

Comparison of Three Stations' PM10 Data for Istanbul, Turkey

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ABSTRACT: Air pollution is effective problem for environment and the health issues. Local investigation of air pollution is gained importance in recently years, because of increasing effects. Especially, on health problems are caused by decreasing on air quality. Metropolitan cities are more suitable for increasing of air pollution. One of the cities under great risk in Turkey is Istanbul. Because of population, transportation, heating, etc. Air pollution analysis of previous years is necessary to take prevention against future risks. In this study, PM10 data are statically analysed which are received from three different air quality stations, Kagithane, Besiktas, and Sariyer in Istanbul, Turkey for 2013-2014 years' period.

KEYWORDS: PM10, Statically Analysis, Air Pollution, Istanbul.

I. INTRODUCTION

In recent years, damages of air pollution have become a situation which cannot be ignored. All man-made (anthropogenic) emissions into the air can be called air pollution, because they alter the chemical composition of the natural atmosphere. The rise in the global concentrations of greenhouse gases CO₂, CH₄, and N₂O, can be called air pollution using this approach, even though the concentrations have not found to be toxic for humans and the ecosystem [1]. One can refine this approach and only consider anthropogenic emissions of harmful chemicals as air pollution [2]. Most common pollutants are particle pollution (often referred to as particulate matter), ground-level ozone, carbon monoxide, sulphur oxides, nitrogen oxides, and lead. These pollutants can harm your health and the environment, and cause property damage [4]. Of the six pollutants, particle pollution and ground-level ozone are the most widespread health threats. EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. The set of limits based on human health is called primary standards. Another set of limits intended to prevent environmental and property damage is called secondary standards [4].

In this study, particulate matter is choosing for analysing of local air pollution distribution. Particle pollution is a mixture of microscopic solids and liquid droplets suspended in air. This pollution, also known as particulate matter, is made up of a number of components, including acids (such as nitrates and sulphates), organic chemicals, metals, soil or dust particles, and allergens (such as fragments of pollen or mould spores). The size of particles is directly linked to their potential for causing health problems. Larger particles are of less concern, although they can irritate your eyes, nose, and throat. Small particles of concern include "fine particles" (such as those found in smoke and haze), which are 2.5 micrometres in diameter or less; and "coarse particles" (such as those found in wind-blown dust), which have diameters between 2.5 and 10 micrometres' [3].

Particle exposure can lead to a variety of health effects. For example, numerous studies link particle levels to increased hospital admissions and emergency room visits and even to death from heart or lung diseases. Both long- and short-term particle exposures have been linked to health problems. Long-term exposures, such as those experienced by people living for many years in areas with high particle levels, have been associated with problems such as reduced

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(An ISO 3297: 2007 Certified Organization)

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lung function and the development of chronic bronchitis and even premature death. Short-term exposures to particles (hours or days) can aggravate lung disease, causing asthma attacks and acute bronchitis, and may also increase susceptibility to respiratory infections. In people with heart disease, short-term exposures have been linked to heart attacks and arrhythmias.

These problems can be avoided with necessary precautions. Analyse of air pollution is important for air quality. In this study, PM10 data are statically analysed which are received from three different air quality stations, Kagithane, Besiktas, Sariyer in Istanbul, Turkey for 2013-2014 years period.

II. METHODOLOGY

Istanbul is the most important city in Turkey, constituting the country's economic, cultural, and historical heart. Istanbul is a transcontinental city in Eurasia, with its commercial and historical center lying on the European side and about a third of its population living on the Asian side of Eurasia. With a population of 14.4 million, the city forms the largest urban agglomeration in Europe as well as the largest in the Middle East, and the sixth-largest city proper in the world. Istanbul's vast area of 5,343 square kilometers (2,063 sq. mi) is coterminous with Istanbul Province, of which the city is the administrative capital. Istanbul straddles the Bosphorus strait in northwestern Turkey, between the Sea of Marmara and the Black Sea. In these study daily PM10 concentrations of Kagithane, Besiktas and Sariyer stations for the period between 2013 and 2014 were used. The stations locations are given in the Fig.1.

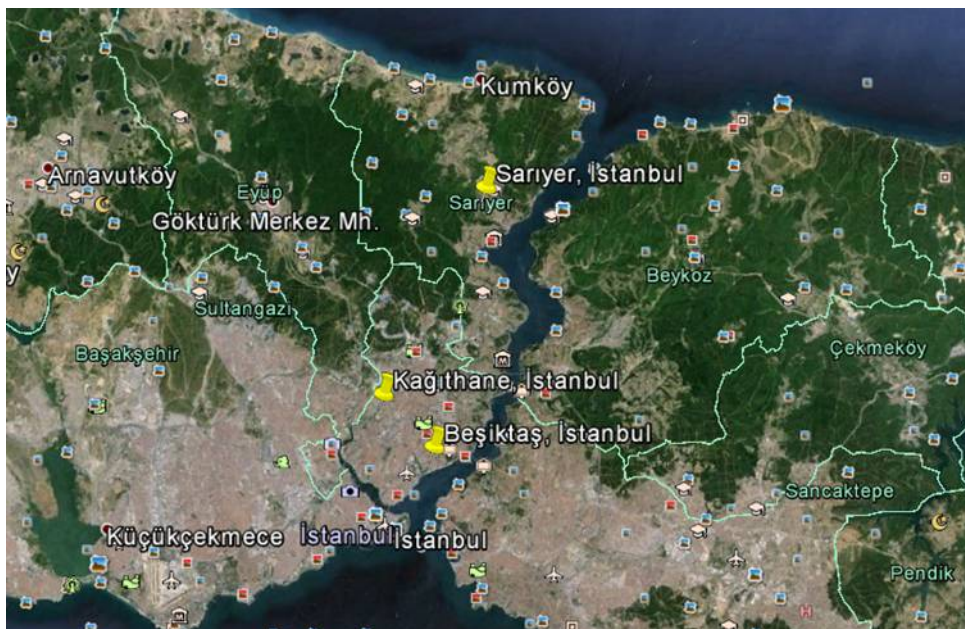


Fig. 1.Locations of 3 air quality stations.

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III. DATA ANALYSIS

For the statistical analysis, daily PM10 concentration data in the period between 2013 and 2014, works with the RStudio standard version of R available from CRAN.

First of all, daily variations of PM10 concentrations of Besiktas, Sariyer and Kagithane stations were plotted in Fig.2. As seen in the Fig.2, Pm10 concentrations of Kagithane station is higher than Besiktas and Sariyer stations. All stations have more fluctuations in winter times. Maximum daily value of Besiktas station is 150 g/m3, maximum value of Sariyer stations is 125 g/m3 and Kagithane station's maximum value is 260 g/m3.

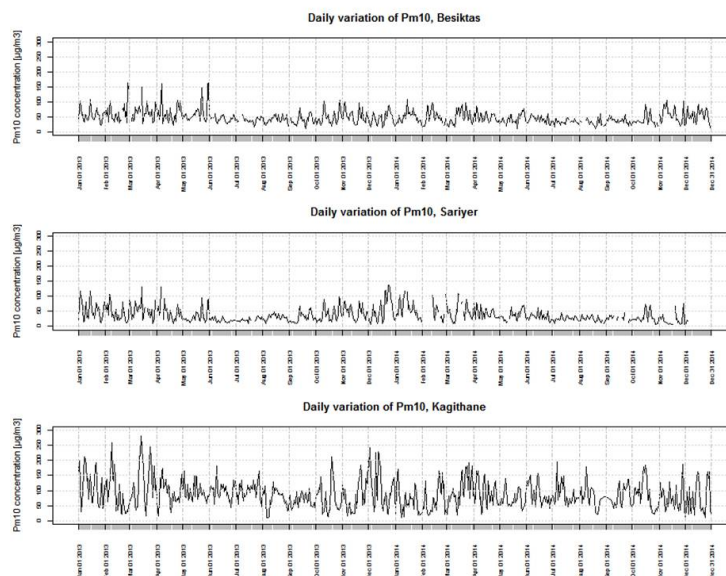


Figure 2. Daily variations of PM10 concentrations of 3 stations in 2013-2014.

Daily variations of Pm10 concentrations of Besiktas, Sariyer and Kagithane stations were plotted with ggplot function of R in Fig.3.4.5. These graphics show oscillations of stations more clearly. Kagithane has the highest Pm10 concentration values. Besiktas and Sariyer stations are near with each other. Maximum PM10 values of 3 stations are shown at different seasons of years. For Besiktas station, daily maximum values are in winter seasons of 2013. For Sariyer station, daily maximum values are in winter season of 2014. For Kagithane station, daily maximum values are shown at winter season of 2013 year.

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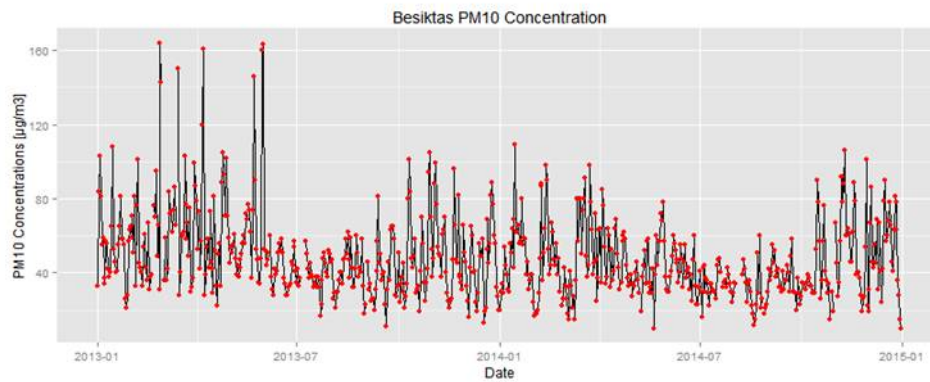


Figure 3. Daily variations of PM10 concentrations of Besiktas station in 2013-2014.

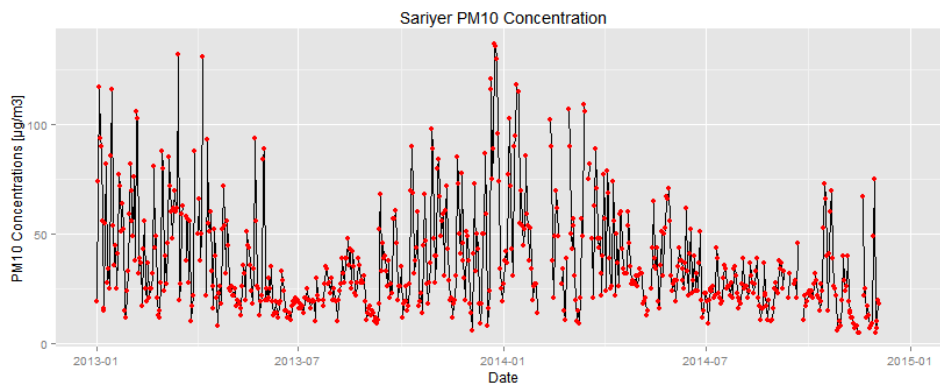


Figure 4. Daily variations of PM10 concentrations of Sariyer station in 2013-2014.

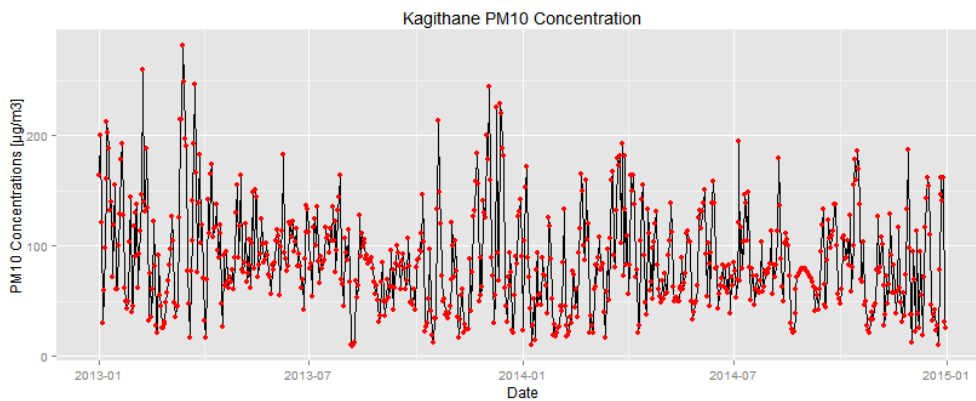


Figure 5. Daily variations of PM10 concentrations of Kagithane station in 2013-2014.

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Histogram of three air quality stations were plotted in Fig.6 to see the statistical distribution for the period of between 2013 and 2014.

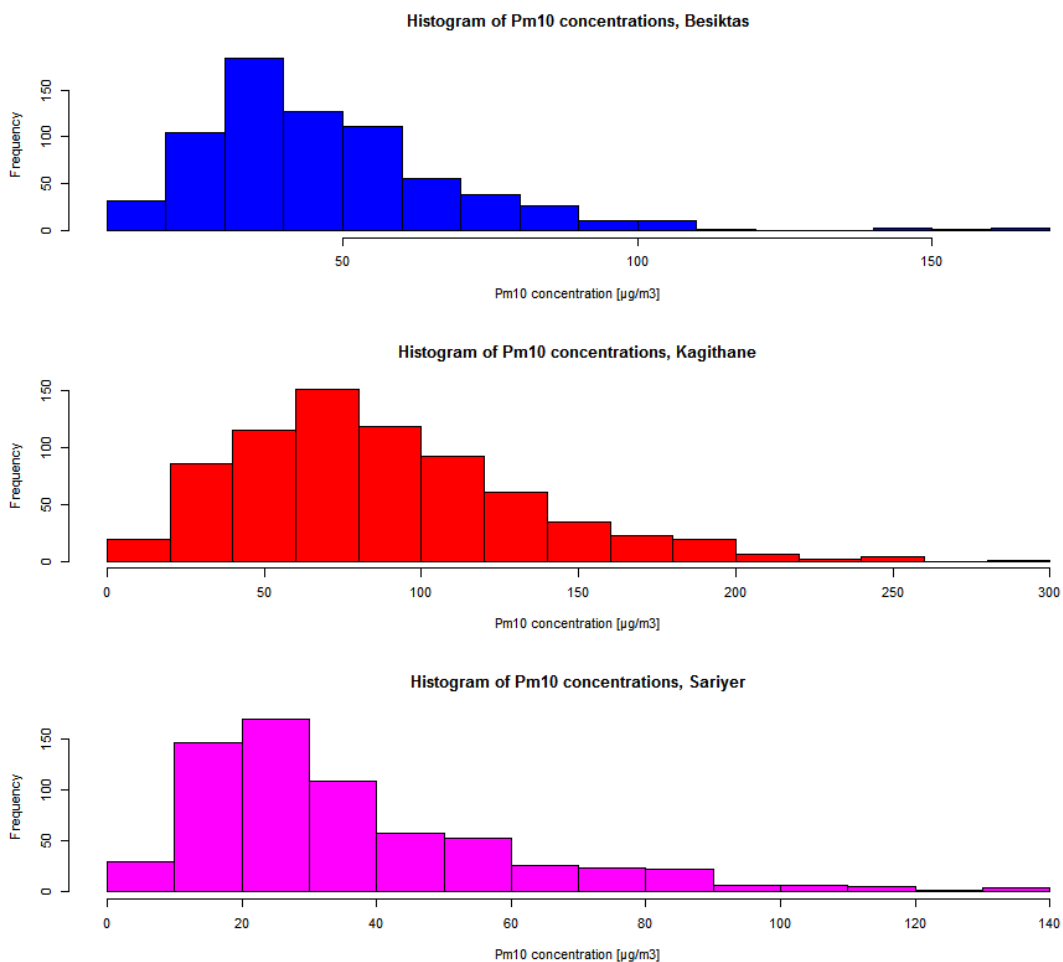


Figure 6. Histogram of Besiktas, Kagithane and Sariyer stations.

It can be seen from the Fig.6 Kagithane, Besiktas and Sariyer stations have positively skewed distribution. Histograms of Sariyer and Besiktas are close each other. But, Kagithane station has higher PM10 values therefore has a larger scale.

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Monthly means of threestations were calculated and plotted in Fig.7,

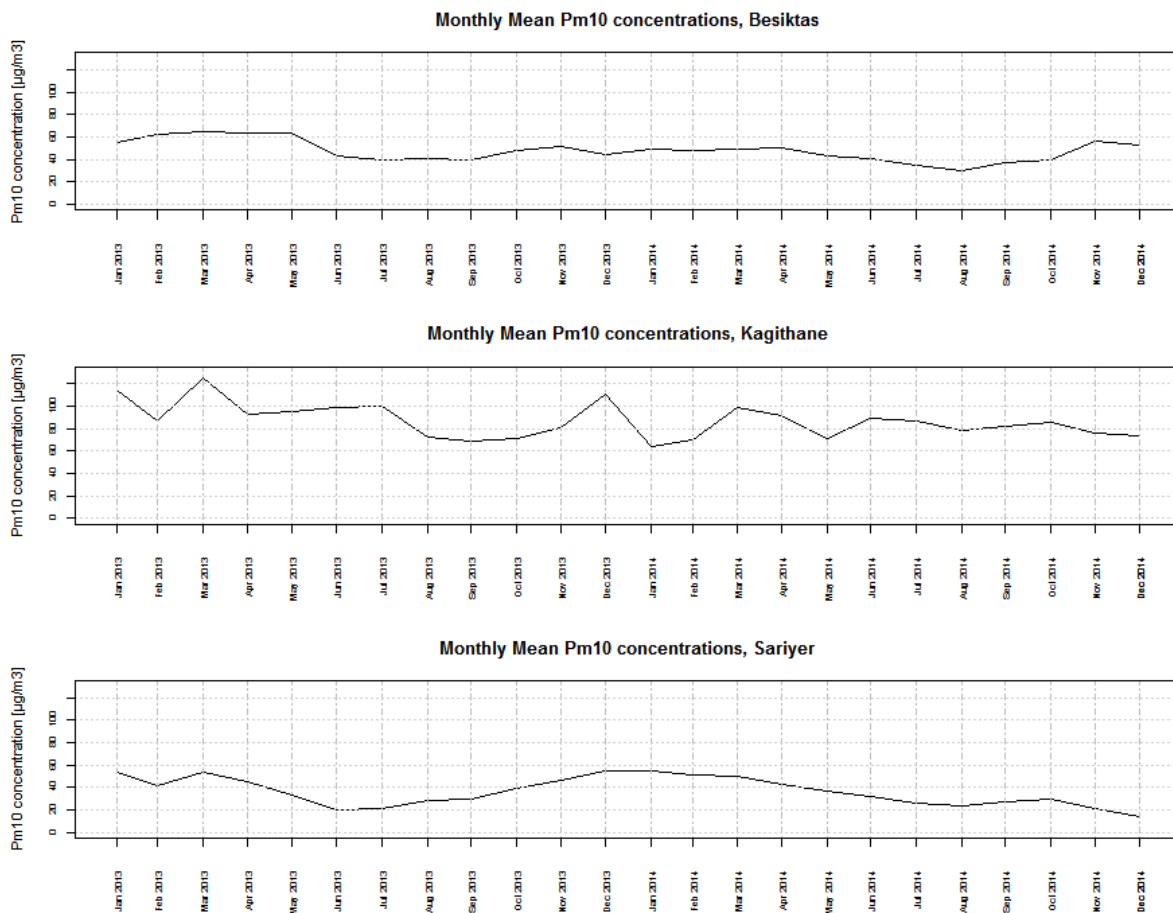


Figure 7. Monthlyvariation of PM10 concentrationsfor Besiktas, Kagithane and Sariyer stations.

Kagithane station has the highestvalues, especially, on winterseason. Besiktas has risingoscillation on summermonths and the Sariyer has samesituation, too. Besiktas and Sariyer stationsshownearlysamedistribution.

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The difference empirical cumulative distribution function is applied and plotted in Fig.8.

Empirical Cumulative Distribution Function

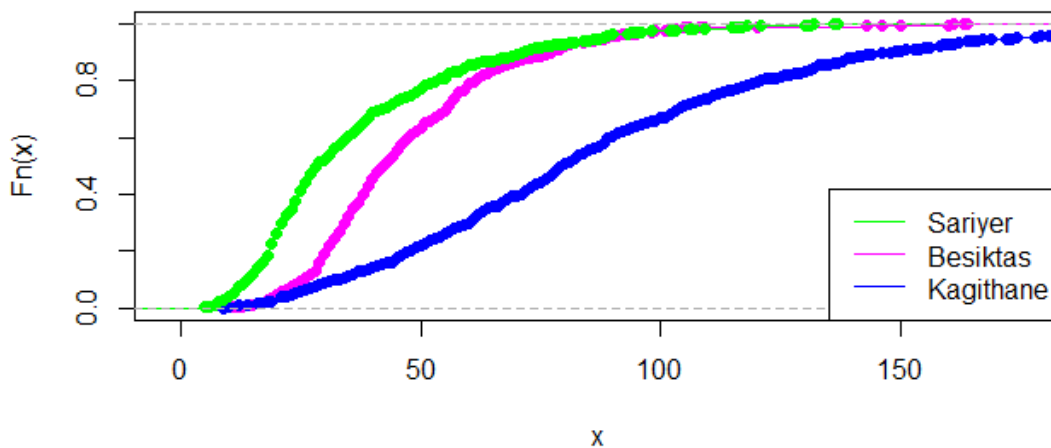


Figure 8. Empirical cumulative distribution function of PM10 concentrations of Kagithane, Besiktas and Sariyer stations for given period.

Clearly it is seen that, Sariyer and Besiktas stations are different from Kagithane station. And also, Sariyer and Besiktas stations are close to each other on ECDF. Seasonal variation of PM10 concentration for 2013 and 2014 years for Kagithane, Besiktas and Sariyer stations was plotted in Fig.8 Fig.9 and Fig.10 respectively. For Sariyer station, at 2014 winter and summer seasons mean of PM10 concentrations is lower than 2013 winter and summer seasons mean of PM10 concentrations. At 2014 spring season mean of PM10 concentrations is higher than 2013 spring season mean of PM10 concentrations. At fall seasons of 2013-2014 years, means of PM10 concentrations have close values. For Besiktas station, at all seasons of 2013-2014 years, means of PM10 concentrations have close values. Only, at 2014 winter season mean values are less than 2013 year mean values. For Kagithane station, at all seasons of 2014 years, means of PM10 concentrations are less than all seasons of 2013. But mean values of PM10 concentrations at summer seasons of 2013-2014 years are very close to each other.

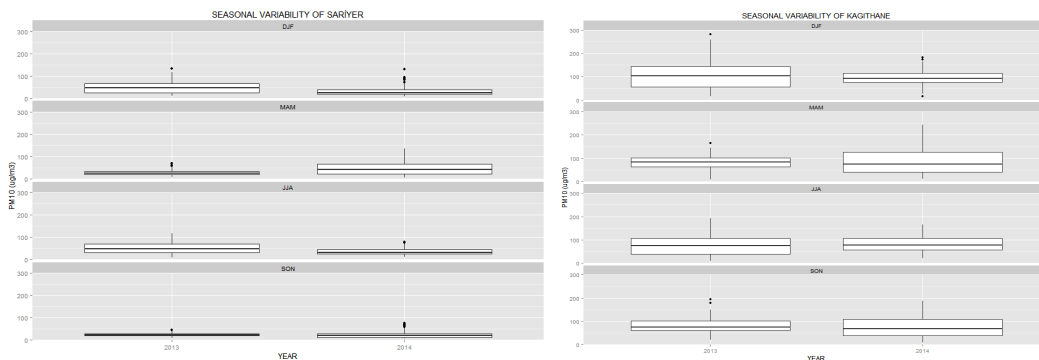


Figure 9-10. Seasonal Variability of PM10 concentrations of Sariyer and Kagithane station for given period.

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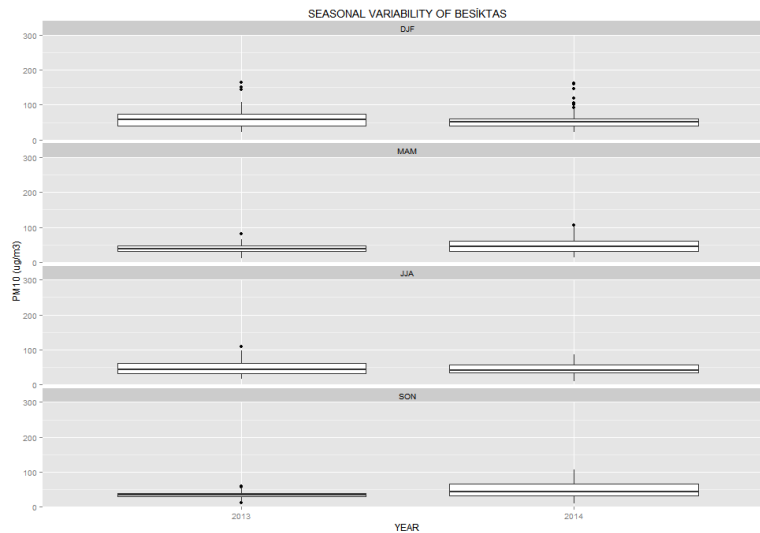


Figure 11. Seasonal Variability of PM10 concentrations of Besiktas station for given period.

To look at seasonal variability from a different angle, the seasonal variability following graphs are plotted.

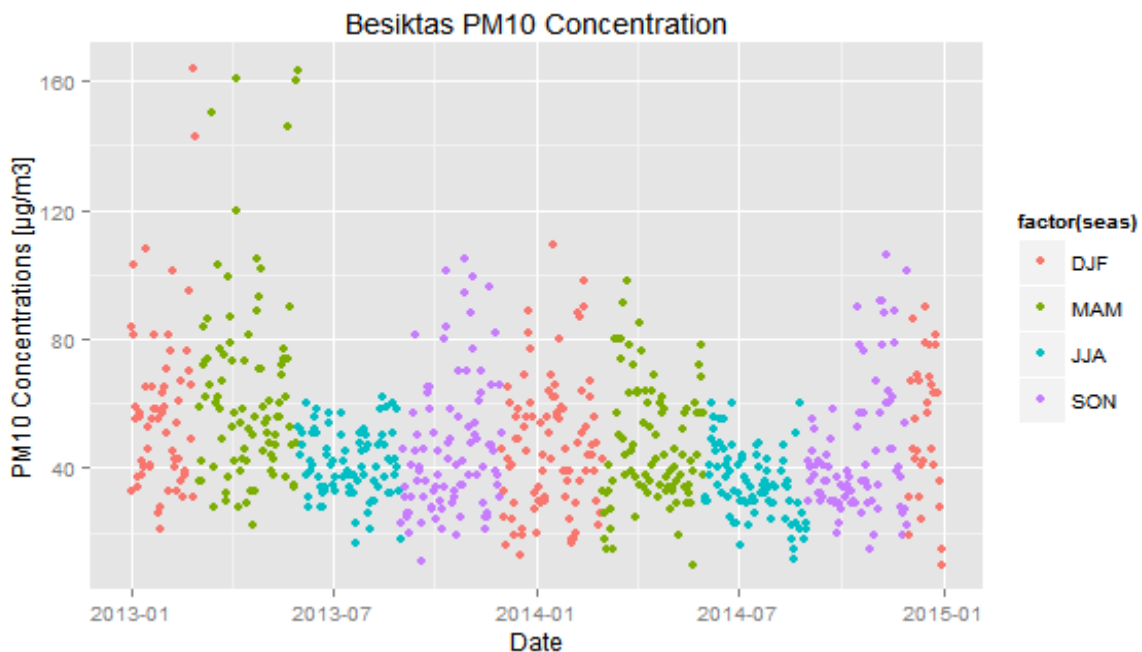


Figure 12. Seasonal Variability of PM10 concentrations of Besiktas station for given period.

For Besiktas station, at winter and spring season of 2013 year have higher values than other seasons. The lowest values are seen in summer season both year. All seasons have lower values in 2014 year than 2013 years.

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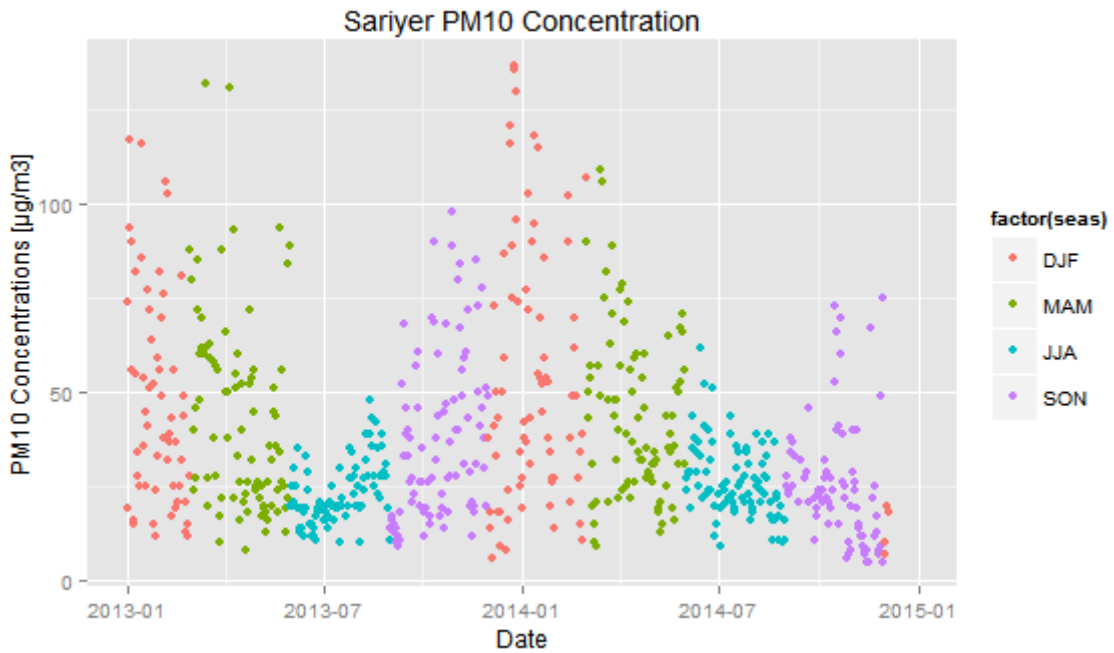


Figure 13. Seasonal Variability of PM10 concentrations of Sariyer station for given period.

For Sariyer Station, at winter season of 2014 year has highest value. Spring seasons of both years have higher values than other seasons.

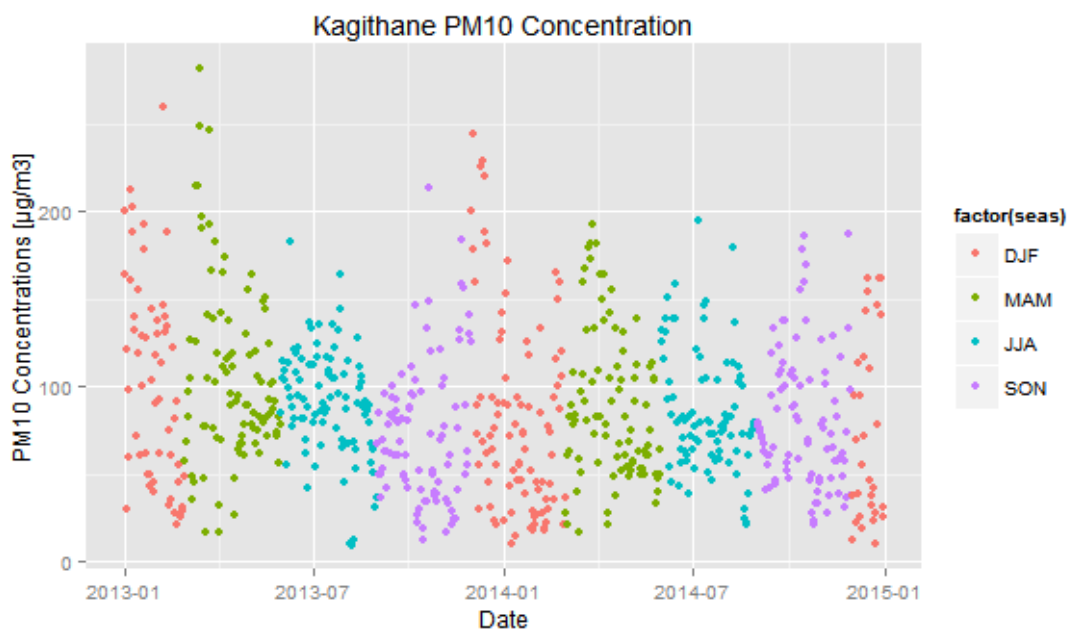


Figure 14. Seasonal Variability of PM10 concentrations of Kagithane station for given period.

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For Kagithane station, spring season of 2013 year has the highest value, winter seasons of both years have close and higher PM10 concentrations.

In addition to exploratory data analysis, hypothesis testing was done. At first correlation coefficients are calculated as binary. The highest correlation coefficient is between Sariyer and Besiktas stations. Kagithane is different from other stations.

```
> cor(BJK, KGT, use="complete.obs", method="kendall")
[1] 0.02230526
> cor(BJK, SRYR, use="complete.obs", method="kendall")
[1] 0.5466337
> cor(KGT, SRYR, use="complete.obs", method="kendall")
[1] 0.02763757
```

Figure 15. Correlation coefficients of stations.

First test is Kolmogorov Smirnov test. Also for this test, our p-value is smaller than 0.05 so null hypotheses is rejected. The result of Kolmogorov Smirnov test is shown in Fig.16.

<pre>> ks.test(BJK, SRYR, alternative="two.sided")</pre> <p style="text-align: center;">Two-sample Kolmogorov-Smirnov test</p> <pre>data: BJK and SRYR D = 0.3651, p-value < 2.2e-16 alternative hypothesis: two.sided</pre>	<pre>> ks.test(BJK, KGT, alternative="two.sided")</pre> <p style="text-align: center;">Two-sample Kolmogorov-Smirnov test</p> <pre>data: BJK and KGT D = 0.4871, p-value < 2.2e-16 alternative hypothesis: two.sided</pre>	<pre>> ks.test(SRYR, KGT, alternative="two.sided")</pre> <p style="text-align: center;">Two-sample Kolmogorov-Smirnov test</p> <pre>data: SRYR and KGT D = 0.5578, p-value < 2.2e-16 alternative hypothesis: two.sided</pre>
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Figure 16. K-S Tests Results of Stations.

<pre>> t.test(KGT, BJK)</pre> <p style="text-align: center;">Welch Two Sample t-test</p> <pre>data: KGT and BJK t = 17.0086, df = 1411.036, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: 33.49475 42.22804 sample estimates: mean of x mean of y 86.91781 49.05642</pre>	<pre>> t.test(KGT, SRYR)</pre> <p style="text-align: center;">Welch Two Sample t-test</p> <pre>data: KGT and SRYR t = 25.8148, df = 1132.771, p-value < 2.2e-16 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: 46.12380 53.71182 sample estimates: mean of x mean of y 86.91781 37.00000</pre>	<pre>> t.test(BJK, SRYR)</pre> <p style="text-align: center;">Welch Two Sample t-test</p> <pre>data: BJK and SRYR t = 6.967, df = 1201.752, p-value = 5.322e-12 alternative hypothesis: true difference in means is not equal to 0 95 percent confidence interval: 8.66127 15.45157 sample estimates: mean of x mean of y 49.05642 37.00000</pre>
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Figure 17. Student-t Test Results of Stations.

Finally, Student's t test was applied between Kagithane-Besiktas-Sariyer. For H_0 hypothesis, $\mu=0.05$ is accepted. When we applied t test to the data our p-value is found $2.2e-16$ and this values is much smaller than accepted p value. So, H_0 hypothesis is rejected and H_1 hypothesis is accepted. According to t-test's result, Kagithane, Besiktas and Sariyer statitons' Pm10 concentration $\mu=0.05$ distribution is different. On the other hand, p value between Besiktas-Sariyer stations is higher than the other comparisons, already p value is smaller than $\mu=0.05$.

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Following these analysis, a special study was done between Besiktas and Kagithane. Firstly, Pm10 levels exceed the value of 100mg/m³ are classified as seasonal for the two districts. Distribution graph of these data is shown in Figure 18. As seen from the graph, correlation between them is low. For all seasons, Kagithane has higher number of PM10 data than Besiktas. Kagithane has the highest Pm10 values which are exceed of 100mg/m³ in the Spring Season. Spring is the season that begins the work of the construction sector, generally. In recent years, Kagithane are preferred by the construction sector. Therefore, the high values which are in spring season can be regarded as normal. Second high values of Kagithane station are observed in winter season. In parallel with the construction industry, the numbers of residential also have a high value in the Kagithane region. Therefore, the sourced from heating pollutants have high value. Values are in the winter season can be regarded as normal, too.

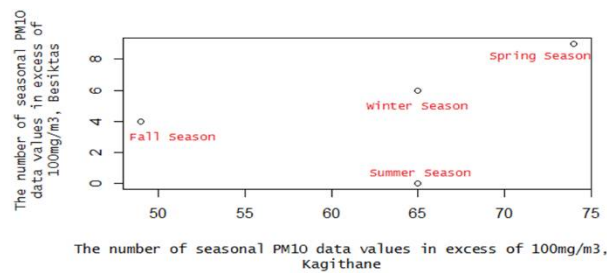


Figure 18. Scatter Plot of the number of seasonal PM10 data values in excess of 100mg/m³.

As a consequence of analysis, daily and monthly variations of PM10 concentration of three air quality station was interpreted. Also histogram, seasonal boxplots were plotted, seasonal distribution of the two years has been shown. Monthly and daily variations of Kagithane, seem different from other two stations. According to hypothesis testing, daily PM10 concentration levels differs from each other. But Kagithane station is exactly differs from Besiktas and Sariyer stations.

Primarily, coefficients are determined for the linear model analysis (Figure 19). Their regression value is regarded as 0.18. This values hows how much of the variability can be explained by regression line. The value which is obtained demonstrates that the relationship between them is weak. But, values of Kagithane and Besiktas stations have positive regression.

```
> mydata.lm = lm(mydata$kagithane ~ mydata$besiktas, data=mydata)
> coeffs = coefficients(mydata.lm); coeffs
      (Intercept) mydata$besiktas
      57.666667      1.175439
> mydata$besiktas = 6
> mydata$kagithane = coeffs[1] + coeffs[2]*mydata$besiktas
> mydata$kagithane
[1] 64.7193 64.7193 64.7193 64.7193
```

Figure 19. CoefficientsResults of Linear Model.

After these studies, linear model was applied for Besiktas and Kagithane stations (Figure 20). And then summary of linear model was plotted (Figure 21). Results of linear model are shown that between the numbers of seasonal Pm10 values that exceeding of 100 g/m³ of Besiktas and Kagithane stations has not a strong relationship. Despite this positive relationship between the Kagithane and Besiktas stations is shown by linear model results.

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```
Call:
lm(formula = mydata$kagithane ~ mydata$besiktas, data = mydata)

Residuals:
    1     2     3     4 
0.2807  5.7544  7.3333 -13.3684

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  57.667    10.165   5.673  0.0297 *
mydata$besiktas  1.175     1.763   0.667  0.5735

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 11.53 on 2 degrees of freedom
Multiple R-squared:  0.1819, Adjusted R-squared:  -0.2272
F-statistic: 0.4446 on 1 and 2 DF, p-value: 0.5735
```

Figure 20.Result of a Linear Model.

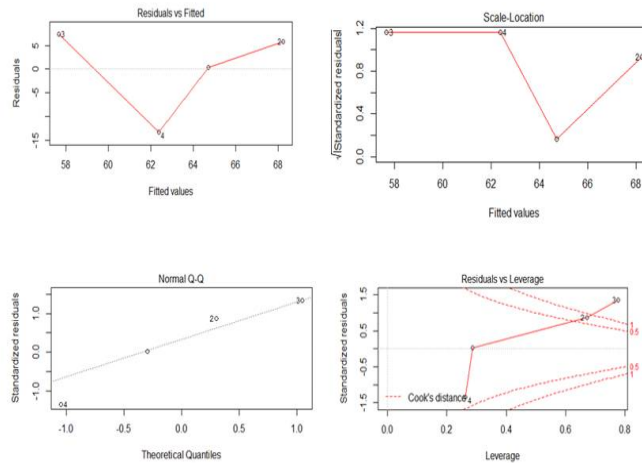


Figure 21.Graphs of the result of Linear Model.

Finally, Durbin-Watson test is done for the numbers of seasonal Pm10 values that exceeding of 100 g/m3 of Besiktas and Kagithane stations. According to dwtest, DW is 1.7352, therefore ρ value is 0 and then H0 hypothesis is accepted. To sum up, there is no auto correlation between Kagithane and Besiktas stations.

```
> dwtest(mydata$kagithane~mydata$besiktas)

Durbin-watson test

data: mydata$kagithane ~ mydata$besiktas
DW = 1.7352, p-value = 0.4693
alternative hypothesis: true autocorrelation is greater than 0
```

Figure 22: Result of Durbin-Watson Test.

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IV. CONCLUSION

As a consequence of analysis, daily and monthly variations of PM10 concentration of three air quality station was interpreted. Also histogram, seasonal boxplots were plotted, seasonal distribution of the two years has been shown. Monthly and daily variations of Kagithane seem different from other two stations. According to hypothesis testing, daily PM10 concentration levels differs from each other. But Kagithane station is exactly differs from Besiktas and Sariyer stations.

Linear model analyses are applied with the numbers of seasonal Pm10 values that exceeding of 100 mg/m³ of Besiktas and Kagithane stations, result of in this model, a weak positive correlation was observed between these stations. Finally, Durbin-Watson test are performed, it was seen that there is no autocorrelation between Besiktas and Kagithane stations.

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