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Research Article

Experimental investigation for the decisive role of vehicles in the air pollution of arak city in Iran and presenting the related solutions to reduce the air pollution

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ABSTRACT

In the World, in many of the large and industrial cities air quality is in a dire situation, and air pollution is considered a major problem. The first step in reducing the level of pollutants is to acquire enough detailed information about these pollutants, including the type, amount, and the rate of annual occurrence. In this study, the data obtained from the existing air quality measuring stations throughout the city of Arak in Iran have been used to conduct an accurate investigation and to perform hourly, daily, monthly, and annual analyses of various pollutants. The hourly analysis of the data collected from the Shariati square station at the downstream of the prevailing wind, which include the collective pollutions of the refinery, petrochemical plant, thermal power plant and the pollution generated by the vehicles in a high-traffic area, with regards to the annual calendar and the variation of pollutants during official holidays, indicates the determining share of vehicles in the air pollution of the city of Arak. Considering the effective role of vehicles in the extensive air pollution of this city, some policies have been suggested for reducing the level of air pollution. As a result of this study, using the stated transportation model the level of pollution in this city is considered to reduce, correcting the city streets and routes from engineering perspective. Also, results showed that the role of industry and vehicles on the air pollution and the pollution points in Arak city in ratio. The levels of all the pollutants like CO, NOx, PM2.5, O3 and SO2 measured by a station at the downstream and resulted about 3ppm, 20ppb, 10, 40ppb and 4 as a ratio respectively. Lastly, result of model was reported at the end of this paper in term of the optimization of the Arak city residential area.

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INTRODUCTION

Industrial development and technological progress have raised the standard of living in human societies and have achieved great accomplishments. But unfortunately, during the implementation of these industrial projects, industrial wastes and contaminants in the form of unwanted, and sometimes harmful, compounds are released into the environment, which leave many adverse and detrimental effects

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on the ecosystem. The phenomenon of air pollution is one of those consequential effects of industrial development; which is getting worse on a daily basis because of the population growth, spread of urbanization, and a higher consumption of fossil fuels.

Air pollution refers to the "presence of harmful substances, in excess of the natural compounds that exist in the atmosphere, which are produced by natural processes or manmade activities [1]. In recent years, this environmental calamity has always been pointed out as a major cause of death in different parts of the world. According to the World Health Organization (WHO) reports, air pollution has been responsible for one-eighth of the deaths in 2012 [2].

Air pollution sources can be divided into natural and artificial (manmade) sources, as follows:

a) Natural sources:
- Volcanic activities and woodland fires
- Natural dust and particulate matter
- Smug and carbon monoxide (CO) resulting from fires
- Radon gas emitted by earth minerals
- Organic compounds released by pine trees

b) Artificial sources:
- Motorized vehicles
- Factories and industries
- Home heating systems

The sources of air contaminants are generally divided into fixed and moving sources. The fixed sources, as the name suggests, include the industries, power plants, and the commercial and residential facilities; and the moving sources consist of various types of vehicles such as motorcycles, aircrafts and ships.

The US Environmental Protection Agency (USEPA) has selected six major pollutants as the index and standard pollutants and has divided them into the primary and secondary groups. The primary pollutants are the substances that enter the environment directly from the generating sources. They include carbon monoxide (CO), nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), particulate matter (PM) and lead (Pb). The secondary pollutants are the substances that are produced by the existing reactions in the Earth's atmosphere. Ozone (O_3) belongs to this group [3]. Carbon monoxide is a colorless, odorless, and very toxic gas, which is mostly produced through the incomplete combustion of fossil fuels [4]. Carbon monoxide forms when there is insufficient oxygen for the combustion of organic materials. This gas affects the human body through the oxygen carrying capacity of the blood. Due to its low solubility, CO easily reaches the aloules along with the oxygen, diffuses through them and competes with oxygen in occupying one of the four iron atom sites in the hemoglobin molecule. The affinity of the iron atom for bonding with CO is 210 times its affinity for oxygen. The outcome of this substitution and bonding is the formation of carboxy hemoglobin (COHb), a compound that reduces the capacity of the blood for transporting oxygen and adversely affects the central nervous system. Exposure to this gas causes blurred vision, reduces the power and stamina to do work, diminishes the ability to learn, and leads to headache, weakness, nausea and overexertion. With the rise in the concentration of this gas, and consequently the increase in the amount of carboxy hemoglobin, coma and even death may ensue [5] [6]. Interestingly, the transportation sector has the highest production share of this contaminant in large cities; such that the amount of CO goes up with the increase in the number of vehicles in different parts of a city. According to WHO estimates, roughly, 2600 million tons of CO per year is produced in the world, of which 60% is generated through human activities [2]. The concentration of carbon monoxide in city zones depends on the traffic load and also varies with different climatic conditions. The non-vehicular sources of carbon monoxide include the industrial furnaces and torches, water heaters, de-coloring agents (such as methylene chloride), pool heaters, any kind of fire smoke, cooking stoves, tobacco smoke, and fireplaces [7].

The oxides of nitrogen are considered important pollutants in many human societies, and millions of tons of these materials enter the atmosphere annually. These oxides are produced at high combustion temperatures of fuels, as the nitrogen in the air combines with oxygen. The other sources for the generation of nitrogen oxides include the industries involved in nitric acid production, internal combustion engines, thermal power plants and the fuel burning units in various industries. Nitrogen dioxide, which is generated by motorized vehicles and industries that use internal combustion engines and which diffuses into the air more than the other oxides of nitrogen, is a brown-colored and foul-smelling gas. This gas causes the irritation and watering of the eyes, coughing, chocking, headache and severe fatigue, and it reduces body's resistance against infections. It also damages the plants considerably [8] [9].

Sulfur dioxide (SO_2), a colorless gas, enters the atmosphere through natural sources such as volcanoes, and also through the activities of human beings. The major source of this gas is the combustion of diesel and fuel oil at homes and factories and in motorized vehicles. Some fossil fuels like coal and heavy oil products (furnace and gas oil) contain large amounts of sulfur, which, during combustion, disperses into the air in the form of SO_2 gas. The major sources for the emission of this pollutant include the power plants, factories, residential areas and the diesel vehicles that mostly utilize the mentioned fuels. This contaminant is found at low concentrations in urban environments and at high concentrations in industrial environments [10] [11] [12]. Sulfur dioxide (SO_2), which is emitted into the air more than the other oxides of sulfur, is a colorless and malodorous gas, which raises the heart and breathing rates, adversely affects the cardiovascular diseases and, at high concentrations, constricts the respiratory capacity and irritates the throat and respiratory tracts [8] [13] [14]. It can also cause lung cancer (Ghias-aldin et al., 2001; Matsumoto et al., 2007; Hwang et al., 2007; Soll-Johanning et al., 1998), kidney cancer (Soll-Johanning et al., 1998), bladder cancer [13] [15] [16] [17], prostate cancer [18], skin cancer [17], chronic bronchitis, asthma and emphysema. This gas prevents the growth of white blood cells and thus weakens the body's immune system, and can sometime affect and alter the hereditary mechanism (Nevers, 2000). It can also lead to the increase in the number of underweight newborns [19] and increase the incidents of miscarriage and stillbirth in pregnant women [20]. The adverse effects of this pollutant on humans and the ecosystem are intensified in the presence of suspended particles and humidity [21]. When SO_2 combines with the water vapor present in the air, it turns into an acid; and the precipitation of this acid rain causes the corrosion of metals, rocks and fabrics. This gas damages and destroys the plants and adversely affects the construction material and the useful life of buildings [21] [22].

Particulate matter includes a mixture of very fine particles and liquid droplets. The constituent components of particulate matter include the acids (such as nitrates and sulfates), organic and chemical substances, metals, and dust. The size of these particles has a direct bearing on the health and sanitary problems that are caused. These particles easily diffuse deep into the lungs through the mouth and nose. Particulate matter consists of a large number of genotoxic substances which, once inhaled, can adversely affect the heart and the lungs and seriously compromise the health of an individual [23] [24]. The World Health Organization has reported that the culprit in about 6% of the deaths resulting from air pollution is the particulate matter, half of which is generated by motorized vehicles [25]. Investigations have indicated that in the city of Ahwaz, in 2010, almost 17.5% of the total death count has been due to the exposure to particulate matter with particle sizes equal to or smaller than 10 μm [26]. Scientific studies have shown that exposure to particulate matter pollution can cause be the cause of numerous maladies including irregular heartbeat, cardiovascular diseases, respiratory illnesses such as bronchitis and asthma, reduction of lung efficiency, lung cancer and premature death [27] [28] [29] [30]. The WHO has reported that for every 10 μg increase in particulate matter, the death rate increases by 1-3% [31].

Heavy metals including arsenic, iron, zinc, lead, cadmium, chrome, copper, manganese and nickel are considered to be very harmful and toxic for biological life. After entering the body, these elements are not expelled; they precipitate in tissues such as fats, muscles, bones and joints, and cause a variety of illnesses; this process in technically known as "un-metabolization" [32] [33]. The accumulation of these elements in the bodies living creatures can causes severe and chronic intoxications and serious diseases including nervous disorders, nutrient deficiency, hormonal imbalance, obesity, miscarriage, respiratory and cardiac arrhythmia, liver and kidney disorders, allergy and asthma, chronic viral infections, reducing the threshold of body resistance, infertility, anemia and fatigue, weakening of the body's immune system, gene damage and destruction, premature aging, memory loss, osteoporosis, hair loss, insomnia, various cancers and death [34] [35] [36] [37].

This pollutant is not dispersed directly into the air, but is produced by the chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight; thus, the amount of ozone produced in summer and in the middle of the day is higher than that at other times [38]. Ozone forms when the pollutants emitted by vehicles, power plants, refineries, chemical factories and other sources react in the presence of sunlight. In our country, and especially in large and industrial cities and adjacent regions, the conditions of severe air pollution and the existence of primary polluting gases, and also the high number of sunny days throughout the year, easily prepare the groundwork for the photochemical oxidation reactions that result in the generation of ozone gas. Due to its oxidative properties, ozone has many industrial applications; and, on the other hand, at concentrations higher than 100 *ppm*, it has a severe damaging effect on the respiratory organs and mucous membranes of animals and on the plant tissues. Thus, ozone at ground level is considered as a major pollutant of air. Exposure to this gas can cause respiratory maladies such as lung capacity reduction and lung disorders, asthma, nose congestion and other complications such as eye irritation and the diminishing of body's immune system against infectious diseases [39] [40] [41] [42]. Ozone enters the body mostly through breathing; 40% of it is usually absorbed in the nose and throat region and the remaining 60% penetrates deep into the lungs [43]. The devastating properties of ozone are not just confined to humans, but also affect the plants. Although ozone mostly forms in the ambient atmosphere of cities and suburbs, in the rural areas away from the industrial regions and polluted cities, the formation of tropospheric ozone is also plausible due to the blowing of counter winds and the traffic of cars and trucks.

In view of what was said, air pollution is considered a great threat to human life; and this threat is felt more in major cities and metropolises, because of the more extensive and concentrated industrial activities and city transportation systems. In recent years, with the installation of measuring devices within major cities, it has become possible to analyze the air quality, compare the obtained data against clean standards, and to easily find out the pollution or cleanliness of air in every examined city and region. However, the more important issue is, in case the air in a city is polluted, what is the root cause of the pollution, and what factors are involved in the pollution of a city or region. Since different industries have been concentrated in the city of Arak, a high degree of pollution is observed in the city. The first step that should be taken in the framework of a comprehensive plan for the reduction of air pollution in this city is that, by carefully studying the data recorded by the measuring devices throughout many years, the effective factor/s for air pollution must be determined. In this research, by analyzing the levels of all the pollutants in the city of Arak, between the years of 2011 and 2014, it is attempted to examine the pollution condition and to determine the influential factors of air pollution in this major city.

Arak City

Arak is one of Iran's major cities and the capital of the Markazi Province. In the year 2011, Arak had a population of 526,182 and was considered as the fourteenth most populous city in Iran. Arak has an altitude of 1708 m from the sea level and is situated at the E49°46' longitude and N34°06' latitude. It has an average annual rainfall of 8,311 mm, with the maximum rainfall of 8,485 mm occurring in the agricultural year of 1992 and the minimum rainfall of 4,154 mm occurring in the agricultural year of 1998. The mean temperature of Arak City is 14.0 °C, with the month of July (with a mean temperature of 27.1 °C) being the warmest month and the month of January (with a mean temperature of 0.0. °C) being the coldest month of the year. The average annual humidity of Arak is 46%, with the month of December (with an average humidity of 68%) being the most humid month and the month of August (with an average humidity of 27%) is being the driest month of the year. The prevailing wind directions in this city are from the West and Southwest; and the highest wind speed (123 km/h) has been recorded for the month of February in 1984 and also for the month of May in 2006. Based on the classification of Dumbarton, the city of Arak has a semiarid climate, and based on the classification of Amberge, it has a dry and cold climate [44] [45].

The geographical position of Arak City plays a significant role in the air pollution condition in this city. Arak is situated at an altitude of 1708 *m* from the sea level, and this is a very important factor in the generation of certain pollutants, like benzene; because the major underlying cause of this pollutant is the incomplete combustion of fuel in vehicles, which is greatly affected by altitude. The Markazi Province is affected by local winds from different directions, arising from the flow of high-pressure currents from central Asia to the currents of the Indian and Pacific Oceans and the Mediterranean Sea. Most of the time, the prevailing direction of wind blowing over the city of Arak is from the Shazand-Malayer terminal towards the center of the city. Because of its climatic characteristics and being surrounded by highlands, and because of a desert (Mighan lagoon) located 5 *km* to the Northeast, Arak is a source of dust in the summer and a source of fog in the winter. Also, the phenomenon of temperature conversion in the fall and winter seasons and the lack of effective atmospheric currents to disperse the pollutants have naturally made Arak susceptible to the conditions of air pollution stabilization; and because of the improper city development, growth of population in the last several decades, establishment of large companies and the activities of heavy industries at the outskirts of the city, and because of the expansion of transportation and traffic, Arak has become one of the eight most polluted cities in Iran.

Some of the industries operating in the city of Arak include heavy industrial units such as the aluminum smelting factory, companies of Mashin Sazi, Hepco, Azar Aab, Pars Wagon and Avangan, petrochemical, refinery and thermal power plants, as well as polluting units such as brick making kilns and foundries which operate in the neighboring areas to the city of Arak.

In the last decade, more than 80% of the industries established in the province have been concentrated in industrial townships and prevented from dispersing in agricultural lands and other parts. The smokestacks of the refinery, petrochemical plant and the thermal power plant near Arak emit different combinations of hydrocarbons into the city air, in addition to the major pollutants. The travels of a large number of vehicles in the narrow streets of Arak, the existence of many intersections throughout the city and a heavy traffic in the downtown area also constitute the major sources of air pollution in the city. In fact, the factors of climatic condition, vehicular traffic, population, and resident industries have made Arak one of the 8 most polluted cities in the country. Fig. 1 shows the city of Arak next to the Mighan Lagoon [46].

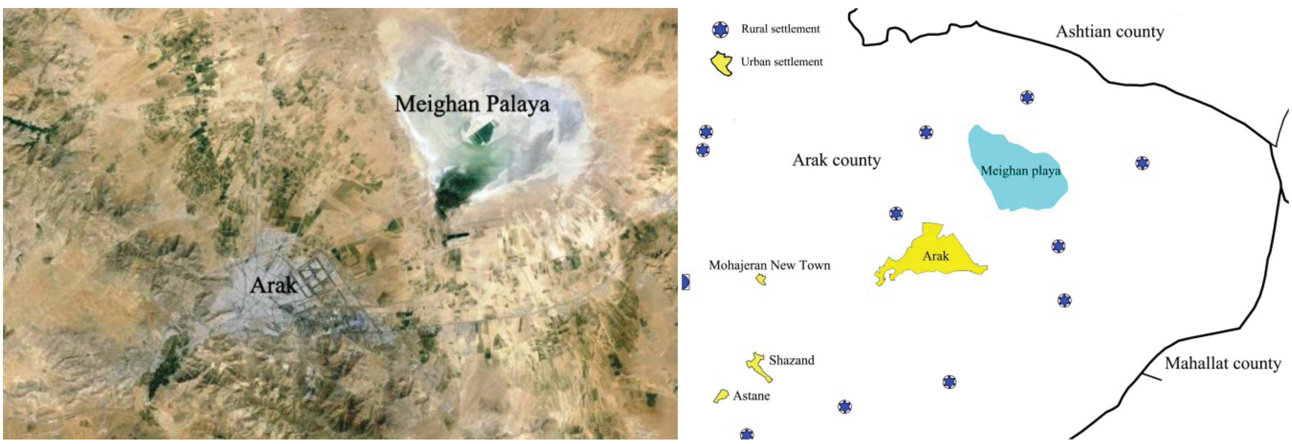

Figure 1. Map of the city of Arak.

MATERIALS AND METHODS

In this research, the data collected by the air measuring stations in the city have been analyzed; but since, with the consideration of the prevailing wind direction and city traffic, the station in Shariati Square has been so situated as it adequately reflects the mutual effects of vehicles, industries, as well as natural phenomena in the parameters it measures, the data collected by this unit have been mostly analyzed in this paper. Fig. 2 shows the position of this station (Google earth, 2015).

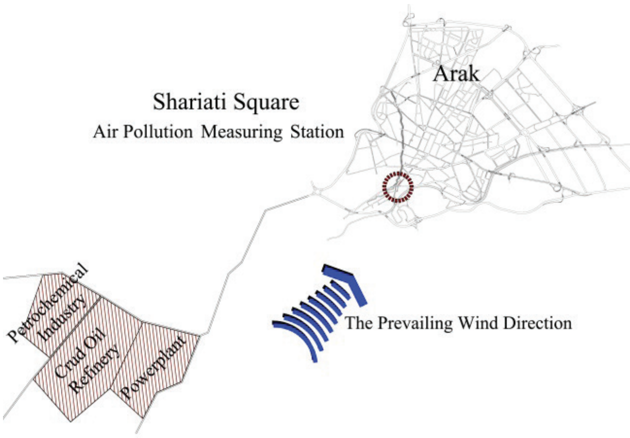

Figure 2. Position of the air pollution measuring device, Shariati station.

RESULTS AND DISCUSSION

The daily levels of SO2 in July (2013) is shown in Fig. 3. According to this figure, from 6 till 9 o'clock in the morning, the diagram for this pollutant has a rising trend and then it falls. Around the noon, it increases a little and then declines; until about 6 in the afternoon, at which time the diagram rises again, and at the end of the night, the quantity of this pollutant diminishes. Factories and city traffic affect the production of this contaminant.

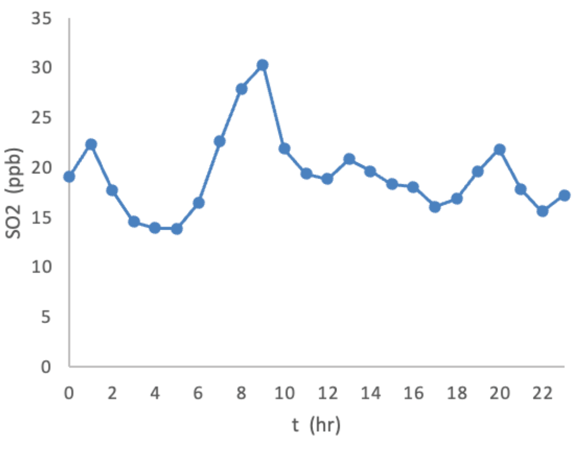

Figure 3. Daily levels of SO_2 in July (2013).

The generated amounts of this pollutant in different seasons have been presented in Fig. 4. This pollutant is produced in almost equal amounts during the spring, summer and fall seasons; and its maximum 24-h amount is less than the permitted limit of 37 *ppb*. In the winter of 2014, the amount of SO_2 has increased and even surpassed the permitted limit. The considerable increase of this pollutant in the winter of 2014 is due to the utilization of fuel oil as a substitute fuel in this season by the power plant adjacent to Arak. Fig. 5 indicates the number of unhealthy days due to the excessive quantities of SO_2. It seems that the industries play a major role in increasing this pollutant; and by utilizing more appropriate and cleaner fuels for power plants and others, the city of Arak will be able to experience fewer unhealthy days as a result of SO_2 pollution.

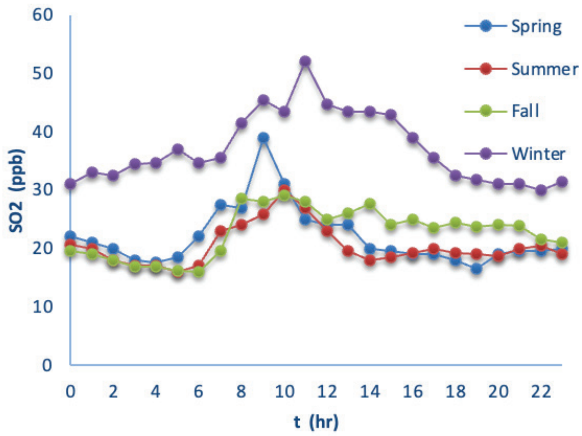

Figure 4. Seasonal averages of SO_2 in 2013.

In view of Figs. 6 and 7, a considerable increase in the amount of ozone is observed around the hours of 11 till 17. As was explained in the section related to pollutants introduction, ozone results from the reaction between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. In the mentioned hours, we have the most intense sunlight, and the increase of this pollutant at these hours can be attributed to the effects of sunlight and vehicles on this contaminant.

Fig. 7 illustrates the 8-hour average amounts of this pollutant based on the information in Fig. 6. It is obvious that the daily average amount of this pollutant in the second 8-h period exceeds the permitted limit. The seasonal values of ozone, sketched in Fig. 8, well indicate that the amount of this pollutant increases considerably in the spring and summer seasons, due to the higher intensity of sunlight. It was said earlier that ozone is classified as a secondary pollutant, and that its constituent components are the oxides of nitrogen (NO_x) and volatile organic compounds (VOCs), both of which are mainly generated by motorized vehicles.

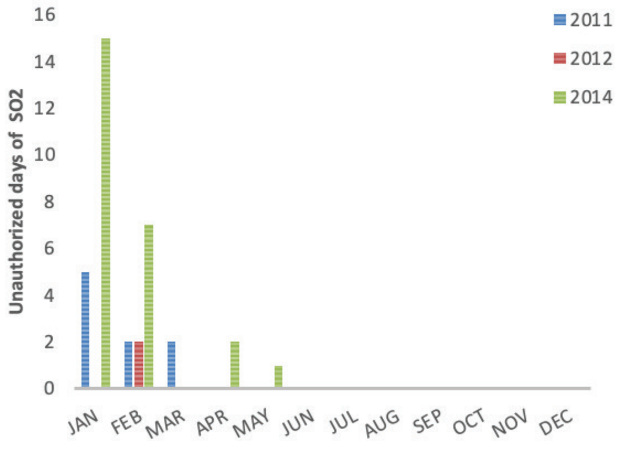

Figure 5. Comparing the number of days on which the SO_2 concentration exceeds the permitted levels.

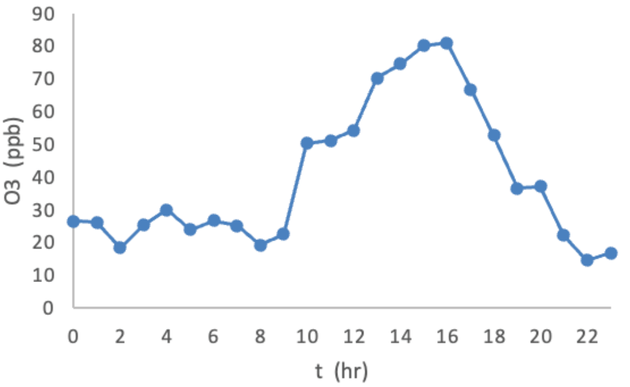

Figure 6. Daily levels of Ozone in the month of July (2013).

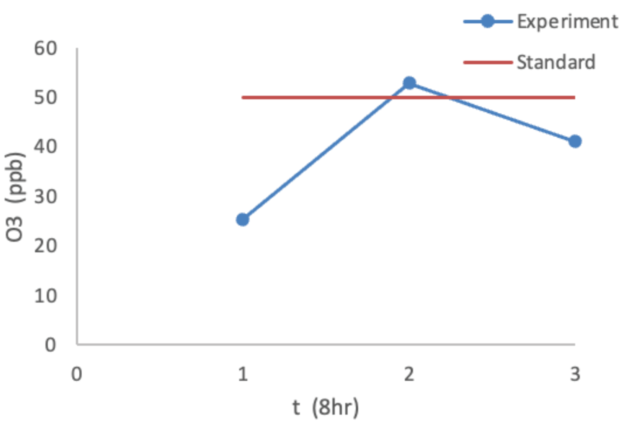

Figure 7. 8-hour levels of Ozone in July (2013).

According to Fig. 9, as the number of vehicles rises in the early morning, the amount of this pollutant increases; and as we approach the evening and rush hour times and the traffic gets heavier, the level of this pollutant increases once again.

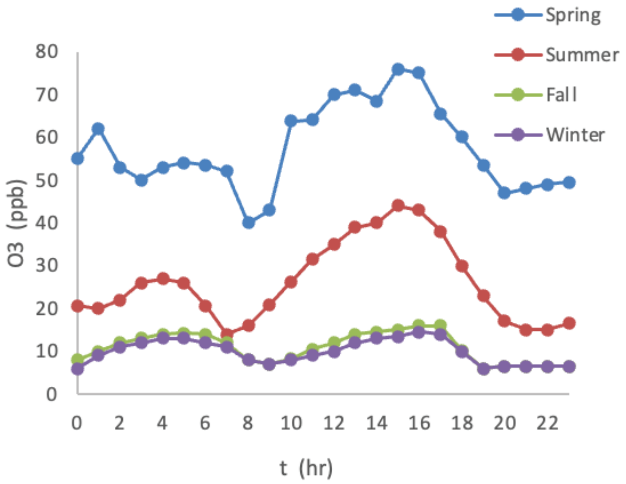

Figure 8. Seasonal averages of Ozone in 2013.

This diagram depicts the measurements in a summer day, and shows the peak vehicular traffic at the end of evening hours and at night. The effects of vehicles on the pollution levels in the city of Arak are clearly visible in this diagram.

To make sure of the significant share of vehicles in the production of pollutants, the amount of NO_2 generated on a holiday (with less vehicular traffic) is evaluated. For example, the quantities of NO_2 remain almost constant for 10 days after the day for which the NO_2 values are shown in Fig. 9. However, on the 11th day, which coincides with the Eid-al-Fitr holiday, the amounts of NO_2 are represented by the diagram in Fig. 10. Based on this diagram, the amount of this pollutant has diminished significantly and, from a concentration of about 30 *ppb* in the previous diagram, it has reached a concentration of less than 25 *ppb* on this holiday; while the polluting industries still work on holidays. This finding indicates the strong role of vehicles in air pollution. It should be mentioned that the seasonal changes have no significant effect on the concentration of NO_2; although the concentration of this pollutant has always remained higher than the average permitted level of 21 *ppb* annually, and the city has always experience polluted conditions.

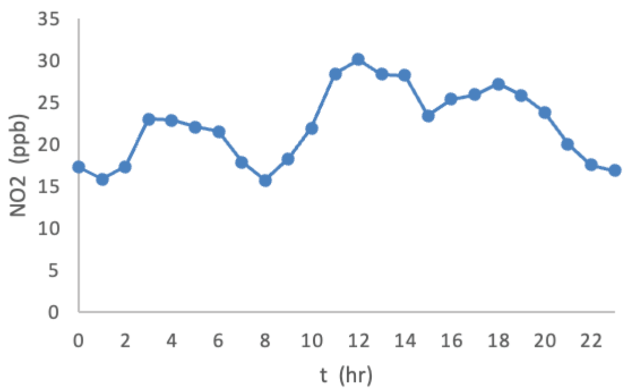

Figure 9. Daily levels of No_2 in August (2013).

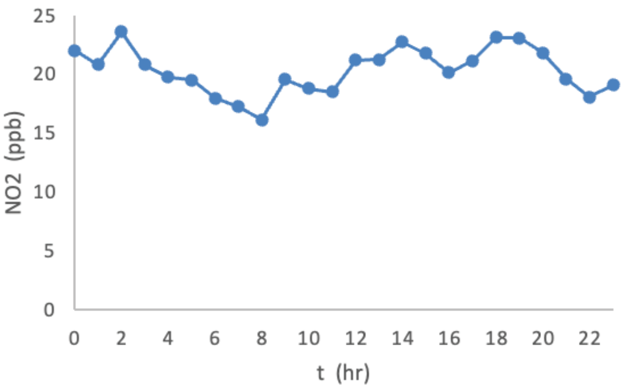

Figure 10. Daily levels of No_2 on a holiday in August (2013).

By examining Fig. 11, it is realized that the maximum amount of CO pollutant has occurred at the hours of 10 A.M. and 9 P.M. and its minimum amount has occurred between the hours of 11 P.M. and 5 A.M. At 6 A.M., with the start of vehicular activity, this pollutant gradually increases until about 9 or 10 A.M., and then it diminishes until 4 P.M. At 4 P.M. (with the increase in vehicular traffic), it starts to increase again, and this increasing trend reaches its peak at 9 P.M., and from this hour on (with the reduction of vehicular activity), the amount of CO decreases again. The permitted hourly concentration of this pollutant is 35 *ppm*; and as is observed in Fig. 11, the amount of this pollutant is far from the standard permitted level.

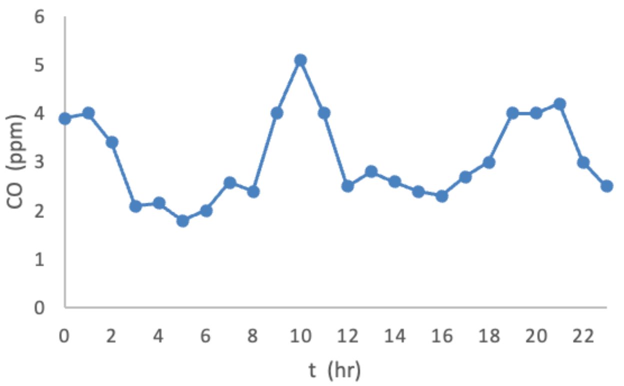

Figure 11. Daily levels of CO in November (2013).

Particulate matter are generally divided into two classes of PM10 and PM2.5 particles. PM10 particles originate from natural sources, while PM2.5 particles mostly have artificial origins. Arak, as one of the western cities of Iran, suffers from the catastrophe of micro-dust. In addition, as is shown in (Fig. 1), the existence of a salty desert and the Mighan lagoon in the vicinity of Arak will add to the extent of this pollutant. (Fig. 12) shows the daily changes of particulate matter, which is mostly affected by climatic and geographical factors such as local wind gusts. By analyzing the data of the air pollution measuring stations, suspended particles of less than 2.5 μm size are responsible for the most polluted days, both in terms of the unpermitted levels and the number of polluted days. In recent years, this pollutant has been on the rise, tremendously, in most of the cities in Iran. In view of the daily variation models of particulate matter in the city of Arak, which has been examined in this paper, vehicles constitute the most important sources for the emission of this pollutant. It is observed in (Fig. 13) that the level of this pollutant continually diminishes from midnight till about 6 A.M., when it starts to rise (with the start of commutes), and around noon (with the reduction of traffic) it diminishes again. The amount of PM increases again at the closing hours of schools and offices, and at about 8 P.M., it continually increases, as the traffic load gets heavier.

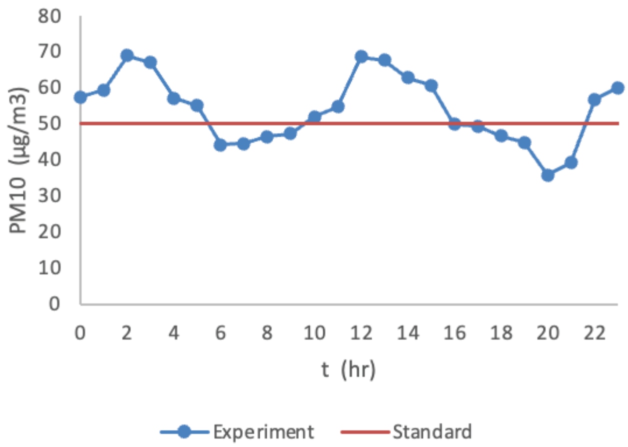

Figure 12. Daily levels of PM10 in September (2013).

Fig. 14 indicates that the levels of PM10 pollutant have remained almost constant in recent years; which indicates that this pollutant is not affected much by the activities of industries and vehicles. However, in view of Fig. 15, the level of PM2.5 has increased, while there has been no increase in the number of industrial units in this city, but the number of vehicles and the traffic load have increased. This indicates the substantial share of vehicles in the rise of this pollutant. It should be mentioned that the empty columns of the data table, related to some months of the year, in Fig. 14 and due to the power outage or the failure of measuring device.

Air pollution seriously threatens the health of people in a society; and in recent years, with the development of cities and the growth of industrialization, this crisis has become more detrimental and the necessity of confronting this problem has become more urgent. Many attempts have been made in the world to solve this problem and numerous researchers have tried to find solutions to this dilemma.

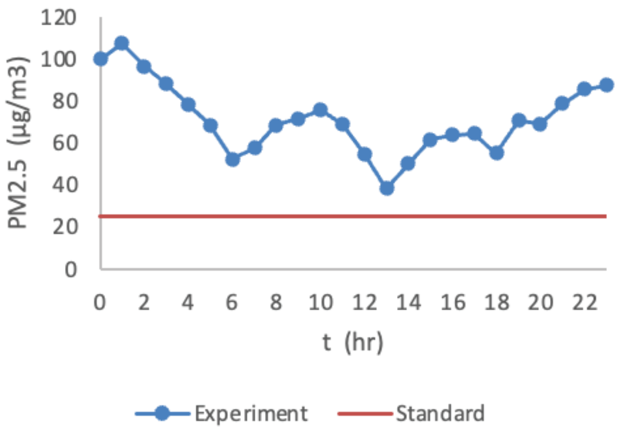

Figure 13. Daily levels of PM2.5 in the month of September (2013).

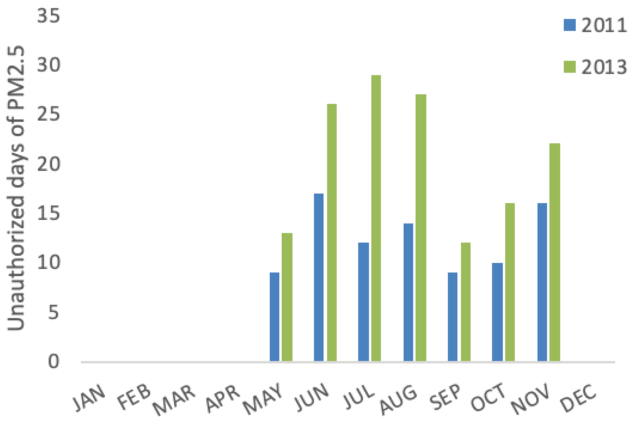

Figure 15. Comparing the number of days on which the PM2.5 concentration exceeds the permitted levels.

The first step in confronting the issue of air pollution is to know the levels of various types of pollutants in the cities in order to find out whether the considered locale is polluted and, if so, by how much and by what type of pollutant. This can be accomplished by establishing pollution measuring stations in the cities. In the next step, the data collected by these stations should be analyzed to find the root causes of air pollution; and finally, serious and decisive steps must be taken to reduce the levels of various pollutants. Thus, a precise analysis of the measured data is an important step in reducing the levels of pollutants.

Considering the existence of numerous industries in the city of Arak, at the first glance, it is felt that these industries are the root cause of pollution in this city. However, with a little introspection, it is realized that the issues of growing air pollution and the ensuing problems have been raised in the last several years, when there has been no substantial increase in the number of industries and, thus, in the levels of pollutants generated by these industries. Therefore, the air pollution in this city could also be caused by the growing number of vehicles. By carefully analyzing the levels of all the pollutants like CO, NO_x, PM2.5, O_3 and SO_2 measured by a station at the downstream of the prevailing wind from polluting industries such as the petrochemical plant and the refinery, it is concluded that vehicles are a major cause of air pollution in the city of Arak; so much that the pollution level diminishes on holidays, with the reduction in the number of commuting vehicles.

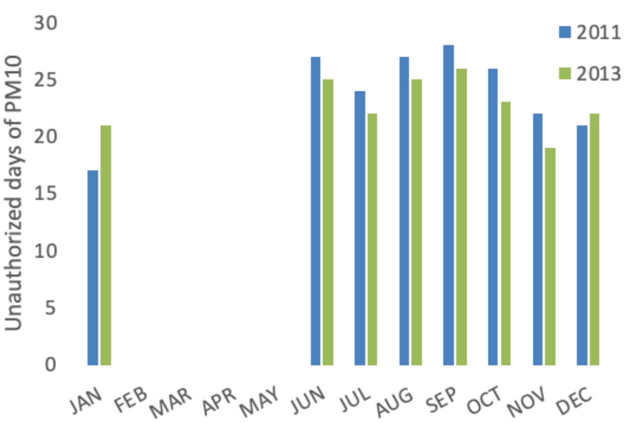

Figure 14. Comparing the number of days on which the PM10 concentration exceeds the permitted levels.

CONCLUSION

In this paper, the level of pollution in this city can be reduced by modifying the transportation model, correcting the city streets and routes from engineering perspective and reducing the traffic load. It should be mentioned that this research doesn't say that industries play no role in the air pollution problem; it just emphasizes the point that the share of vehicles in air pollution, if not higher, cannot be less than the share of industries. Also, with just one downtown for the city of Arak, the pollution concentrates in the central region of the city. Moreover, industrial development comes with some pollution; and in all the developed countries, the industries produce some levels of pollution, and the issue will not be resolved by eliminating the industries. Therefore, the most effective step in solving the air pollution problem of Iran's major cities, including the city of Arak studied in this paper, is to have a sustained development plan for the city. According to results level of all the pollutants CO, NOx, PM2.5, O_3 and SO_2 measured by a station at the downstream and resulted about 3ppm, 20ppb, 10, 40ppb and 4 as a ratio respectively. The implementation of the following policies in a systematic plan can help reduce the level of pollution within a specific time period:

- Implementation of an expertly devised and targeted plan for increasing the green spaces within the city in proportion with the growth of pollutant levels, and the implementation of a green band around the city. The kinds of trees and plants that can absorb more pollutants must be planted, and the locations of these greeneries should be expertly determined; for example, in high traffic areas and the edges of highways.

- Modifying the city form and structure and developing a city intelligently; this means preventing the concentration of the populace at city centers and uniformly distributing the needed goods and services to reduce the number of commutes.
- Using green architecture in order to reduce the adverse effects of pollutants on humans in a closed space.
- Applying the air pollution level factor in the pricing of housing in order to control the population density and thus the concentration of pollution.
- Providing necessary facilities and appropriate jobs in the towns and villages around the capitals of provinces in order to stop the migration of people to major cities and to prevent the congestion of population
- Dealing with the problem of traffic and making it more smooth and flowing by adopting proper strategies such as widening the streets in the older parts of the city, building multilevel intersections, implementing appropriate traffic plans, and constructing pedestrian crossing overpasses.
- Raising the environmental standards for the automobile manufacturers with regards to the exiting conditions.
- Supporting the manufacturing of hybrid cars.
- Supporting the conversion of cars to use CNG according to proper standards.
- Supporting and investing in the public transportation sector, establishing special commuter lines, rapid transit buses, metro and taxicab systems.
- Culturally promoting the use of city transportation system, bicycles and walking.
- Supporting and promoting the development of electronic banking and E-commerce according to the successful European models in order to cut down on the number of vehicular travels.

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AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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