RESEARCH ARTICLE

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Investigation of Years of Life Lost Caused by Dust Storm in Western Part of Iran

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Background & Aims of the Study: In this study, we evaluate the respiratory deaths which were caused by exposure to PM_{10} in Ahwaz, Bushehr and Kermanshah cities of Iran during 2015 by Air model Q2.2.3.

Materials and Methods: The required data gathered from the department of environment and meteorological organization in three study areas. Data were analyzed, using Excel software at the next stage with implementation of pressure and temperature correction, programming, processing (average) and filtering.

Results: The results showed that approximately 17% of respiratory deaths in Kermanshah are attributed to over 30 $\mu g/m^3$ concentration of PM_{10}, 19% of respiratory deaths in Bushehr city are attributed to concentrations over 20 $\mu g/m^3$ and 25% of respiratory deaths in Ahwaz are attributed to concentrations over 120 $\mu g/m^3$. The higher percentage of death due to this implication might be because of higher average of PM_{10} or duration of days with high concentration in Ahwaz city which were caused by recent dosage of dust in this city compared to two other cities. In accordance with the comparison of total respiratory death which is attributed to PM_{10} at three study areas in 2015 indicated that Ahwaz had the most respiratory mortalities while Kermanshah had the lowest one and the risk of respiratory deaths would increase by 1/2% with 10 $\mu g/m^3$ increase in PM_{10} concentration. The total lost years of life attributed to PM_{10} during last 10 years have been 348874 years, 43839 and 11660 in Ahwaz, Kermanshah and Bushehr, respectively.

Conclusion: Results shown Ahwaz has the largest number of lost years of life and Kermanshah had the fewest number of lost years of life.

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Background

About 90% of existing particulates in atmosphere have natural origin and the remained 10% have artificial origin (1-3). Health effects of particulates have a wide range but mostly are related to respiratory and cardiovascular systems. Although, population is affected by air pollution, intensity effect can be different according to age, health of persons and sensitivity to pollution (3,4). The rate of possible implications will be increased with increase in persons' exposure to pollution (5,6). There are few evidences on a suggested threshold without any unfavorable effect in it.

In fact, low levels of concentrations with proven unfavorable effects are not higher than mass concentration. Mass concentration is estimated to 3-5 µg/m^3 for particulate matters with a diameter equal to or less than 2.5 micron in USA and West Europe (5). Epidemiological evidences also proved unfavorable effects of suspended particles with two short-term and long-term forms. Since, there is not any determined threshold for suspended particles and resistance of persons against a determined contact is distinguished, it is impossible to determine any standard or instruction for full protection against unfavorable effects of suspended particles (3,5). Particulates are a mixture of organic and inorganic materials which are classified based on their diameters in terms of chemical nature. Although, the diameter of particulates plays an important role in diagnosing the health effects, various requirements need to be observed for such selection (1,5). The first considered parameter by air pollution experts was "total suspended particles" which numerous rules were legislated by United States World Health Organization and Environmental Protection Agency with the aim of reducing this parameter (3,5). Then, this parameter was replaced with particles which had aerodynamic diameters of less than or equal to 10 microns. Nowadays, the majority of air quality monitoring stations prefer measuring PM_{10} to other concentrations of particulate matters. Most of the epidemiological studies have also considered PM_{10} as an index (3,5). Particulate matters with aerodynamic diameter of equal to or less than 10 µm have the highest effects due to their ability to penetrate the pulmonary alveoli and these particles are divided into two categories of large size (2.5-10microns) or small (less than 2.5 microns) (1,3). Large particulates with more than 2.5 diameter are formed by mechanical processes such as re-suspension of dusts or erosion and destruction of materials and objects. Fine particulates usually are formed by combustion processes, chemical reactions or cryopreservation of gaseous materials (1,5). Both categories of particulates are existing in the majority of urban environments while their ratio is different based on geographical situation, meteorology, transportation pattern and energy consumption in different cities. Toxicity of suspended particles will be increased if there are heavy metals or arsenic in them (3-5). Particles' cleaning is treated as the first defensive line of respiratory system to protect body against harmful effects of remained particulates. The reaction of respiratory system can be distinguish based on the place in which the particle is remained (7). Macrophages exist in all parts of respiratory system and engulf particles remained in system. In fact, macrophages are white globules with diameters of 10-70 microns that metabolize the particles and bacteria during phagocytosis process (7-8). The deposited suspended particles in nose and throat are cleaned by mucosal secretions of respiratory system. The particles trapped and stopped by macrophages or mucosal layer of respiratory system would direct to upside though ciliary movement of airway cells (8). These secretions are discharged or swallowed through the mouth and nose through sneezing and coughing. It takes several hours to clean suspended particles in trachea and bronchi. A minor part of these particles can be more slowly removed. Evidences indicate that a small part of these particles travel to epithelial cells and underlying tissue. Suspended particles traveling to alveolus space would most probably engulfed by macrophages (8). Some particles that have traveled to macrophages gradually reach to terminal bronchioles then removed by ciliary epithelial lifter. Some of particles travel to regional lymph nodes through the lymphatic system and some other directly reach to blood flow (9). There have been many studies conducted on particulates' effects. An epidemiological study conducted by Winkshein et al in Buffalo Erie, New york, USA in which, the two-year average of suspended particles ate

four pollution levels reported as follows: lower than 80µg/m^3 at level 1, between 80 and 100 at level 2, 100-135 at level 3 and more than 135 at level 4. Each of polluted regions divided into five socioeconomic classes. Mortality rate was increased due to fetal factors such as respiratory diseases and gastric cancer with an increase in particulates' concentration, and the result was independent from economic situation of studied society (1,5). Morgan et al (1998) carried a study on a range of children from newborn to 15 year old and concluded that there is a relation between the concentrations of 130µg/m^3 and infectious lower respiratory system (10). World Health Organization has estimated annual cost spent over health and hygiene sector caused by air pollution in Austria, France and Switzerland to 30 billion pounds equal to 6% of total mortalities (11). Annual health cost of high concentration of particulates is estimated to 23 billion pounds in USA (12). Suspended particles which are smaller than 2.5 microns would increase mortality by 6% per 10 µg/m^3 increase in their concentrations during long-term exposures. Along with such increase, cardiovascular diseases will increase by 12% and lung cancer by 14% (13).

Aims of the study:

The purpose of this study was the estimation of respiratory deaths which were caused by exposure to PM_{10} in Ahwaz, Bushehr and Kermanshah cities of Iran during 2015, by used Air model Q2.2.3.

Materials & Methods

Methods

The present research has been conducted to quantify and compare respiratory deaths attributable to PM_{10} between three cities of Ahwaz, Kermanshah and Bushehr based on the model in 2015, using information which were derived from Environment Protection Organization. In this regard, the required raw data collected from Environment and Meteorological Organization, then, data were analyzed through EXCEL software and they were entered into AIR Q Model. To estimate the years-of-life-lost (YLL), second part of model called Life Table was applied. This model is a valid and a reliable model which was introduced by World Health Organization in order to estimate short-term effects of air pollutants.

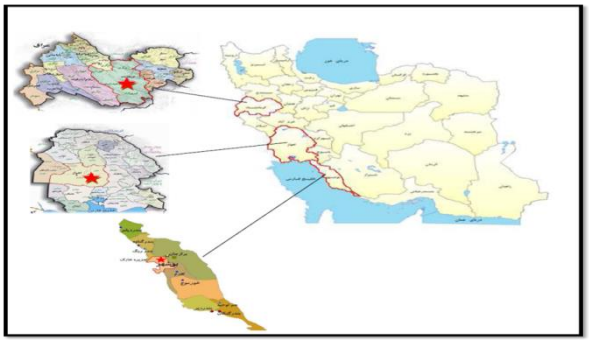

Figure 1) Map of study areas (Ahwaz, Bushehr, and Kermanshah)

Research implementation steps are as follows:

Data collection

Information which were related to the concentration of PM_{10} in 2015 were taken from Environment Organization of Ahwaz, Bushehr and Kermanshah in form of Excel file.

Providing input-file of model, using raw data;

To prepare this file, following steps were done, respectively:

Temperature and Pressure correction and unit compliance with the model

Since the data, which were obtained from Environment Organization of Ahwaz, Bushehr and Kermanshah are raw and obtained from direct reading instruments, the initial raw data changed to data based on pressure and temperature of measurement point and a new file was created to obtain the required unit.

Primary process

This stage consists of removal, sheet classification of pollutants and time integration for average estimation.

Secondary process

This stage consists of three parts including coding, mean calculation and condition modification.

Coding

Coding depends on pollutant type and considered mean. For instance, if the data of PM_{10} and daily average are considered, the command Left (Ax; 5) is inserted in cell one located at right-hand column beside PM_{10}, and is generalized to remained cells.

Calculation of daily average based on coding

As mentioned in coding, the written command is different based on the type of pollutant and considered average type. IF (B26<>B27; AVERAGE (C3:C26)) is a sample of this command that means: if the number in cell B26 (row 26 column B) is not equal to number in cell B27 then the average of C3-C26 should be calculated.

Condition modification

For instance, the modification of above command in cell in front of adjacent column will be IF (B26<>B27, AVERAGE (D3:D26)). The result will be rows including daily averages while the other rows consist of incorrect (Error) word.

Primary filtering

At this stage, we select item Sort & Filter, then select filtering command. The obtained result of this command will be 365-366 numbers that each of them shows the average of each day. The new file is saved with the name of "Intermediate".

Secondary filtering

This time, we activate auto-filter for Intermediate file then filtering is done for model between demanded concentrations' distances.

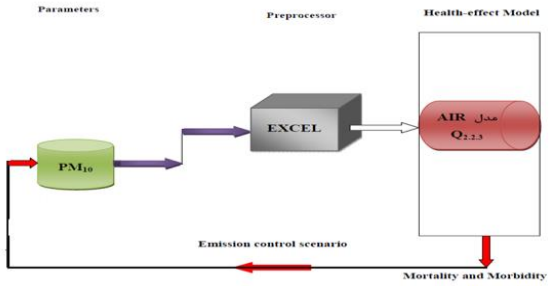

Figure 2)A view of research

Results

This part of study represents the results which are obtained from the quantification of PM_{10} in percent, states options of each implication in form of tables in Ahwaz, Bushehr and Kermanshah, 2015.

According to the calculated relative risk in table 1, cumulative number of death cases caused by PM_{10} obtained to 164 members in Ahwaz, 2015.

According to the calculated relative risk in table 2, cumulative number of death cases caused by PM_{10} obtained to 94 members in Kermanshah, 2015.

Table 1) Estimation of relative risk indexes, attributed component, and cases attributed to PM_{10} for deaths caused by respiratory diseases (BI=66) (Ahwaz, 2015)

estimation index	relative risk (average)	attributed component	cumulative number of cases
low	1.008	18.6568	119.3
average	1.012	25.5974	163.7
high	1.037	51.4748	329.2

Table 2) Estimation of relative risk indexes, attributed component, and cases attributed to PM_{10} for deaths caused by respiratory diseases (BI=66) (Kermanshah, 2015)

estimation index	relative risk (average)	attributed component	cumulative number of cases
low	1.008	11.8809	66.1
average	1.012	16.8220	93.6
high	1.037	38.4976	213.7

According to the calculated relative risk in table 2, cumulative number of death cases caused by PM_{10} obtained to 94 members in Kermanshah, 2015.

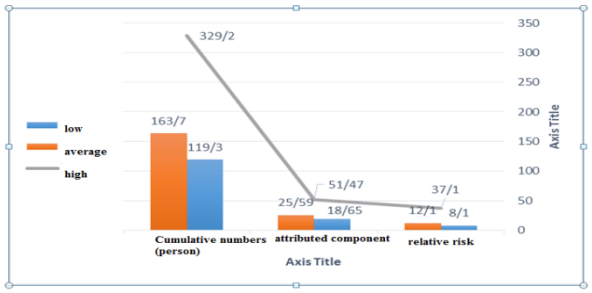

Figure 3) Estimation of cumulative number of deaths caused by respiratory disease attributed to PM_{10} in Ahwaz, 2015

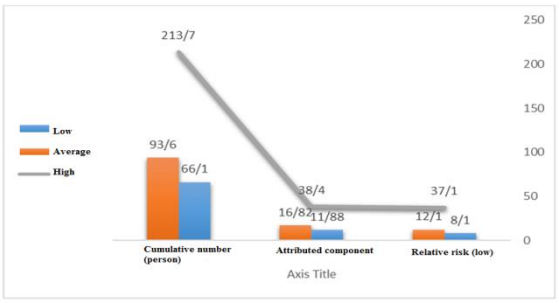

Figure 4) Estimation of cumulative number of deaths caused by respiratory disease attributed to PM_{10} in Kermanshah, 2015

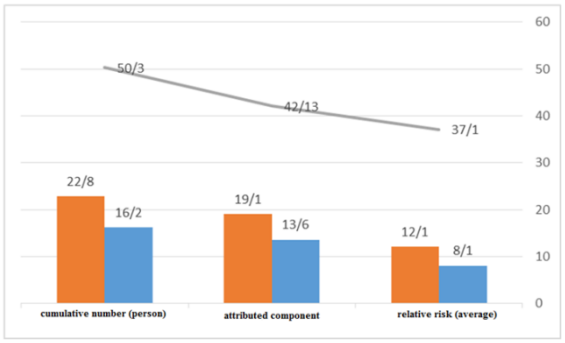

Figure 5) Estimation of cumulative number of deaths caused by respiratory disease attributed to PM_{10} in Bushehr, 2015

Table 3) Estimation of relative risk indexes, attributed component, and cases attributed to PM_{10} for deaths caused by respiratory diseases (BI=66) (Bushehr, 2015)

estimation index	relative risk	attributed component	cumulative number of cases
low	1.008	13.6021	16.2
average	1.012	19.1039	22.8
high	1.037	42.1343	50.3

Discussion

Quantification of PM_{10} effects on death caused by respiratory disease in Ahwaz City: According to the calculated relative risk of cumulative number of respiratory death cases caused by PM_{10}, it was estimated to 164 members per annual in Ahwaz city which hasbeen increased by 49 members compared to 2014. 28% of this death has been occurred during days with lower than 400µg/m^3 concentration. In figure 3, sharp slope of curve related to RR=1.012 implies the largest number of death cases (32 members) at this area (>400µg/m^3) while this region (200-250µg/m^3) has second rank in terms of respiratory death (21%). Upward and downward curves illustrated in figure have the sharpest slope at these areas. The subtle slope observed at concentration distance of 10-160 µg/m^3 with the lowest number of respiratory death cases is coordinated with this range. Obviously, subtle decrease or lowest level of respiratory death cases corresponds to intensive decrease in percent of person per day; in other words, this percent indicates few days of exposure to such concentration range in Ahwaz.

Quantification of PM_{10} effects on death caused by respiratory disease in Kermanshah city

According to the calculated relative risk of cumulative number of respiratory death cases caused by PM_{10}, it was obtained to 94 members per annual in Kermanshah city. 74% of this death has been occurred during those days with lower than 250µg/m^3 concentration. In figure 4, sharp slope of curve related to RR=1.012 implies the largest number of death cases (24 members) at this area (200-250µg/m^3). Upward and downward curves illustrated in figure have the sharpest slope at these areas. The subtle

slope observed at concentration distance of 10-160 µg/m^3 with lowest number of respiratory death cases is coordinated with this range. Obviously, subtle decrease or lowest level of respiratory death cases corresponds to intensive decrease in percent of person per day; in other words, this percent indicates few days of exposure to such concentration range in Kermanshah.

Quantification of PM_{10} effects on death caused by respiratory disease in Bushehr city

According to the calculated relative risk of cumulative number of respiratory death cases caused by PM_{10}, it was obtained to 23 members per annual in Bushehr city. 60% of this death has been occurred during those days with lower than 300µg/m^3 concentration. In figure 5, sharp slope of curve related to RR=1.012 implies the largest number of death cases (6 members) at this area (>400 µg/m^3) and the area of (200-250 µg/m^3) is at the second rank having 4 members. Upward and downward curves illustrated in figure have the sharpest slope at these areas. The subtle slope observed at concentration distance of 10-160 µg/m^3 with lowest number of respiratory death cases is coordinated with this range. Obviously, subtle decrease or lowest level of respiratory death cases corresponds to intensive decrease in percent of person per day; in other words, this percent indicates few days of exposure to such concentration range in Bushehr.

According to the conducted studies in 29 European cities and 20 American cities and some Asian cities, health effects which are related to short-term exposure to PM_{10} are similar among different cities of developing and developed countries, and risk level of respiratory death will be increased by 0.5% per 10µg/m^3 increase in daily concentration of PM_{10}. Therefore, 150µg/m^3 concentration means 5% increase in daily death (14). Carried out studies and meta-analyses with the aim of determining effects of short-term exposure on respiratory death indicated that a 10 µg/m^3 increase (with confidence intervals to 95%) (15) leads to effect obtained to 1.7% (1.1-2.3%) in Bangkok (16), 1.83% (0.9-2.7%) in Mexico city (17), 1.1% (0.9-1.4%) in Santiago (18), 0.8% (0.2-1.6%) in Inchen (19), 1.6% (0.5-2.6%) in Brisbane, Australia (20) and 0.95% (0.32-1.6%) in Sidney (21). Some reports have been presented about the estimation of mortality which are associated with PM_{10} or TSP in Shin Yang in China, seven cities in South Korea and New Delhi of India. It can be observed that these studies have been done in cities vary with a broad range in terms of different conditions such as population, climate, smoking level, houses chimneys, occupational exposure, social-economic situations and PM_{10} concentration (22). Therefore, generalization of existing information to other areas might be logical. For instance, conducted studies in Mexico City, Bangkok and Santiago reported the average concentration in these cities to 45, 65 and 115 µg/m^3, respectively; also, the maximum concentrations were equal to 121, 227 and 360 µg/m^3. Nevertheless, the equation of concentration possibly is not linear in more polluted cities (23). Therefore, the presumption of linearity should be taken cautiously. In total, these studies create reliable evidences on the considerable role of PM_{10} in increase of mortality. Although, the relative risk for each person is low but when a large number of people are exposure to PM_{10}, there would be a significant effect of this pollutant on general health (24). Swartz conducted a study on a regression model on air pollution in 10 cities of USA and estimated relative risk among people who were older than 65 equal to 2% per 10µg/m^3 increase in PM_{10} (26). In 2005, Tominz et al applied Air Q model to estimate health effects of PM_{10} in Trieste, Italy. According to the results which are obtained from this study, 2.5% of respiratory deaths attributed to concentrations of more than 20µg/m^3 (25). Goodarzi et al (2007) used Air Q model in order to estimate the health effect of PM_{10} in Tehran, Iran. According to the obtained

results of this study, 4% out of total respiratory deaths attributed to more than 20µg/m^3 concentrations (27). Mohammadi et al (2009) also applied Air Q model with the aim on estimating health effects of PM_{10} in Ahwaz. According to the obtained results of their study, 13% of respiratory deaths attributed to more than 180µg/m^3 concentrations (28). The same model was used at the present study and the comparison of obtained results in Ahwaz, Bushehr, Kermanshah, Tehran and Trieste indicates that 17% of respiratory deaths in Kermanshah are attributable to more than 30µg/m^3 concentrations. In Bushehr, about 19% of respiratory deaths are attributable to more than 20 µg/m^3 concentrations. In Ahwaz, about 25% of respiratory deaths are attributable to more than 120 µg/m^3 concentrations. The higher average of PM_{10} or the higher concentration due to current dusts, the higher the mortality rate will be. According to the comparison of respiratory death attributed to PM_{10} at three study areas in 2015, it was proven that Ahwaz had the most respiratory losses and Kermanshah had the lowest respiratory losses. Studies over these regions indicated that the respiratory death risk will increase by 1.2% per 10 µg/m^3 increase in PM_{10} concentration.

Conclusion

Based on the result of this study, in accordance with the age structure of population, mortality statistics and long-term (10-years) concentration of PM_{10} (224 µg/m^3) in Ahwaz city, life expectancy for citizens of this city is 55. Expected lifetime for a 20 years old person is equal to 39. It is expected to lose 10 years of life with an average of 20 years living in Ahwaz. Years of life lost in last 10 years for total population of Ahwaz has been equal to 348874 because of excessive concentration of PM_{10} compared to base level. Also, in accordance with the age structure of population, mortality statistics and long-term (10-year) concentration of PM_{10} (110 µg/m^3) in Kermanshah city, life expectancy for citizens of this city is 74. Expected lifetime for a 20 years old person is equal to 57. It is expected to lose 3 years of life with an average of 20 years living in Ahwaz because of remained pollution in city. Years of life lost in last 10 years for total population of Ahwaz has been equal to 43839. According to the result of our study about the age structure of population, mortality statistics and long-term (10-year) concentration of PM_{10} (134 µg/m^3) in Bushehr city, life expectancy for citizens of this city is 74. Expected lifetime for a 20 years old person is equal to 58. It is expected to lose 3 years of life with an average of 20 years living in Bushehr because of remained pollution in city. Years of life lost in last 10 years for total population of Bushehr has been equal to 11660 because of excessive concentration of PM_{10} compared to base level.

Footnotes

Conflict of Interest:

The authors declared no conflict of interest.

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