Consequences and health effects of toxic air pollutants emission by industries

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ABSTRACT

Emission large amounts of air pollutants can cause many problems in the environment and human health. The purpose of this review study was evaluating consequences and health effects of toxic air pollutants and expressing strategies for controlling these pollutants.

A narrative review of the literature was done based on searched databases. All relevant studies published 1998 until 2021 gathered. According to the databases, 360 articles were retrieved. 24 studies were screened after review and 16 full-text articles entered into the analysis process. Finally, 9 articles were selected in this study.

The results of this study showed that industrialization, increasing urbanization, technological development, rapid population growth, increased desertification and deforestation, occurrence of dust phenomenon, uncontrolled growth of motor vehicles, entry of various pollutants and environmental degradation cause a phenomenon called air pollution. Based on the results, the toxic air pollutants causes many health endpoints in human such as respiratory disease, asthma, chronic lung disease, respiratory and cardiovascular system dysfunction, decreased immune system, headache, dizziness, gastrointestinal disease and increased risk of cancer (lung, stomach, intestine, eye, liver and brain).

According to research related to the subject, air pollution is a positive function of energy consumption, volume of industrial activities, and the uncontrolled increase of human activities. The most vital factors are increasing the level of public awareness, reducing the exposure to toxic air pollutants, improving quality of the products and consumption of consumed fuels.

Review

Air is the main component of the five fundamental elements (air, water, food, heat and light) for human survival, so that without air, humans cannot survive even for 5 min [1,

2]. The addition of any substance changes the physical and chemical properties of clean air to some extent. Air pollution issues are related to a variety of different types of pollutants [3]. Air pollution is the presence and spread of one or more solid, liquid, gas, radioactive or non-radioactive pollutants that cause hazards to humans, organisms and plants [4]. Today, the issue of air pollution is one of the main problems of cities, where a large level of pollutants enters the atmosphere daily by anthropogenic activities, which are mostly fossil fuels so that the dilution of pollutants (self-purification) could not meet this volume of pollution [5, 6]. Air pollution causes major global problems such as ozone depletion, acid rain and global warming [7]. The source of air pollution in the second half of the eighteenth century was mainly coal industry and fuel, while in the twenty to twenty-one century is the expansion of urban transportation. The use of fossil fuels on one hand and the consumption of raw materials in industries and factories and manufactured products on the other hand are major causes of human-caused pollution [8]. In general, natural and artificial are two categories sources classify for air pollution [9]. Natural sources existed before artificial sources, and these artificial sources, which are considered human activities, have sometimes intensified pollution cases out of the atmospheric capacity. Manmade air pollutants also affect physical and mental health [10]. In terms of origin, pollutants are also divided into two important groups, which are: primary and secondary pollutants. Primary pollutant is a pollutant that enters the atmosphere directly from artificial and natural sources including transportation, combustion, industrial processes, solid waste and miscellaneous materials. Secondary pollutant is a pollutant caused by the interaction between the primary pollutant and environmental factors [11]. Major toxic air pollutants include Sulfur dioxide (SO_2), Nitrogen Oxides (NO_2), Carbon monoxide (CO), Ozone (O_3), Particulate Matter (PM), Polycyclic Aromatic Hydrocarbons (PAH), Heavy Metals (HM), Pb, Volatile Organic Compounds (VOCs) and hydrocarbons [12, 13]. Carbon monoxide is colorless, odorless, water-insoluble, flammable, blue gas. It comes from natural and artificial sources such as car exhaust and incomplete incineration of solid waste, the share of natural sources in terms of its emission rate is almost 10 times higher than emission from artificial sources. Out of the eight nitrogen oxides in the atmosphere, only three are Nitrous Oxide (N_2O), which is a colorless, non-flammable, non-toxic gas with a relatively good odor. Nitric Oxide (NO) is a colorless, non-flammable, odorless and toxic gas and nitrogen dioxide (NO_2) is a reddish-brown, non-flammable, odorless, and highly suffocating gas [14, 15].

These pollutants enter the atmosphere from natural and artificial sources. Based on reports different study natural source emission carbon monoxide and sulfur dioxide. Also, the main agent emitted the level of pollutants on atmosphere is full combustion. Hydrocarbons exist in three physical states including solid, liquid and gas. If they have one to four carbon atoms, they are in the gaseous state, which is the most important cause of air pollution. If they have five or more carbon atoms, they are liquid or solid. Most hydrocarbons enter the atmosphere from natural sources, so that bacterial interactions are the main sources, including swamps, stagnant water, and plants, especially trees. Therefore, the aim of this study is evaluation of cultural and economic damages and health effects due to toxic air pollutants emission by industries.

Search strategy and inclusion criteria

Based on different databases: Science Direct (Scopus), Google Scholar, Springer, PubMed and Web of Science a review of the study was conducted (Table 1). Search of restrictions done on the basis of English language. Identify all relevant studies published 1998-2021. According to databases three hundred and sixty articles were retrieved.

Table 1. Search terms and query results of reviewed papers in the study

Term	Science Direct (Scopus)	Google Scholar	Web of Science	PubMed	Springer	Unique results
Industries	23	12	5	8	41	89
Toxic pollutants	16	7	4	6	19	52
Air pollutants	15	8	3	10	13	49
Health risk	11	5	10	13	24	63
Health effects	7	13	12	10	28	70
Industries and toxic air Pollutants	8	3	5	4	17	37
Total	51	142	48	39	80	360

Data collection

In this review two steps was used in search of resources. Keywords search terms: 'Industries', 'Toxic Pollutants', 'Air Pollutants', 'Health Risk', 'Health Effects', and 'Industries and Toxic Air Pollutants', used in the first step of searching for resources. The range of study period (1998 to 2021) was limited in the study.

According to search articles on the industries and toxic air pollutants, including articles published in domestic and foreign journals and searches in science direct (Scopus) search 51 articles, springer database 80 articles, web of sciences received 48 articles, 142 articles in the Google scholar and PubMed database 39 articles.

 64 and 9 articles were found and selected based on records identified through database searching and additional records identified through other sources. In the next stage, 24 studies were screened after review and 16 full-text articles entered into the analysis process. Finally, 9 articles were selected in this study. The how to prepare studies and the selection process articles showed in Fig. 1.

Extraction of the data

Data from selected publications were extracted and documented in the Excel spreadsheet.

Ethical approval

According to the national guidelines, studies such as this do not require individual consent.

Production resources of air pollution

The main sources that produced the toxic air pollution are population growth, factories, industries, personal transportation, increase the use of fossil fuels, the use of chemicals substance, the destruction of vegetation, and waste dumping. This issue has created many problems due to lack of proper planning and lack of coordination between different organizations [16, 17]. The issue of transportation in metropolitan areas is the main problem causing air pollution [18]. Among the various pollutants emitted, carbon monoxide accounts for the largest share of pollution in passenger car transport. Following it, marine

plants, chlorophyll growth and degradation that are second major source the oceans [19]. The easiest solution to this problem is the use of public transport and the last solution to this problem is to impose fines on violators [16]. Another major cause of air pollution is factories and industries, which due to the increase in construction and development infrastructure, the growth of cement factories is increasing, and sulfur dioxide is the main pollutant that enters the air [20]. Another type of industry that has a potential risk of lung cancer is the rubber industry, where inhaling air in such an environment reduces lung capacity, shortness of breath, and emphysema (destruction of the lung parenchyma), even for short periods of time [21]. Another factor is gas power plants
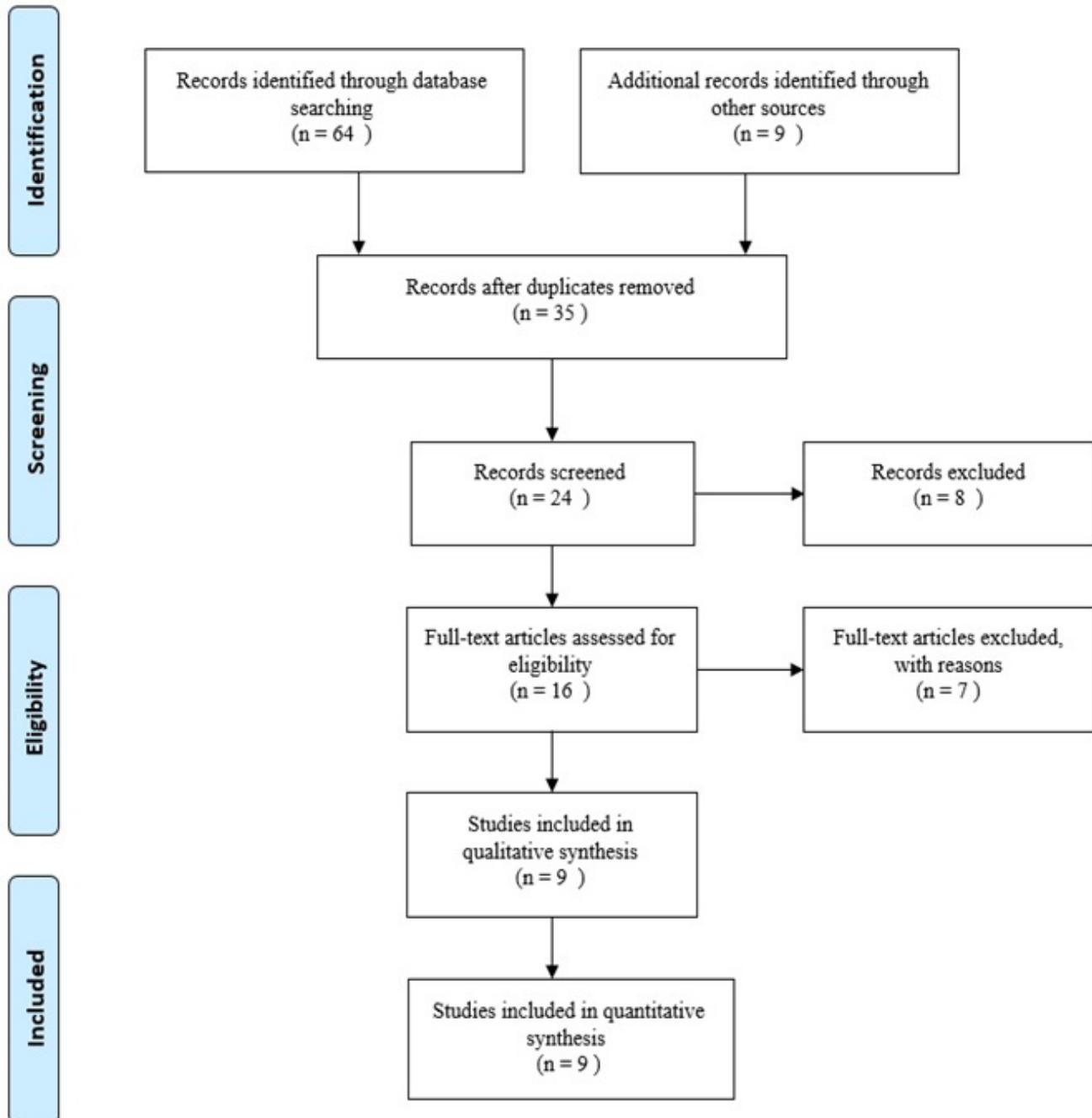
Fig. 1. Flowchart of study entry steps for the studies

that form a large share of greenhouse gases and enter the air every year, the solution to which can reduce fuel consumption and thus reduce the amount of greenhouse gases [22]. Dust from the textile industry could be another cause of air pollution, and workers working in the area have been diagnosed with lung disease, according to studies [23]. Important causes of dust can be considered as low rainfall and drought, surface water control, uncontrolled abstraction of water resources, land condition and land use change, grain size and soil type, lack of vegetation, wind and moisture [24]. In addition, the wood paper industry due to the destruction of vegetation and also the operations and processes performed to convert wood to paper can be another cause of air pollution, which in this factory has four main

units: preparation and preparation Wood chips, pulp production, chemical recovery system and paper production unit can be named that each of the above units alone causes environmental pollution [25]. Heavy metals such as lead and cadmium in the paint industry can be the causes of air pollution. The inhalation of them will lead to many complications such as lung cancer [26]. Nowadays, the development of economics and industries cause a lot of environmental damage, including air pollution, which can be referred to steel and iron industry by importing various pollutants into the atmosphere. Carbon monoxide, sulfur oxides and nitrogen, and etc. are considered as the main air pollutants by industries [27]. Due to the increasing habit of smoking in different communities, one of the important causes of
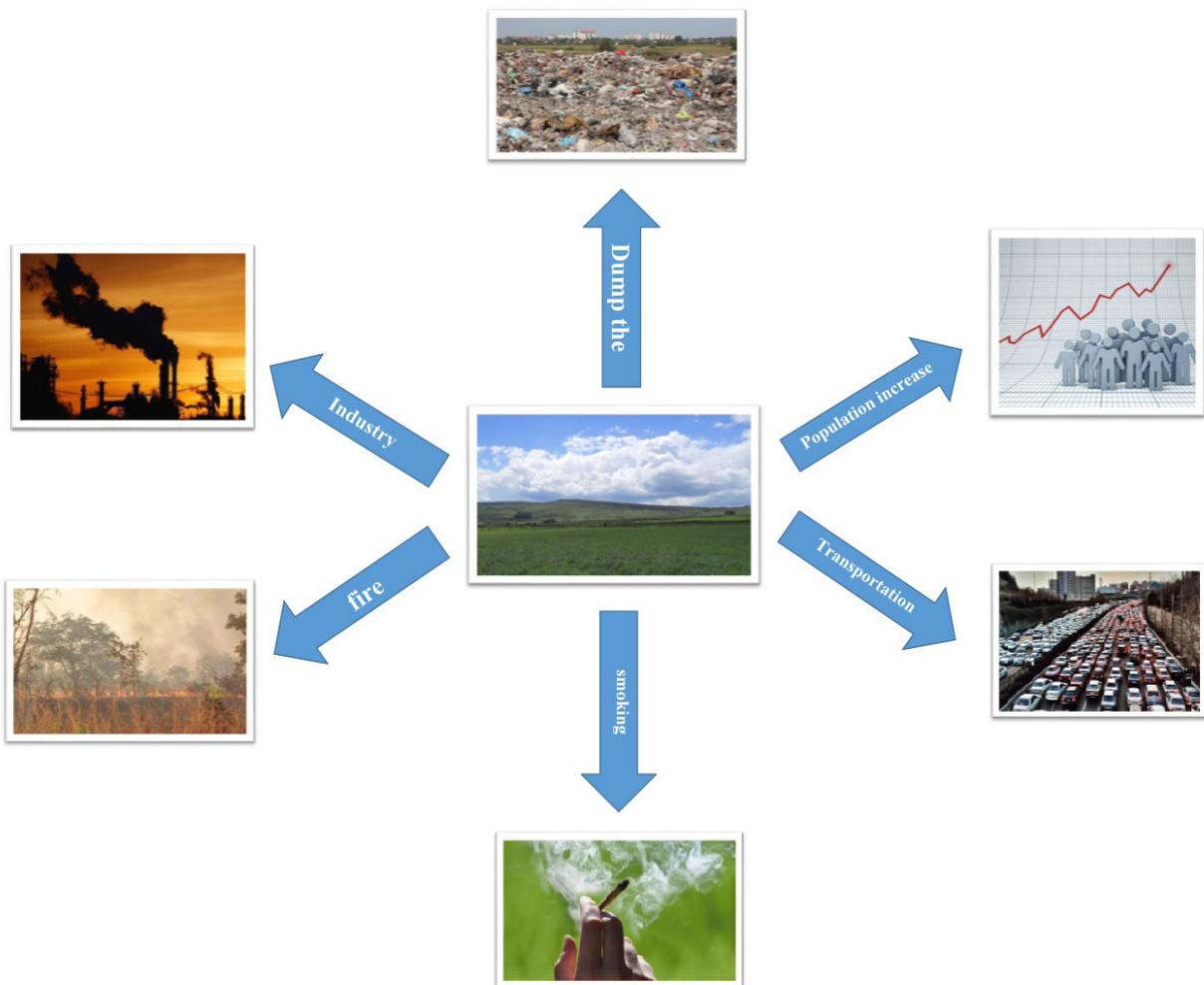
Fig. 2. Production sources of toxic air pollutants

mortality among people, this social problem can be one of the important causes of air pollution. Significant amounts of the carcinogenic pollutants including benzene, formaldehyde, arsenic and cadmium enter the atmosphere through each pack of cigarettes. Non-smokers are exposed to these pollutants from cigarette smoke and suffer from serious complications [28]. In the past, due to insufficient knowledge, municipal waste was transferred to incinerators for incineration, which was considered as a large source of air pollution due to the release of various toxic pollutants. But over time, the solution of dumping waste on low-lying land outside the city limits became popular, which itself caused many environmental problems. Today, with the availability of modern equipment and suitable locations for sanitary disposal and disposal of waste, many problems related to waste dumping have been eliminated, which are the ways to achieve a healthy environment and urban development [29]. Field and forest fires occur in both natural and intentional forms despite the loss of vegetation, they increased the amount of dust in the air. The entry of pollutants into the air has direct impact on the physical and chemical properties [30]. Fig. 2 showed production sources of toxic air pollutants.

Consequences of toxic air pollutants

Visibility is one of the atmospheric variables that is often measured with instruments installed in airport-based devices. Smoke and fumes from the chimneys of industries as well as dust storms that occur as a result of the reduction and destruction of vegetation are among the causes of air pollution. Another effect of toxic air pollutants that suspended particles and gaseous pollutants cause is absorbing and scattering light. Therefore, air temperature reduces and increase the prevalence of eye and respiratory diseases. Transport disruption and economic damages also occur [31]. Air pollution has a wide range of effects, including the impact on the cancellation of flights due to reduced visibility, school closures and impact on historical objects and monuments over time, as well as the reduction of tourists

from recreational and historical places, ozone depletion, and excessive obesity in people (Fig. 2). Impact on plants is another effect of air pollutants, which is evident as the effect of carbon monoxide at concentrations of 100 ppm though it rarely reaches this amount. Among nitrogen oxides, NO has less effect on plants, so that when bean and tomato plants expose to it at 10 ppm, no immediate decrease in photosynthesis is measured. However, cotton, pinto, and endive plants become spotted when exposed to NO_2, which indicates gradual decay (rot or tissue damage). Exposure to NO_2 at low concentrations during a long time has fewer effects, long-term exposure causes very mild changes in the pigment becomes tissue and increases leaf fall and reduces the fruitfulness of the orange tree [32, 33]. Nitrogen oxides are also effective in textile dyes. Accordingly, they lose color when emitted to textile dyes with NOx. These dyes include those used in rayon, cotton and viscose ions. Decolorization of silk fabrics that are dried with gas dryers is another complication because of the nitrogen oxides used to heat the dryers during the combustion of natural gases.

All hydrocarbons that cause air pollution, only ethylene at a concentration of 1 ppm inhibits the growth of plants, as well as discoloration of leaves and death of flower limbs. Ozone, which is one of the criteria air pollutants, can cause irreparable damages to cotton, acetate, nylon and polyester as well as affecting organic polymers of rubber, and natural and synthetic fabrics [34]. Sulfur oxides are one of the most important causes of air pollution, which manifest their effects by affecting plants and objects. When plants exposure to high concentrations of them during a short time, the leaves dry out or turn light green (acute effect) [35]. Also, the low concentrations of, this contaminant for long duration cause gradual yellowing of leaves due to preventing chlorophyll formation (chronic effect). SO_2 and O_3 as well as SO_2 and NO_2 together produce significant synergistic effects [36]. Consequences of economic, social and environmental related to toxic air pollutants illustrated in Fig. 3.
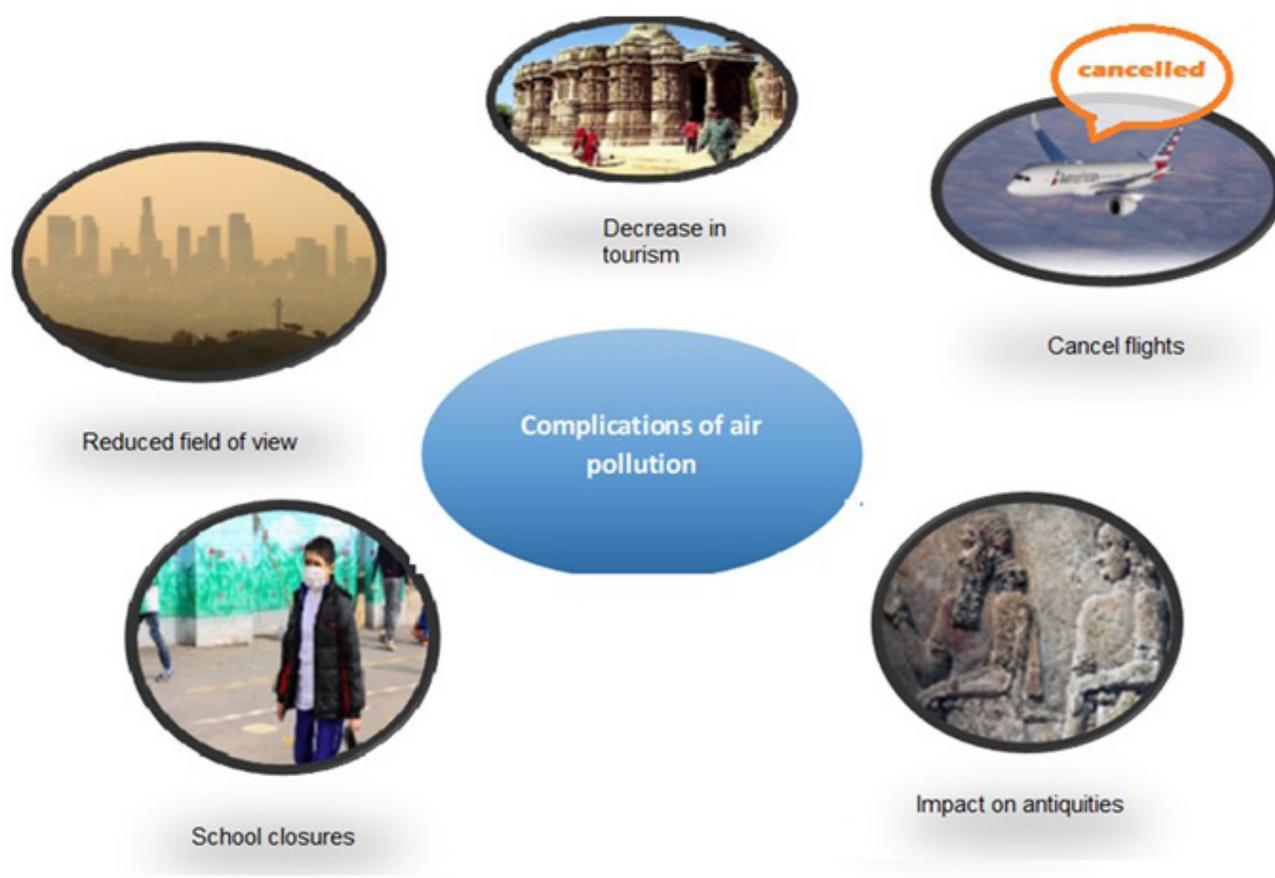
Fig. 3. Consequences of economic, social and environmental related to toxic air pollutants

Health effects of toxic air pollutants

Air pollution can have short-term and long-term effects. The most evident health outcome are fetal formation, human birth, asthma, chronic lung disease, respiratory and cardiovascular system dysfunction, decreased immune system, headache, dizziness, gastrointestinal disease, increased risk of cancer (lung, stomach, intestinal, eye, liver, liver and brain) [37-40]. The major pollutants in air pollution are PM_{10} and $PM_{2.5}$ known as coarse and fine particulate matter, which their sources are dust storm and fossil fuels [41]. Toxic air pollutants can cause respiratory and immune system problems, decrease of health performance, increase costs of health care system, bronchitis, asthma, changes in heartbeat and increase risk of lung cancer [42-44]. According to a study conducted attributed to the concentration of PM_{10} in the industries, demonstrated that was less than the standard the reason for the lower average concentration of particulate matter was related to the installation of pollution control systems in the industries [45]. Environmental factors such as drought, lack of humidity, rainfall and high temperature along with large industrial facilities are potential causes of suspended solids and air pollution [46]. Other related pollutants are NOx, which enters the air through fossil fuels and causes respiratory, gastrointestinal, and skin problems. Studies show that NO_2 is 4 times more toxic than NO. The proven effects of this contaminant are completely limited to the respiratory effect and

the severity of the poisoning depends on the time of exposure and concentration. Exposure to this contaminant has consequences such as impaired breathing, nasal disorders, nerve and pulmonary edema (accumulation of watery fluids), inhibition of enzyme activity and eventually death. According to a research conducted in the different indoor and outdoor regions the concentration of nitrogen dioxide in closed areas is higher than in open environments and this issue causes exposure with a higher concentration of the desired pollutant [47]. Also based on the results different studies, toxic air pollutants play an important role in many health endpoints such as stroke, cardiovascular deaths, hospital admissions and chronic obstructive pulmonary [48]. Carbon monoxide (CO), whose main source is vehicle, reduces oxygen delivery to tissues due to combination with hemoglobin (met-hemoglobin formation), increases impairs growth and causes damage to the central nervous system and heart [49]. The first signs of carbon monoxide poisoning can be headache, weakness, dizziness, nausea and vomiting, drowsiness and lethargy. After a long time of exposure, the symptoms are bruising around the lips and fingertips, shortness of breath and anesthesia. A study conducted in this regard in 2020 indicates that the causes of death due to carbon monoxide in every day is related to the increase of this pollutant in two-week lag [50].

Finally, Sulfur dioxide (SO_2), which is mainly produced by power plants, also impairs lung function. Prolonged exposure to this contaminant causes allergies, pneumonia, lung cancer, shortness of breath, cough, sneezing and decreased lung capacity [51]. The most common symptoms of air pollution can be irritation of eyes and upper respiratory tract. There is also a significant relationship between this problem and blood pressure, which will lead to liver and kidney damage. Ultimately pregnant women who are exposed

to air pollution showed excessive weight loss at birth. An increase in the number of babies younger than gestational age was also observed [52]. Simultaneously with the air pollution event, the hospitalized patients with cardiovascular disease showed increase of heartbeat. Air pollution is also significantly associated with respiratory diseases such as chronic lung disease and pneumonia. According to the information obtained from a study conducted in 2019, carbon monoxide and ozone had the greatest impact among the pollutants, which has reached its maximum at the beginning of winter due to temperature inversion [53]. Based on performed study in relation to the concentration of CO showed that opposite correlation with FVC (volume of air that can enter in lungs after a deep breath and maximum power out of the lungs) [54]. Fig. 4 showed the health effects of toxic air pollutants.

Air pollution control strategies

In order to reduce emissions and adverse health and economic effects, city managers and environmental experts should develop public transport fleet, advertise for more use of public transport, create green space and increase vegetation. In terms of factories that produce major air pollutant, it is necessary to improve production quality and conditions in industries, use of air pollution control devices and equipment such as filters, use of local suction ventilation over heavy industries (oil, gas, petrochemical and steel), decommission used vehicles, and raise public awareness about ways to reduce emissions of pollutants. It also refers to some cases to reduce air pollution, including strict rules and regulations about motor vehicles, polluting factories and power plants. In addition, it is recommended to increase the use of natural gas, use of central heating and cooling equipment, remove chimneys, create space passage for pedestrians through parks, correct location of highways and freeways, and optimize flame temperature.
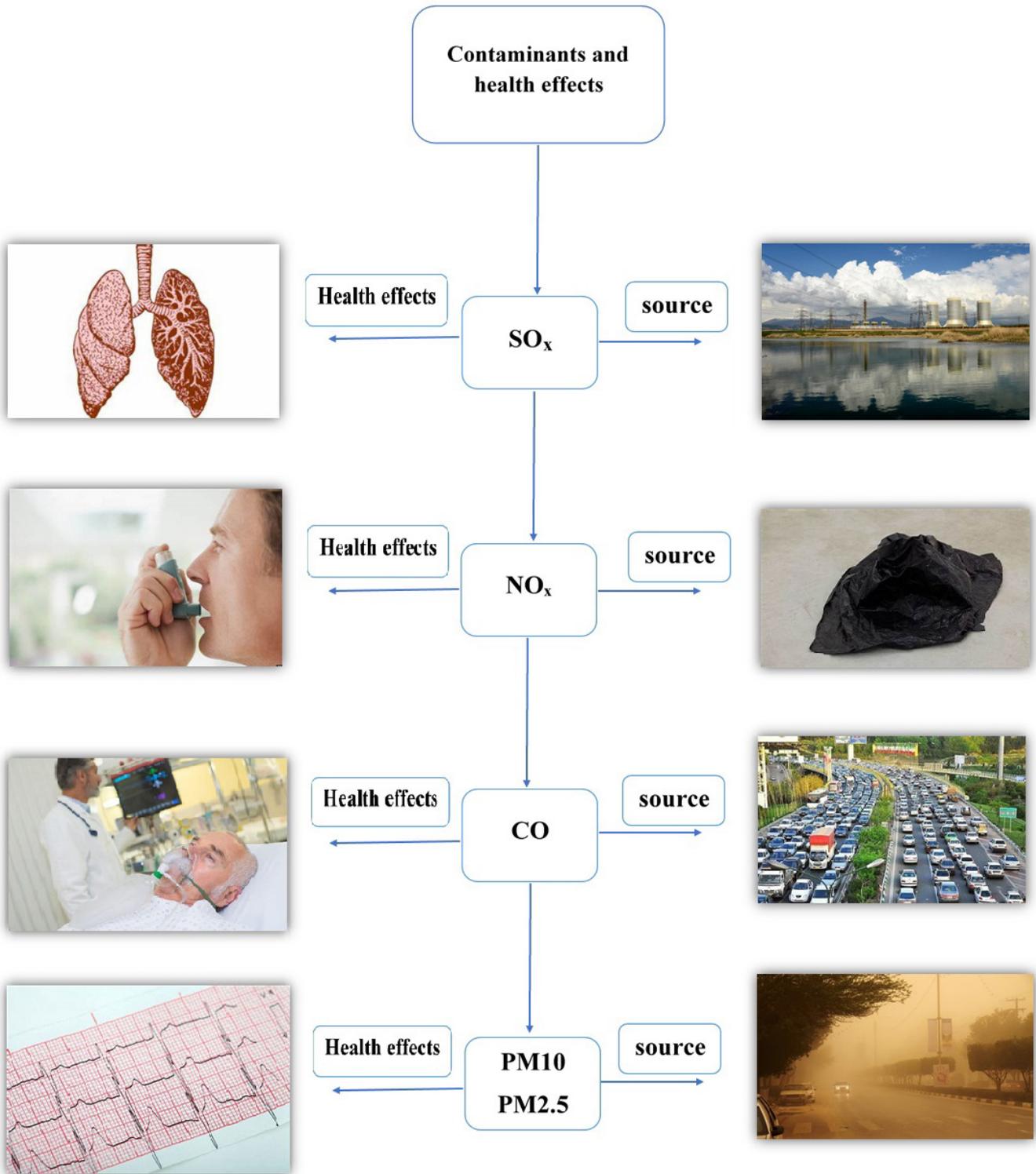
Fig. 4. Health effects of toxic air pollutants

Conclusion

According to the studies performed and the results obtained, it was determined that NO_X, SO_X, CO, PM_{10} and $PM_{2.5}$ pollutants are among the important cases of air pollution. The findings of this study showed that toxic air pollutants emitting by industries can causes social, economic and health effects on the environment and society. The increasing development of heavy industries such as oil, gas, petrochemicals and steel, the excessive production, use of vehicles with fossil fuels combustion and emission of various hazardous pollutants caused by these activities. Long-term exposure to these toxic and dangerous pollutants can cause irreversible complications such as cancer and death in humans. Therefore, updating production processes in industries, the use of advanced technologies and the use of clean energy can be of great help for reducing hazardous air pollutants emission.

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Competing interests

The authors of this article declare that they have no conflict of interests.

Author's contributions

Mohammad Javad Mohammadi, A. Heri Iswanto, Sara Mansourimoghadam, Ahmed Taifi, Heydar Maleki, Yasser Fakri Mustafa, Behzad Fouladi Dehaghi, Arghavan Afra, Masoume Taherian, Fatemeh Kiani, Maryam Hormati were principal investigators of the study and drafted the manuscript. Mohammad Javad Mohammadi, Sara Mansourimoghadam, Ahmed Taifi, Masoume Taherian, Fatemeh Kiani and Maryam Hormati were advisors of the study. A. Heri Iswanto, Ahmed Taifi, Heydar Maleki, Yasser Fakri Mustafa, Behzad Fouladi Dehaghi, Arghavan Afra and Mohammad Javad Mohammadi performed the statistical analysis. All authors contributed to the design and data analysis and assisted in the preparation of the final version of the manuscript. All authors read and approved the final version of the manuscript.

Ethical considerations

According to the national guidelines, studies such as this do not require individual consent.

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