Analysis of Air Quality Index Distribution of PM$_{10}$ and PM$_{2.5}$ Concentrations in Ambient Air of Al-Hillah City, Iraq

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Abstract. Air pollution is the most hazardous form of pollution because simply the amount of air is very limited on this planet and human beings cannot survive for more than a few minutes without air. In this work, air pollution with suspended solids will be investigated, where the concentrations of both PM$_{10}$ and PM$_{2.5}$ in Al-Hillah City have been measured by establishing three monitoring stations in a major street. The street has two main hospitals, a stadium, and many organizations. Temp monitor (model: Airing-1000) was utilized for this purpose. During the study period (five months), the range of PM$_{10}$ and PM$_{2.5}$ concentrations were from 7.8 to 32.5 μg/m$^3$ and 4.5 to 11.1 μg/m$^3$, respectively. The average PM$_{10}$ concentration from station H2 exceeds the annual standard of WHO while the PM$_{2.5}$ averages were within the annual standard of WHO except reading from site H2 during May 2019 was higher than the WHO limit. Many factors assist to raise the PMs concentrations in urban areas such as vehicle emission, measurement season type as well as dust events. In this study, we have noticed all factors are playing a significant role in increasing PMs concentrations.

1. Introduction

As it has been mentioned in the abstract of this paper; there are many forms of pollution facing the population of the Earth planet, including water, air, and soil pollution. It is well-known that all these forms of pollution directly affect public health and the eco-system of the Earth’s planet [1-3]. However, air pollution the most hazardous form of pollution because simply the amount of air is very limited on this planet and human beings cannot survive for more than a few minutes without air [1, 4]. For example, water pollution could be controlled to a large extent by applying efficient water treatment methods [5-7], such as chemical and physical treatments [8-14], or by applying restricted limitations for wastewaters [15-17]. Additionally, the underwater living organisms and plants help to balance the pollutants in water bodies [18-
Similarly, soil pollution that results from landfills [24-27] or injection of pollutants into the soils [28-32] could be controlled by applying efficient treatment methods [33-37]. Contrary, air pollution is categorized as the most hazardous form of pollution due to the limited amount of air on this planet, and the fact that humans can not survive for more than a few minutes without air [1]. Though air pollution could result from natural sources, such as volcanoes, the man-made sources are the most significant source of air pollution. For example, the cement industry generates millions of tonnes of carbon dioxide gas [38-40] along with a significant amount of particulates and other gases [41-43]. Furthermore, man-made sources generate significant volumes of greenhouses gases that cause a phenomenon known as global warming [44-47], which caused severe environmental pollution and water shortages in many countries [48-51]. Generally, the pollution of air could result from hazardous chemicals or suspended solids. Ambient air pollutants including sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3), nitrogen dioxide (NO2), and particulate matter of aerodynamic diameter (especially PM2.5 and PM10, less than 2.5 and 10 μm in diameter, respectively) can affect human being by causing diseases and death even when exposed to a low concentration of these pollutants. Particulate matters (PMs) are causing the most negative health impact with approximately 2.1 excess deaths [52]. Coarse particle matters between 2.5 and 10 (PM 2.5-10) have the ability to deposit in the upper side of the respiratory tract [52], whereas PM2.5 (fine particles) can lodge in the lung with the ability to stay a long period of time tending to enter the blood system. Epidemiological and toxicological studies have reported several health impacts for PMs such as lung cancer, myocardial infarctions, respiratory disease, stomach cancer, and cardiovascular disease. PMs are bounded mixtures of chemical composition in form of solids and liquids of different sizes. These chemicals are inorganic (magnesium, chloride ammonium sulfates, and nitrates), organic (black carbon, metals, and polycyclic aromatic hydrocarbons), and biological components (such as pollens). The relationship between the type of land and the PMs concentrations is controversial. Studies concluded that there has been a positive relationship between PM2.5 and residential lands [52]. However, others have shown lower PMs concentrations in the same lands but a positive relationship between PMs concentrations and commercial lands. However, numerous studies have stated that high concentrations of PMs in industrial areas and others found low PM values in green lands. Heavy traffic density has founded its effect on PM2.5 concentrations. Studies are varied in terms of PMs relationship with the development density. For example, Tang and his colleagues have found that high PM10 values in high building volume whereas others have stated that there is a positive correlation between PM2.5 and average building height [53]. Numerous studies have investigated the PMs concentration worldwide with the relationship to the built environment. In our study, we have examined a very important street in Al-Hillah city in terms of PM10 and PM2.5 concentrations. The street (Al-Jazaer –BabAlHussein) has two main hospitals (Hayat Hospital and Morgan Medical city), a stadium, and many organizations, which make this road always has high traffic density.

2. Method

2.1. Area of Study

There are five major cities in the Babylon governorate with a total population of 2.2 million people. Al-Hillah city is the main city which is located about 100 km south of the capital of Iraq (Baghdad). The length of the studied segment is 3000 m, three monitoring stations were used, namely H1: near Al-Hayat Hospital, H2: near Morgan Medical city, and H3: near the main roundabout in this road. Figure 1 is represented the sampling locations with the coordinates.
2.2. Data

MP_{10} and MP_{2.5} were measured using a Temtop monitor (model: Airing-1000) which was provided by the Department of Environmental Engineering, University of Babylon. The used detector has 0-999 μg/m³ as a measurement range with 0.1 μg/m as accuracy. Other operating parameters were as follows: the temperature from 0 to 50 °C, Humidity range from 10-90%, and 1 standard atmospheric pressure. The MP_{10} and MP_{2.5} measurements were from January to May 2019 with an average of six readings in the three monitoring stations H1, H2, and H3 to determine PM values. These months were chosen because they represent the wet
and dry seasons in Iraq (January to March is a wet period, while the period from April to May is a dry one). As mentioned earlier, the importance of the street has two main hospitals in addition to compensation of residential, commercial, and green lands along with the stadium and many organizations, thus, the H1 monitoring station was near Al-Hayat Hospital, H2 station was near Morgan Medical city, and H3 was near to the main roundabout in this road.

3. Results and discussion

Figure 2 summarized the measured MP_{10} concentrations in Al-Hillah (μg/m^3). The range of PM_{10} concentrations for the measurements of five months was from 7.8 to 32.5 μg/m^3. The averages for the three stations were 18.4, 20.12, and 19.06 μg/m^3 for H1, H2, and H3, respectively. The daily mean of MP_{10} was measured during the 15th of May 2019 and was 28.4, 31.3, and 30.2 μg/m^3 at H1, H2, and H3, respectively which was higher than 20 μg/m^3, the WHO annual standard for PM_{10}. The minimum PM_{10} value was observed during February in station H1 with a value of 7.8 μg/m^3.

The concentrations of MP_{2.5} in Al-Hillah (μg/m^3) during five months with the average illustrated in Figure 3. The range of PM_{2.5} concentrations during the whole period was from 4.5 to 11.1 μg/m^3. The averages for the three sites were 6.5, 8.02, and 6.88 μg/m^3 for H1, H2, and H3, respectively. The daily mean of MP_{2.5} was measured during the 15th of May 2019 and was 9.3, 11.2, and 9.8 μg/m^3 at H1, H2, and H3, respectively. The H3 station recorded higher PM_{2.5} concentrations than the WHO annual standard, 10 μg/m^3. The minimum PM_{2.5} concentration was during January in station H1 with a value of 4.5 μg/m^3. Figure 4 is represented by the PM_{10} and PM_{2.5} 2D Kernel Density Graph. It is suggested that the increased concentration of both PM_{10} and PM_{2.5} in the urban area was due to vehicles’ emissions seen every day during the year which was also supported by others [53]. In addition to the vehicle's emission, the measurement at the start of the year were noticed to be lower than those at the end of the measuring period, this was due to the highest monthly rainfall at the start of the year which reduced the amount of PMs concentration in the atmosphere. Another reason for increasing the PMs values in the middle of Al-hillah City is the dust events. Usually, dust is generated when there is increasing in wind speed with low humidity. The dust is reached from the deserts in Iraq, Saudi Arabia, Syria, Kuwait, and other parts of Africa, and it also results from the desertification phenomenon.

![Figure 2. MP_{10} concentrations in Al-Hillah at the three stations.](image)
Finally, it can be seen from the provided literature and the experimental studies in this study the presence of fine particles in the atmosphere could result in grave effects on human health, which emphasizes the need for real-time monitoring for the concentrations of fine particulates, especially in the sensitive areas, such as hospitals. The literature shows successful applications of sensors to provide real-time data, such as the concrete [54, 55], water quality [56], and communications [57]. Thus, these sensors could be used to monitor the concentration of fine particulates in sensitive areas or buildings.
4. Conclusion
The study was conducted in Al-hillah City, Iraq. The segment has two main hospitals, a stadium and many organizations. It was monitored the concentration of both PM$_{10}$ and PM$_{2.5}$ by utilizing Temtop monitor (model: Airing-1000). The range of five months’ measurements of both PM$_{10}$ and PM$_{2.5}$ concentrations were from 7.8 to 32.5 μg/m$^3$ and 4.5 to 11.1 μg/m$^3$, respectively. It was observed that the average PM$_{10}$ value from station H2 was higher than the annual standard of WHO and H2 station was also recorded a value of PM$_{2.5}$ higher than the limit. Because of the increased number of vehicles especially in the study sites as well as the observed dust events, the ambient PMs concentrations were high. Thus, implementing a strategic plan such as planting near the sites can significantly reduce the dust event which leads to PMs reductions. Additionally, as mentioned above, the literature shows successful applications of sensors to provide real-time data in different fields. Thus, more researchers are needed to investigate the applicability of these sensors to monitor the concentration of fine particulates in sensitive areas or buildings.

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