Duzce, the annual mean PM10 concentration was found to be 106.42 ± 102 μg/m^3, whereas the annual mean SO_2 concentration was found to be 6.15 ± 5.39 μg/m^3. Air pollution occurs due to local, regional and global problems. Therefore, it is possible to take measures with multidimensional studies, industrial activities, increased level of traffic, destruction of forests, combustion of biomass and continuous energy production trigger climate change and as a result of this situation, natural disasters like sea level rise, floods, hurricanes and drought may emerge. In each country, a national air quality monitoring network should be established as it is in Turkey. So as to reduce air pollution, as society, we should use public transport, use energy-efficient appliances and energy-saving light bulbs, use clean energy such as wind, geothermal and solar energy and also organize public education on these issues.

4. Conclusions

In conclusion, the lower levels of air pollution during the summer months give rise to thought that the level of heating-based pollutants decrease and the traffic reduces relatively in the city of Istanbul during the summer months. As the particulate matter pollution is within high concentrations during these two years and throughout all the seasons, it has shown that air pollution emerges as a problem awaiting solutions in Istanbul, where is industrially intense, highly populated and also with high traffic density.

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