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CHARACTERIZATION AND MORPHOLOGICAL ANALYSIS OF AEROSOLS IN TEHRAN TRAFFIC ZONE

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ABSTRACT:

Introduction: The identification of effective factors in air pollution is necessary to plan for decreasing the impacts. Tehran is one of the most polluted cities in Iran and the world, which is constantly affected by air pollution. The traffic zone is attributed to most crowded places in Tehran with some limitations for vehicles. In this study, samples were taken from the limited traffic zone in Tehran.

Materials and methods: The sampling was done with high volume sampler for a period of 6 -24 h. Preliminary SEM/EDS measurements were performed on some of the samples to get elemental information on individual aerosol particles. The aerosols were collected by fiber-glass filters and using a sampling flow of 1.5 m^3 / min.

Results: The results show that the largest source of atmospheric particles in Tehran is due to the combustion of fuel released by mobile resources such as transportation and also, stationary resources such as industrial and factories as the second source of atmospheric particles production. Also, mineral particles with irregular shape were observed in coarse particle which may be mainly derived from natural sources such as soil dust, resuspension of dust from road, crust and some other anthropogenic activities such as construction and vehicles.

Conclusions: These particles morphology and chemical composition, illustrate an abundance of natural elements within the zone. However, some of the elements presented are directly related to human activities, and are interested by the public health and environmental perspectives.

INTRODUCTION

Air quality has been an important concern in all over the world with the concentrations of criteria pollutants exceeding the standards in many places, particularly in developing countries. Several studies on the phenomenon of dust have been conducted on the factors affecting occurrence to determine the distribution areas. In some studies, the relationship between climate, vegetation and the occurrence of dust storms is expressed using satellite imagery, which indicates characteristics of the earth's surface can be effective in storm surges [1 - 4]. The sources of PM are divided into three major categories; natural, an-

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thropogenic and secondary. Windblown dust, sea sprays, volcanoes, fires and pollen are examples of natural sources. On the other hand, anthropogenic sources are further classified into stationary and mobile subcategories; stationary sources are fixed-site producers such as power plants, factories, mines, farms, and waste - disposal sites. Whereas, mobile sources are mainly the transportation means such as cars, trucks, planes and ships that emit pollutants while moving [5]. Finally, secondary fine particles are formed in the atmosphere through chemical reactions among the gaseous pollutants involving; SO_2, NOx, VOCs and NH_3 [6]. Elevated levels of ambient PM might lead to considerable adverse effects on public health and the environment. On the one hand, it contributes to visibility degradation, acid deposition, and influences the climate either directly by scattering and absorbing sunlight radiation or indirectly through providing condensation nucleus for cloud droplets [7]. On the other hand, both short and long-term exposures to PM cause respiratory and cardiovascular diseases and are also linked to overall increased mortality [8]. However, the size of the particle plays an important role in its potential hazard. As such, smaller particles have a larger surface area available for physical and chemical interactions, travel farther distances, remain suspended for longer times, and penetrate deeper into the human respiratory system [9]. Tehran is one of the most polluted cities in the world, and air pollution is one of the greatest challenges for its inhabitant. The increase in the frequency of dust storms, especially in recent years, has led to an increase in the high level of suspended particles. Due to the presence of many human pollutants, Tehran's main air pollutants include CO, NOx, SO_2, O_3, HC and PM that 85% of car fuel and the remainder are created by factories and homes heating equipment [10]. The high congestion of cars, high buildings, stable air without wind have increased the concentration of air pollutants in a dangerous level and have made air pollution as one of the most important environmental problems in Tehran. Air pollution is considered as one of the environmental problems in citizens of Tehran so that solving the air pollution problem requires more effective programs. So, in this work, we have tried to study the origin, chemical composition, and particle morphology by studying PM in the atmosphere of Tehran.

MATHERIALS AND METHODS

Sampling

The sampling time for each station was 6 - 24 h. Also, glass filters were used to collect particles by High-volume sampler. Preliminary SEM/EDS measurements were performed on some of the samples to get primary information on individual aerosol particles. Particles were imaged by Zeiss EV050XP SEM. The X - ray energy spectra were measured using a Bruker Quantax 200 EDS system with a Peltier-cooled X Flash silicon detector. The aerosol samples were coated with a thin layer of conductive material before the measurements. The images of samples were taken at a magnification of 500 ×, 1,500 ×, 5,000 ×, 20.000 × and 50,000 ×. These selected magnifications allow to analyze the morphological parameters and chemical of particles in entire particle size range. The spectra of individual particles were obtained after scanning an electron beam with an accelerating voltage of 25 kV for determination the individual elemental chemical composition of the particles. The main chemical group of particles is identified by EDS spectra.

Study area

Tehran traffic zone starts from the north; Hemmat highway toward the south; Besat highway.

This area is limited to east and west, between the Imam Ali and Navab Safavi highways (Fig. 1). This limitation starts at 6:30 and lasts at 19. Table 1 shows the annual emission of air pollution in Tehran [11]. According to the reports, particulate organic matter was the dominant component during most of the year, with a contribution of 13 – 54 % and an average of 35%. Organic matter and elemental carbon comprised 44% of fine PM on average, reflecting the significance of anthropogenic urban sources, i.e. vehicles. The concentration of these heavy metals increased during cold seasons [12]. The determined major mass components of $PM_{2.5}$ accounted for about 89 % of the particulate mass. The determined dominant components were dust 25 %, nitrate 2 %, sea salt 1 %, ammonium 5 %, elemental carbon 9 %, organic carbon 1 %, non - sea salt sulfate 11 % and organic matter 35 %. The effects of meteorological parameters on air quality of Tehran are significant, and this amount is from + 5 % to – 5 % [12]. The western winds are the prevailing winds for all seasons and the highest wind speed is observed in spring, which is associated with the best air quality in comparison with the rest of the studied year [12]. According to the result of the studies in Tehran, concentrations of criteria air pollutants are well beyond the national standards and the WHO standards [13, 14]. The most air pollution in 2014 originated from mobile sources, including carbon monoxide (97 %), volatile organic compounds (VOCs) (86 %), particulate matter (70 %), and nitrogen oxides (46 %) [12].

RESULTS AND DISCUSSION

Previous researches on particles matter have been focused on their classification based on concentration, chemical composition and size of whole particle masses; with few details relatively on the shape, chemical composition and size of their individual components. In this researches, environmental conditions such as climate change, vehicle traffic and industry activity have caused pollution in rural (non - urban) and urban areas. The weather conditions cause the transmission of this pollution from rural area to urban area and

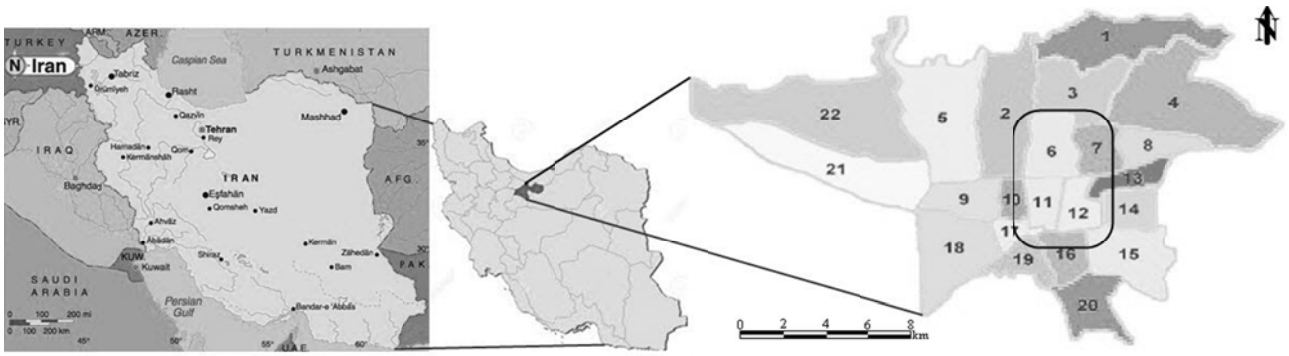

Fig. 1. Geographical location of the study area

Table 1. Annual emission of air pollution in Tehran

Source	NOx (%)	CO (%)	PM (%)
Stationary	53.2	2.5	29.8
Mobile	46.8	97.5	70.2

urban area to rural area [15, 16, 17, 18]. In these studies, the physical and chemical differences in the aerosol particles in the urban and non - urban environment have been pointed out and have revealed the fundamental differences between these particles. Based on the results of samples taken in the urban area, apart from the dominating elements were determined elements such as calcium, iron, chlorine, and potassium - rich particles, silicon, aluminum, and magnesium. It represents the presence of soot particles in the case study of the area. Fig. 2 shows an SEM image of the aerosol particles in the area. The results of images from SEM for particles less than 1 μm showed that these particles show irregular, spherical, fine-rod like and crystalline shapes. From the SEM image of particles, it is observed that particles with the size of 2.5 μm were spherical, irregular and cluster shapes. These SEM images showed that Ca, as the most dominated particle among others, can be considered as the form of calcium carbonate related to the calcite phase, $CaCO_3$.

Major elements found in the $PM_{2.5}$ aerosol include Si, O, C, Mg, Ca, Mn and K. In general, common major crustal elements found in atmospheric particles over all the sites are Si, Al, and Fe. Mineral particles usually derived from natural sources such as resuspension of dust from roads, soil dust crust. Other particles produced by anthropogenic activities are such as fuel combustion by vehicles, particles produced in various industries, roads and urban development and

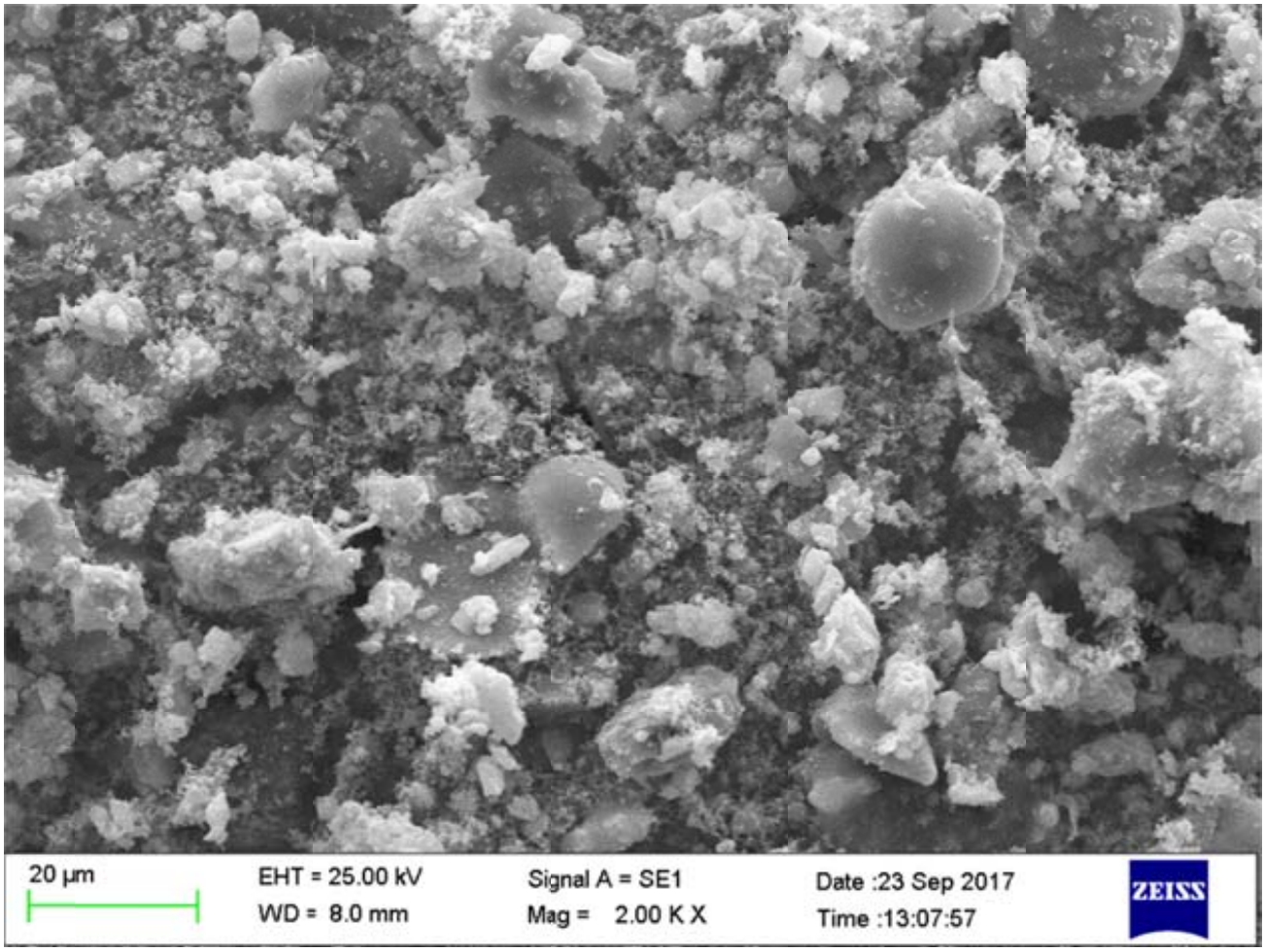

Fig. 2. SEM images of aerosol particles in central regions of the study area

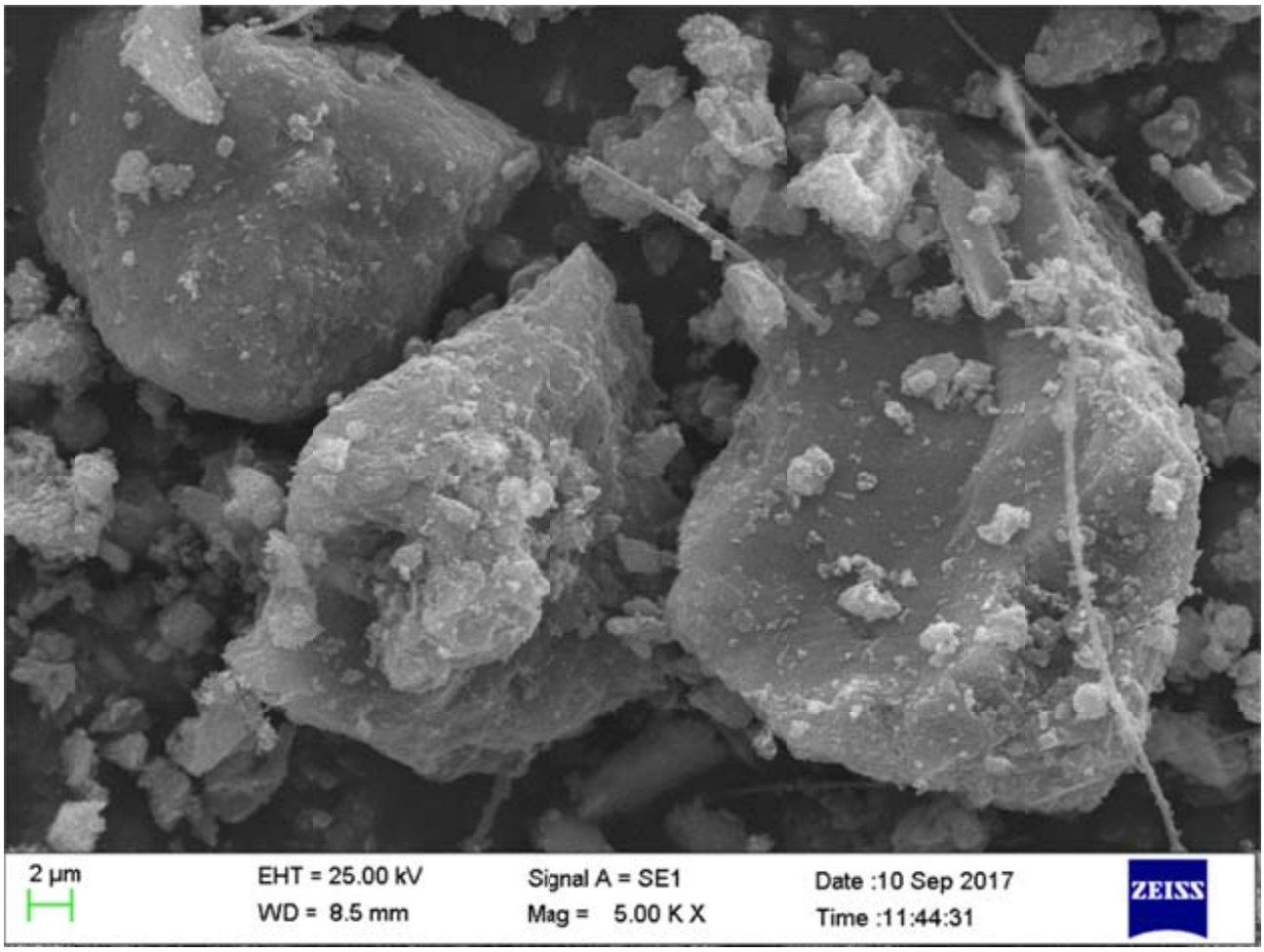

Fig. 3. Scanning electron micrograph of aerosols less than 2.5 µm

abrasion of metallic materials. Morphology and shape of the particles are generally irregular and coarse. Elements such as Zn, Ti, Fe, and C were observed in varying concentrations in all over the area, especially in the northeastern regions of the study area. Also, these results indicate the presence of anthropogenic sources in the composition of the particles. Fig. 3 shows a scanning electron micrograph of the particles.

Table 2 shows the concentrations of elements of aerosol particles produced by stationary sources in the area. The elemental composition of these particles indicates that Zn, Ca and K rich particles

Table 2. Concentrations of elements of aerosol produced by stationary sources

Elements	Weight %
C	24.52
O	45.72
Na	4.62
Al	1.92
Si	16.39
K	1.52
Ca	0.70
Zn	2.02
Ti	2.60

were dominant. The other dominated elements were O, Si, and Al. This could be as the fly ash origin. These particles can be related to construction activities, regional transportation in the urban zones, or the agricultural vegetative burning and natural dust. These particles are composed of feldspat (Ca, Si and Al) and clay (Al, Fe and Si) originated from crustal. They can also come from erosion of building products and road dust. Other elements are present in minor concentration in the alumina - silicate particles and they are Mg, Na, Ti, and Zn. Due to the large volume of construction in different parts of Tehran and the lack of supervision in the activities of sand and gravel factories, the suspended particles are high in the atmosphere of the region. Since the location of these factories is located in the dominant wind direction in the region, the emission of particles from these sources is always one of the main sources of air pollution in Tehran.

In addition to the mineral particles released by wind currents in the atmosphere of Tehran, there are other sources in the region including the main suspended particles in the western regions and the central regions. These particles are formed from burning biomass in the marginal areas of Tehran and are flowing through the winds in the region from the west and southwest regions and extending to the northern and northeast areas. Due to the atmospheric conditions in the region, the suspended particles in the atmosphere are divided into two major groups: urban particles that are the result of combustion of fossil fuels in the region. In the second group, resources are generated outside of the urban boundaries and in the marginal areas of the study area, which mainly consist of particles from dust storms, biomass, and from stationary and mobile sources. Land use change in the western of the selected zone and the conversion of vegetation cover and rangelands to residential and industrial areas are the main reasons for the emission of pollutants in these area. The shape of these particles is irregular due to the origin of the mineral , moreover the presence of biomass particles are regular and sometimes spherical forms. Carbon and silica are mainly found in the composition of these particles.

CONCLUSIONS

Results showed the high concentration of particulate matters in the study area, that exceeds the allowable limits. Therefore, long and short - term strategies should be implemented to reduce the levels of ambient particulate to preserve the environment which in turn would enhance quality of human life. The assessment of the chemical composition and morphology of suspended particles in the atmosphere of Tehran reveal two sources for these particles. Other sources are the suspended particles from combustion of fuel in mobile sources, such as cars, motorcycles and bus lines, which exceed the global standards of pollutants emissions. On the other hand, there are some stationary sources in the southern zone as the second source of suspended particles emission. But due to the chemical composition and morphology of the particles, the sources of these particles are outside the scope of the study, so that these particles are produced by biomass burning sources. These particles enter the center of region by wind from the west and southwest. With the wind blowing, these particles can be removed from the northeastern and eastern regions. But due to the atmospheric stability in winter and autumn, and the occurrence of a temperature inversion phenomenon in most of days, the concentration of these particles increases at near the ground level. So it threatens the environment and makes environmental problems. Therefore, according to the study, the mobile sources are considered

as the most important sources of suspended particles emission in the study region and it needs to make new decisions. In order to solve this problem, it is necessary for the first step to identify the sources of pollutants and the amount of pollution in different regions.

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COMPETING INTEREST

The authors declare no competing interests.

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ETHICAL CONSIDERATIONS

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and / or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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