The Influence of Relative Humidity on Concentrations (PM$_{10}$, TSP) in Baghdad City

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Abstract: The aim of this research is to study the effect of relative humidity on the concentrations of pollutants suspended particulate (Particulate Matter diameter less than 10 µm (PM$_{10}$) and Total Suspended Particulates (TSP)) for Al-Andalus Square station (Commercial-Residential) in Baghdad city, through the use of methods and statistical programs. It was found that the relationship between relative humidity and suspended particulates (PM$_{10}$, TSP) is an extrusive (positive) correlation to all hours of study. And found that the highest concentrations of suspended particulates (PM$_{10}$, TSP) when hours morning and evening study reported in the days (20/6, 22/7, 15/8) of the summer months, followed by hours days (18/3, 17/4, 20/5) of the spring months and then-hour days (17/9, 22/10, 14/11) of the autumn months, and lower concentrations of the suspended particulates (PM$_{10}$, TSP) when the hours of the morning and evening study reported in the days (17/12, 17/1, 15/2) of the winter months. And that the concentrations of suspended particulates (PM$_{10}$, TSP) through high morning hours, and in the evening were a few. And found that there are exceeded in the concentrations of suspended particulates (PM$_{10}$, TSP) world determinants and local at the morning and evening study hours to days (20/6, 22/7, 15/8), either at study hours to days (17/12, 17/1, 15/2) The concentrations of suspended particulates PM$_{10}$oscillatory world and local determinants and two for concentrations TSP was higher than the world and less than the local determinant. But when study hours and days (18/3, 17/4, 20/5) was concentrations PM$_{10}$ higher than the world and determinant local concentrations TSP was higher than the world and less than the local determinant fixed for station. But when the study hours to days (17/9, 22/10, 14/11) were concentrations PM$_{10}$ higher than the world and local determinant and concentrations TSP was higher than the world determinant and oscillatory local determinant for Al-Andalus Square station.

Key words: relative humidity, suspended particulate, air pollutants, aerosols, Iraq

1. Introduction

Progress of the World Cultural and Urban continuous and that is the product of humanitarian efforts towards a better life for mankind has on the lives of secretions negative organisms if the case did not take into account the balance of nature and those factors atmosphere factors. The smoke of factories and car exhaust as well as the smoke of oil installations and other sources of natural contaminants adversely affect directly the lives of living beings in general as well as the impact of up to things non-living, too, which draws attention to the seriousness of the economic and health atmospheric air pollution process [1]. The air we breathe is a mixture of gases and particulates air, which consists of solids and liquid, called Aerosols and some of the material comes from natural sources, etc. The other comes from human activities such as the use of modes of transportation, local activities and the industry that launches the suspended particulates (PM$_{10}$, TSP) [2].

Where released into the air either from natural sources or human sources of many of gaseous, liquid and solid proportions and sizes and concentrations varying such as (PM$_{1}$, PM$_{2.5}$, PM$_{7}$, PM$_{10}$, TSP) and this would be harmful to humans, animals, plants and even inanimate objects are divided air pollutants to several sections, including the Gaseous Pollutants and Particulate Pollutants [3].

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He knew pollution as a harm to human and what surrounds it, either directly or indirectly. It also defines pollution as any defect affects water, air, soil and food systems, which directly or indirectly affect the organisms and damaging economic property [4] and is generally considered pollution is all leads as a result of the technologies used to add a foreign substance into the air, water or atmosphere Air to ground in quantitative and affects the quality of resources and an updated variation in properties and inadequate use [5]. Some consider pollution word meaningful year has meant the emergence of something inappropriate or undesirable in a particular place although it sometimes this thing may be desirable in another place. Pesticides and chemical fertilizers are needed to protect the flora and increase agricultural yield and undesirable for the impact of toxic and harmful to humans and animals [6]. And it is considered by some pollution that that change is desirable in the physical and chemical properties and biological air, water and soil, which cause damage to humans and the rest of the objects [7].

2. Data and Study Area

Work was performed with hourly data of the suspended particulates (PM$_{10}$, TSP) during the official working hours of the period (08:00, 09:00, 10:00, 11:00, 12:00, 13:00, 14:00, 15:00) days (17/1, 15/2, 18/3, 17/4, 20/5, 20/6, 22/7, 15/8, 17/9, 22/10, 14/11, 17/12) for the year 2012, which was obtained by the (technical/section control circuit and evaluate the air quality and noise Iraq/Ministry of Environment) at Al-Andalus Square station and at a height of 16 meters above the ground level using AEROCET 531 Handheld Particle device (Fig. 1), and was obtained relative humidity at a height of 18 meters above the ground level using wireless weather station (Davis weather link 5.7 vantage pro2) (Fig. 2), over the Department of Atmospheric Sciences/College of Science/Al-Mustansiriya University) for the same period in which the measured suspended particulates (PM$_{10}$, TSP), and Al-Mustansiriya area is located at latitude 33°22'18" N and longitude44°24'70" E and located at Al-Andalus Square area latitude 33°18'86" N and longitude 44°25'29" E. Was chosen as Al-Andalus Square area to see pollution where suspended particulates and considered to be of a residential nature and commercial area (mixed size) (Fig. 3).
3. Statistical Analysis

3.1 Simple Linear Regression (SLR)

Is to predict or estimate the future value of one variable based on the knowledge of the values of the other variable is used in determining the shape of the relationship between two variables mathematically. Chart of the form of the regression line and the straight line relationship is given by the following equation [9]:

\[ \bar{Y} = a + b\bar{X} \]  

\[ b = \frac{n\sum xy - (\sum x)(\sum y)}{n\sum x^2 - (\sum x)^2} \]  

\[ a = \frac{\sum y - b\sum x}{n} \]

Where \( \bar{X} \): Independent variable, \( \bar{Y} \): The variable or approved, \( a \): A steady regression or part of the lump-axis (Y) to the equation (1), \( b \): Slope of straight line or a slope of regression straight line and \( n \): Sample size.

3.2 Spearman Correlation Coefficient (SCC)

If the variables measuring both ordinal scale

Assuming that the variable X his ranks \( R_X \) and variable Y his ranks \( R_Y \) and assuming that \( D \) stands for teams grades in the sense that [10]:

\[ D = R_X - R_Y \]

The ranks of the Spearman correlation coefficient \( r_s \) gives the following equation:

\[ r_s = 1 - \frac{6\sum D^2}{n(n^2-1)} \]

Where \( r_s \): Spearman correlation coefficient, \( D \): The difference between a couples of ranks. And there is no correlation between a couple of ranks when \( (r_s = 0) \) and there is a correlation between a couple of ranks when \( (r_s < 0 \text{ or } > 0) \).

3.3 Mann-Kendall Test (MKT)

Is a non-parametric link to an unspecified number of data coefficient is used to assess the association between the data and is symbolized by the Greek symbol \( \tau \), which looks like a Spearman correlation coefficient sets of data are ordinal and Borders link Mann Kendall coefficient between \((+1 \text{ to } -0.1)\) and link Mann Kendall coefficient has many formats such as \((\tau_{Ken,a})\) and \((\tau_{Ken,b})\) and \((\tau_{Ken,c})\) is given the following equations [11]:

\[ \tau_{Ken,a} = \frac{(C-d)}{\sqrt{\frac{n(n-1)}{2}}} \]
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\[ \tau_{ken,b} = \frac{(c-d)}{\sqrt{\left( \frac{(u(u-1)}{2}\right)}} \]  
\[ \tau_{ken,c} = \frac{2(c-d)}{n^2} \]  

Where \( t \): Is the number associated with the measured values, \( u \): Is the number associated with the calculated values, \( c \): Is the number of matching pairs and \( d \): Is the number of discordant couples.

3.4 Probability Value (P-Value)

It is a number used to evaluate metrics statistical, a value shows that the contrast factor it is an influential factor really or is ineffective, as if the value of P-value less than (0.05), the influential factor in the variable that we are trying to study the change, and consider worker effective until the value of P-value equal to (0.1), but if increased from (0.1), it means that the worker should be excluded from the model and therefore is not an influential factor [12].

4. Results and Discussion

The relationship between the relative humidity and concentration of (PM$_{10}$, TSP) show in Figs. 4 and 5. Tables 1 and 2 illustrate the type and strength of the correlation between relative humidity and concentration of suspended particulates (PM$_{10}$, TSP), and the slope of the regression for hours and days of study for months in 2012 for the station of Al-Andalus square, found that the relationship between the relative humidity and concentrations of (PM$_{10}$, TSP) is a positive relationship and that the concentrations of (PM$_{10}$, TSP) when the morning study hours (08:00, 09:00, 10:00, 11:00) are high and relative humidity values when the morning hours are also high. The reason a positive relationship dates back to the water droplets in the air to attract and increase air pollutants and particulate matter on the surface of the water droplets and limit the spread of contaminants and particles towards the top and enhances the density of pollutants and suspended particulates, while in the afternoon (12:00, 13:00 14:00, 15:00) are less than the morning hours and the relative humidity may be said because the temperature increased in the afternoon even lower relative humidity. Also, the relative humidity is less than even lower when the amount of water droplets in the air, which is working on the collection and retention of pollutants and suspended particulates in the air is even lower concentrations of (PM$_{10}$, TSP) and the a positive relationship clear through correlation coefficients values and the values of a slope positive regression.

Fig. 4  The relationship between relative humidity and concentration of PM$_{10}$ during the hours (08:00 AM -15:00 PM) for study days in 2012 to Al-Andalus square station.
Followed Fig. 4
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Followed Fig. 4
Table 1  Test the strength and type of relationship between relative humidity and concentration of PM$_{10}$ results during the hours (08:00 AM -15:00 PM) for study days in 2012 to Al-Andalus square station.

<table>
<thead>
<tr>
<th>Hours for Days</th>
<th>Simple Liner Regression</th>
<th>Spearman Test</th>
<th>Mann-Kendall Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P-value</td>
<td>Relationship</td>
<td>$r_s$</td>
</tr>
<tr>
<td>17/1</td>
<td>0.09</td>
<td>Non-linear</td>
<td>0.7</td>
</tr>
<tr>
<td>15/2</td>
<td>0.0005</td>
<td>Linear</td>
<td>0.9</td>
</tr>
<tr>
<td>18/3</td>
<td>0.5</td>
<td>Non-linear</td>
<td>0.4</td>
</tr>
<tr>
<td>17/4</td>
<td>0.05</td>
<td>Linear</td>
<td>0.7</td>
</tr>
<tr>
<td>20/5</td>
<td>0.1</td>
<td>Non-linear</td>
<td>0.5</td>
</tr>
<tr>
<td>20/6</td>
<td>0.07</td>
<td>Non-linear</td>
<td>0.5</td>
</tr>
<tr>
<td>22/7</td>
<td>0.2</td>
<td>Non-linear</td>
<td>0.5</td>
</tr>
<tr>
<td>15/8</td>
<td>0.2</td>
<td>Non-linear</td>
<td>0.4</td>
</tr>
<tr>
<td>17/9</td>
<td>0.2</td>
<td>Non-linear</td>
<td>0.5</td>
</tr>
<tr>
<td>22/10</td>
<td>0.03</td>
<td>Linear</td>
<td>0.8</td>
</tr>
<tr>
<td>14/11</td>
<td>0.7</td>
<td>Non-linear</td>
<td>0.04</td>
</tr>
<tr>
<td>17/12</td>
<td>0.1</td>
<td>Non-linear</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Followed Fig. 4.
Fig. 5 The relationship between relative humidity and concentration of TSP during the hours (08:00 AM - 15:00 PM) for study days in 2012 to Al-Andalus square station.
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Followed Fig. 5.
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Table 2 Test the strength and type of relationship between relative humidity and concentration of TSP results during the hours (08:00 AM - 15:00 PM) for study days in 2012 to Al-Andalus square station.

<table>
<thead>
<tr>
<th>Hours for Days</th>
<th>Simple Linear Regression</th>
<th>Spearman Test</th>
<th>Mann-Kendall Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P-value</td>
<td>Relationship</td>
<td>r_s Correlation</td>
</tr>
<tr>
<td>17/1</td>
<td>0.02</td>
<td>Linear</td>
<td>0.7 Extrusive high</td>
</tr>
<tr>
<td>15/2</td>
<td>0.001</td>
<td>Linear</td>
<td>0.8 Extrusive high</td>
</tr>
<tr>
<td>18/3</td>
<td>0.5</td>
<td>Non-linear</td>
<td>0.3 Extrusive few</td>
</tr>
<tr>
<td>17/4</td>
<td>0.05</td>
<td>Linear</td>
<td>0.7 Extrusive high</td>
</tr>
<tr>
<td>20/5</td>
<td>0.09</td>
<td>Non-linear</td>
<td>0.5 Extrusive medium</td>
</tr>
<tr>
<td>20/6</td>
<td>0.2</td>
<td>Non-linear</td>
<td>0.6 Extrusive medium</td>
</tr>
<tr>
<td>22/7</td>
<td>0.3</td>
<td>Non-linear</td>
<td>0.6 Extrusive medium</td>
</tr>
<tr>
<td>15/8</td>
<td>0.2</td>
<td>Non-linear</td>
<td>0.4 Extrusive medium</td>
</tr>
<tr>
<td>17/9</td>
<td>0.08</td>
<td>Non-linear</td>
<td>0.5 Extrusive medium</td>
</tr>
<tr>
<td>22/10</td>
<td>0.07</td>
<td>Non-linear</td>
<td>0.9 Extrusive very high</td>
</tr>
<tr>
<td>14/11</td>
<td>0.6</td>
<td>Non-linear</td>
<td>0.04 NO correlation</td>
</tr>
<tr>
<td>17/12</td>
<td>0.1</td>
<td>Non-linear</td>
<td>0.6 Extrusive medium</td>
</tr>
</tbody>
</table>

5. Conclusions

Through the foregoing can be summarized the main conclusions reached by this research:

- There is a clear effect of relative humidity on the concentrations of particulate matter (PM_{10}, TSP), where the correlation coefficients showed a positive relationship between them and to all hours of the morning and evening study and all study days of the months in 2012 for the Al-Andalus square station.
- That the concentrations of particulate matter (PM_{10}, TSP) through high morning hours, and in the evening hours were few.
- The highest concentrations of suspended particulates (PM_{10}, TSP) Al-Andalus square station when study hours morning and evening, and recorded in the days (20/6, 22/7, 15/8), followed by hours days (18/3, 17/4, 20/5) hours and then days (17/9, 22/10, 14/11), and less concentration of suspended particulates (PM_{10}, TSP) recorded in the days (17/12, 17/1, 15/2).
- Found in the morning and evening study hours to days (20/6, 22/7, 15/8) during the summer months exceeded the concentrations of particulate matter (PM_{10}, TSP) for world and local determinant.
- In the morning and evening study hours to days (17/12, 17/1, 15/2) during the winter months, where the concentrations of PM_{10} relationship world and local determinant oscillatory. As for the concentration of TSP for hours study was higher than the world and less than the local determinant.
- In the morning and evening study hours to days (17/4, 20/5, 18/3) during the spring months, where the concentrations of PM_{10} are all higher than the world and local determinant, but for TSP concentrations were higher than the world and less than the local determinant.
- In the morning and evening study hours to days (17/9, 22/10, 14/11) during the autumn months PM_{10} concentrations were higher than the world and local determinant or oscillatory, as for TSP concentrations were higher than the world determinant and oscillatory in terms of exceeding the local determinant.

References

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