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Evaluation Effect of Inhalable Particulate Matter Exposure on Human Health in Center of Karbala City

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Abstract:- **Recently inhalable particulate matter $PM_{2.5}$ and PM_{10} acquired great interest because of its reverse impact on human health and its pollution caused inevitable economic losses for society. This study tried to evaluate hourly and daily means of particulate matter ($PM_{2.5}$ and PM_{10}) concentrations risk in the center of Karbala city in central of Iraq, from 1 June to 20 July 2015. These concentrations crossed WHO permissible limits at ratios of 16% and 12% for $PM_{2.5}$ and PM_{10} respectively. According to health risk assessment, this place outed of hazard risk represented by hazard quotient HQ < 1 for all days also safe for carcinogenic impact; all days had cancer risk CR < 10^{-6}. This study approved that the proportions of attributable fractions AF and excessing risk ER (long-term exposure to $PM_{2.5}$) for lung cancer mortality and cardiopulmonary mortality might decreasing at about 19%, 27%, 23% and 36% respectively at 95% confidence interval if the concentrations of $PM_{2.5}$ kept at 3μg/m^3. Finally, air quality index categorized the ambient air of this place at rating B (good).**

Keywords: Air pollution, inhalable, attributable fractions, excess risk, air quality index

1. INTRODUCTION

Air pollutants categorized as gaseous or particulate matter (Bree et al., 2000). Pollutants classified also according to the type of formation into primary and secondary pollutants. Primary pollutants released into the atmosphere directly from multiple sources, such as wood burning or vehicle exhaust (Gozzi et al., 2017). Secondary pollutants already presented in the atmosphere and formed from the reactions of pollutants with each other in the presence of sunlight (Barn et al., 2011). Air pollution poses a clear threat to public health, and the huge increasing in population, vehicles, industrial activities and rapid economic growth had caused a noticeable increase in air pollutants' concentrations. The World Health Organization WHO confirmed in its report published in 2013 that the number of deaths reached 2 million cases due to ambient air pollution, according to epidemiological studies. Exposure to polluted air causes either short-term (acute, up to 24 hours) and long-term (chronic, months or years) effects on humans (Morakinyo et al., 2018).

Among all air pollutants, many toxicological studies had shown that particulate matter were the most effective pollutants entering the human body. Particulate matter had a wide range of sizes it was not a single pollutant also it was different in shape and chemical composition containing organic, inorganic, metallic and silicate compounds. It caused many diseases of the respiratory system, lungs and heart. Continuous exposure to particulate matter leads to death. PM_{10} (particles of diameter≤10μm) (Filonchyk et al., 2016), deposited on the surface of the larger airways of the upper region of the lung, $PM_{2.5}$ (particles of diameter ≤2.5μm), deposited on the deeper surface of the lung depending on particle size (Jeffrey et al., 1997).

There is a positive relation between exposure to daily mean concentrations of PM_{10} and the incidence of respiratory symptoms, when PM_{10} > 60μg/m^3 in cases of chronic respiratory or cardiovascular diseases (Villamizar et al., 2012).

Because of the increased risks of pollution on human health, especially in urban areas, health risk assessment needed to estimate the relationship between the duration of exposure to these pollutants and their reverse health effects. These pollutants can directly effect on human health in hot weather because increasing in temperature degree causes extra stress on human body as recorded in physiology studies (Xu et al., 2014). This paper adopted health risk assessment related with exposure to inhalable particulate matter ($PM_{2.5}$ and PM_{10}) in summer in center of Karbala city resulting from the increasing of pilgrims from inside and outside of Iraq to visit the holy shrines there. Attributable fraction and excess risk also estimated to decrease the proportion of mortality by avoided the excessive exposure to inhalable particulate matter.

2. METHODOLOGY AND MATERIALS

2.1 Study Area and Population

Karbala city located in middle of Iraq, at about 97 km southwest of Baghdad, and a few miles east of Razzaza Lake. Karbala had an estimated population of 1,378,0000 people in 2013. This city considered a holy city for Muslims because of the location of shrines of Imam Hussein ibn Ali and Abbas ibn Ali (peace be upon them). Twice a year millions of Muslims visited this site, in the tenth day of the Muharram month, (Hussein's martyrdom) and the main event is the 40th day. Most of the pilgrims travelled on foot from all around Iraq and other countries. Karbala had a desert hot climate (hot, long, dry summer and mild winter). Between November and April all of the yearly precipitation occurred, anyway no any wet month (https://ar.wikipedia.org/wiki/). Fig.1 showed study site. Hourly particulate matter $PM_{2.5}$ and PM_{10} concentrations in center of

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Karbala city collected from Karbala Environment Department. These concentrations were done using Aeroqual M60 New Zealand origin.

Fig.1: Description of Study Site.

2.2 Exposure and Risk Analysis

Exposure to particulate matter $PM_{2.5}$ and PM_{10} caused carcinogens and non- carcinogens diseases. The effects of exposure evaluated by following the standard methods used in many previous studies:

$$ID = \frac{C * IR * ET * ED * EF}{AT * BW} \quad ...1$$

ID inhalation dose (μg/kg/day), C particulate matter concentration (μg/m^3), IR rate of inhalation (m^3.day^{-1}) (14.25 m^3.day^{-1} took averaging rate of inhalation for adult male and female), ET exposure time (hr/day) (24hr/day), ED exposure duration (year) (70 year), EF exposure frequency (day/year) (365 day/year), AT average time(day) (8760 day for non-carcinogens impact and 25550 day for cancer risk) and BW average body weight (kg) (62.8 kg) , (Habeebullah et al., 2015).

2.2.1 Hazard Index

Non- carcinogens effect from exposure to particulate matter estimated as:

$$HQ = \frac{ID}{RfD} \quad ...2$$

HQ hazard index (no unit), RfD is the reference of inhalation dose (mg/kg/day) (for PM_{10} 1.1*10^{-2} mg/kg/day). (Kosowska, 2018). Reverse effect on human health occurred when HQ > 1. (de Oliveira et al., 2012).

2.2.2 Cancer Risk

Below formula used to estimate carcinogens effect from exposure to particulate matter:

$$CR = ID * SF \quad ...3$$

$$SF = \frac{RU}{IR * BW} \quad ...4$$

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CR cancer risk (no unit), SF slope factor for inhalation $(mg/kg/day)^{-1}$ and RU risk unit (0.008 $\mu g/m^3$ for $PM_{2.5}$ as EPA assumption) (Odekanle, 2020). EPA reported that range: ($10^{-4} < CR < 10^{-6}$) was acceptable, this mean if CR less than 10^{-6} no cancer risk and when CR greater than 10^{-4} cancer risk was exist (Al-Husseini, 2017).

2.2.3 Relative Risk

In relative risk analysis, environmental burden disease method was adopted with attributable fractions AF that evaluated deaths proportion which increasing from diseases such as lung cancer, cardiopulmonary and mortality. When particulate matter concentrations eliminated to 10 $\mu g/m^3$ for (PM_{10}) and 3 $\mu g/m^3$ for ($PM_{2.5}$), attributable fractions proportion decreased (Odekanle, 2020). Relative risk RR also estimated the probability of (all-cause mortality) or (lung cancer and cardiopulmonary mortality) in human exposed to more than 10 $\mu g/m^3$ of PM_{10} . Relative risk calculations divided into two categories:

a. all-cause mortality for all ages:

$$RR = \exp.[\beta(X - X_0)] \quad \ldots 5$$

X means of PM_{10} concentrations $\mu g/m^3$, X_0 baseline concentration for PM_{10} (10$\mu g/m^3$) and β risk function coefficient (0.0008; for 95% confidence interval, CI: 0.0006–0.0010) (Chalvatzaki et al., 2019).

b. lung cancer and cardiopulmonary mortality for age > 30year

$$RR = \left[\frac{(X+1)}{(X_0+1)}\right]^{\beta} \quad \ldots 6$$

X means of $PM_{2.5}$ concentrations $\mu g/m^3$, X_0 baseline of concentration, for $PM_{2.5}$ (3$\mu g/m^3$) and β risk function coefficient (0.23218;for 95% confidence interval, CI: 0.08563–0.37873) for lung cancer mortality and β (0.15515 ; for 95% confidence interval, CI: 0.0562–0.2541) for cardiopulmonary mortality.

Then found attributable fractions AF as following:

$$AF = \frac{(RR - 1)}{RR} \quad \ldots 7$$

Attributable fractions evaluated the proportion of deaths from diseases, which can be avoided if particulate matter levels reduced to 10$\mu g/m^3$ for (PM_{10}) and 3$\mu g/m^3$ for ($PM_{2.5}$) (Chalvatzaki et al., 2019). Excess risk for inhalable particulate matter can be estimated as follows:

$$ER = RR - 1 \quad \ldots 8$$

3. ANALYTICAL RESULTS AND DISCUSSION

3.1 Ambient Air Standards and Air Quality Index

Table .1 showed the statistical indices of the particulate matter ($PM_{2.5}$) and (PM_{10}) in addition to WHO standards for mean daily data. Figs.2 and 3 explained the hourly and daily means concentrations of particulate matter $PM_{2.5}$ and PM_{10} receptivity 16% of daily means $PM_{2.5}$ concentrations and 12% of daily means PM_{10} concentrations are out of WHO standards.

Table 1. Statistical Indices of the Particulate Matter and WHO Standards (WHO Air quality guidelines, 2005).

Pollutant	Statistical Indices($\mu g/m^3$)		WHO Standards($\mu g/m^3$) Daily Means (24-hour)
$PM_{2.5}$	Max.	53.825	25
	Min.	4.78625	
	SD.	15.62341	
PM_{10}	Max.	84.22875	50
	Min.	7.900417	
	SD.	23.75863	

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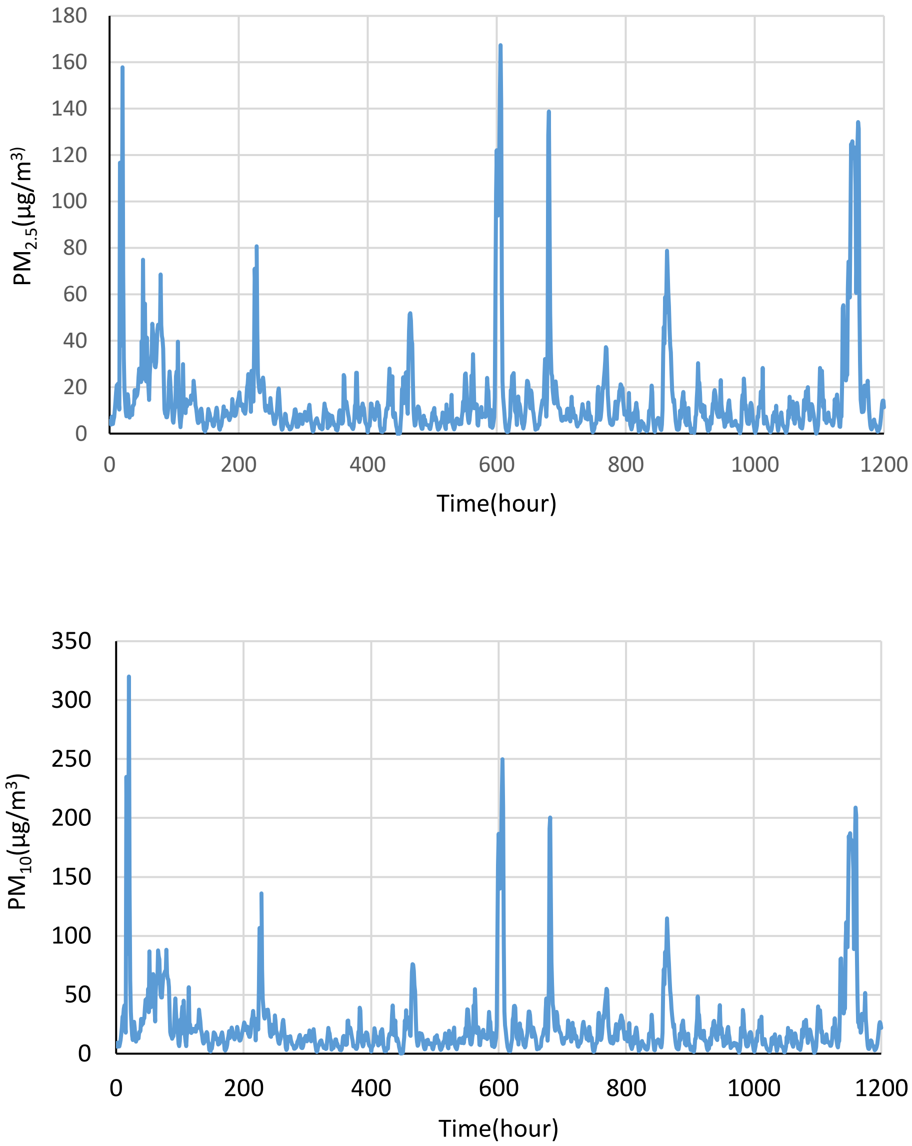
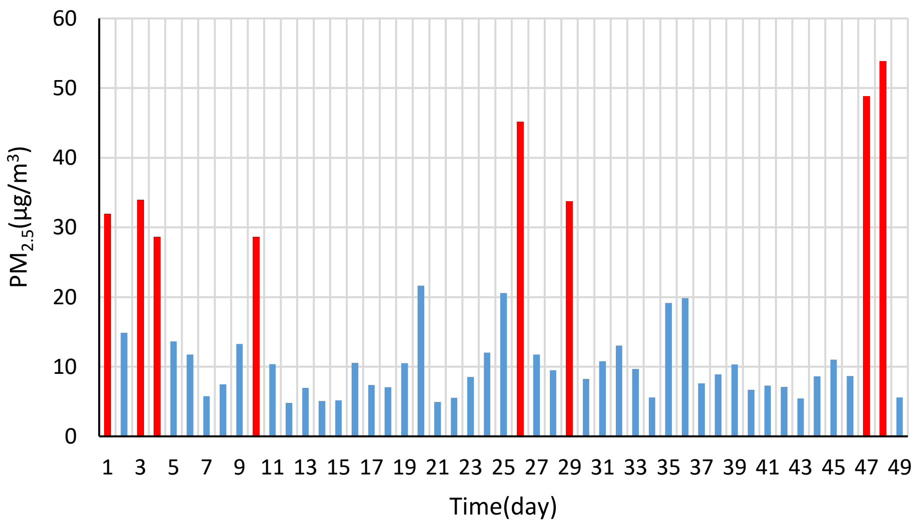


Fig.2 (a and b): Hourly Particulate Matter ($PM_{2.5}$ and PM_{10}) Concentrations from 1 June to 20 July.



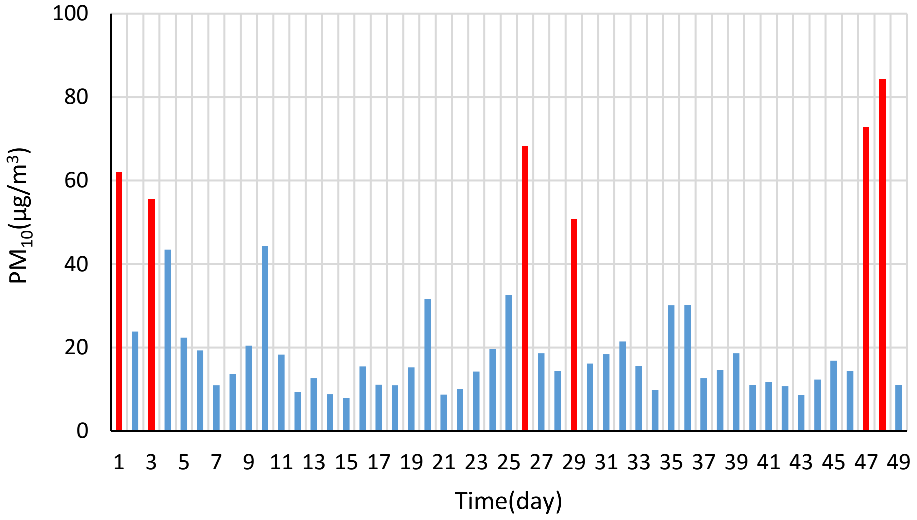


Fig.3 (a and b): Daily Means Particulate Matter ($PM_{2.5}$ and PM_{10}) Concentrations from 1 June to 20 July.

Air quality index AQI gave another indication of inhaled particulate matter PM_{10} impact on ambient air quality as recorded in Table 2. Mean daily concentrations of PM_{10} is (23.044 μg/m^3) categorized in rating B (good), no information available about PM2.5 ratings.

Table 2.Air Quality Index of Inhaled Particulate Matter PM_{10}.

Rating	PM_{10}(μg/m^3)	Category
A (0 – 15)	0 – 15	Very good
B (16 – 31)	16 – 75	Good
C (32 – 49)	76 – 100	Moderate
D (50 – 99)	101 – 150	Poor
E (> 100)	>150	Very poor

3.2 Health Risk Indices

Health risk analysis associated with carcinogenic and non-carcinogenic indices ,which described reverse effect of inhalable particulate matter on human health. First, the chronic daily intake ID was calculated for $PM_{2.5}$ and PM_{10}, and the hazard quotient HQ values were determined for PM10 only, no determined value of RfD for $PM_{2.5}$. From Fig.4 it is clear that all the calculated values are less than 1 and this means no hazard risk.

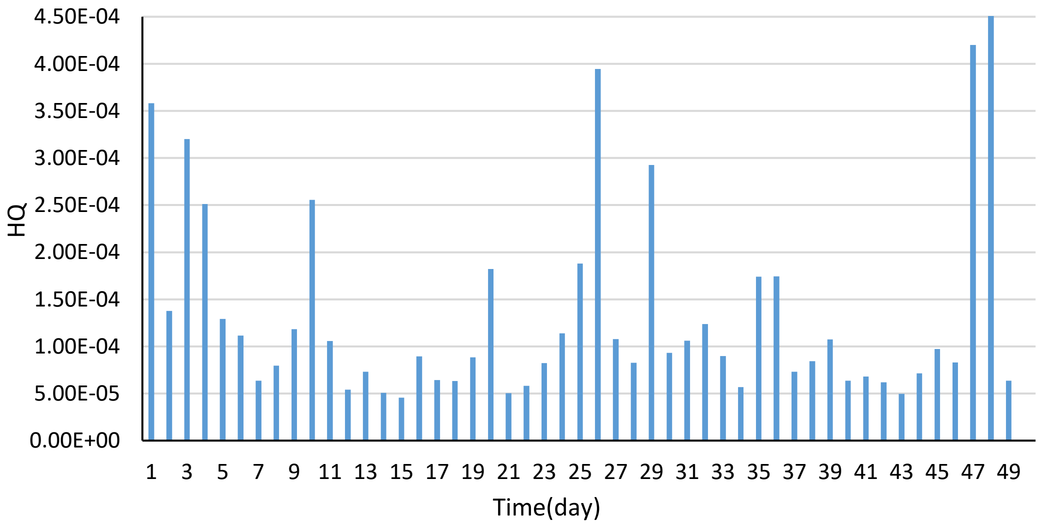


Fig.4: Hazard Quotient for Inhalable Particulate Matter PM_{10}.

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For carcinogenic effect, carcinogenic risk index CR associated with $PM_{2.5}$ concentrations are evaluated according to the equations submitted in methodology. Fig.5 showed that all determined values of CR are higher than 10^{-6} so no health threat with carcinogenic diseases by inhalation of $PM_{2.5}$.

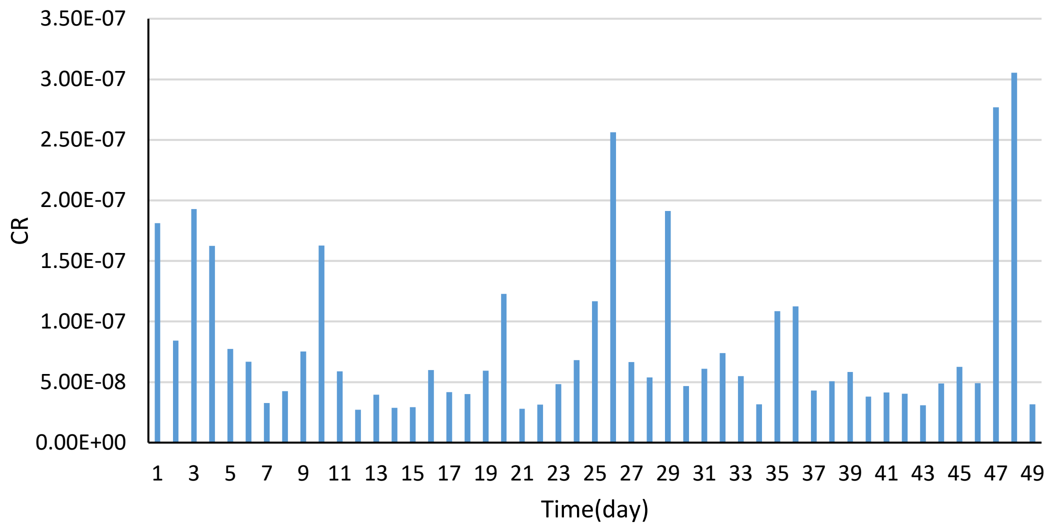

Fig.5: Cancer Risk for Inhalable Particulate Matter $PM_{2.5}$.

The summery for calculated attributable fractions AF and excess risk ER placed in Table 3. Generally, the proportions of attributable fractions AF and excessing risk ER for lung cancer mortality and cardiopulmonary mortality for long-term exposed to $PM_{2.5}$ might decreasing at about 19%, 27%, 23% and 36% respectively at 95% confidence interval if the concentrations of $PM_{2.5}$ kept at 3µg/m^3. For PM_{10} no noticeable effect exited.

Table 3: Proportions of Attributable Fractions and Excess Risk for $PM_{2.5}$ and PM_{10}.

Pollutant	AF%	ER %
PM_{10} All-Cause Mortality (For confidence interval (95%) CI: 0.0006–0.0010).	0.01	0.01
$PM_{2.5}$ Cardiopulmonary Mortality (For confidence interval (95%) CI: 0.0562–0.2541)	0.19	0.23
$PM_{2.5}$ Lung Cancer Mortality (For confidence interval (95%) CI: 0.08563–0.37873)	0.27	0.36

4. CONCLUSIONS

This paper was concerning with the airborne concentration of ($PM_{2.5}$ and PM_{10}) in center of Karbala city to assess (health risk) related with exposure to these particles. Health assessment used to evaluate this impact on human health. Results showed that this place had rating B (good) according to air quality index AQI. Hazard quotient was less than one in all days and the place is safe for carcinogenic impact. Generally, the proportions of attributable fractions AF and excessing risk ER for lung cancer mortality and cardiopulmonary mortality for long-term exposed to $PM_{2.5}$ might decreasing at about 19%, 27%, 23% and 36% respectively at 95% confidence interval if the concentrations of $PM_{2.5}$ kept at 3µg/m^3. For PM_{10} no noticeable effect exited.

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