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DETERMINE THE IMPORTANT HEAVY METALS IN AIR DUST OF ZAHEDAN, IRAN

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ABSTRACT

Air pollution is categorized among the major issues due to the fluid nature of air. The most important environmental problems in urban and industrial areas that threaten human health are due to the fact that some of these pollutants are the suspended particles in the air leading to dust phenomenon. Qualitative and quantitative evaluation of dust plays an important role in determining the origin of planning to contain and deal with them. For this purpose, due to the possible presence of metals Hg, Pb, and Cd along with dust particles, the analysis of Teflon and fiberglass filters was used in air pollution monitoring stations in the city of Zahedan. The amount of metals was measured by atomic absorption spectrometry after acid digestion. The results of this study showed that the amount of lead, cadmium and mercury measured in both types of air filters (Teflon and fiberglass) are within the limits permitted by international standards, California, EU Target WHO and Federal.

KEY WORDS : Particulate matter, Dust, Cadmium, Lead, Mercury, Air pollution, Zahedan

INTRODUCTION

Arid and semiarid regions and desert areas are constantly associated with the phenomenon of wind erosion. The symptoms of this phenomenon may affect vast areas of the region, and the scope of it including the replacement of dust can also affect humid areas and even the planet's northern latitudes (Biglari *et al.*, 2016d, Biglari *et al.*, 2016a; Biglari *et al.*, 2016c). Iran is continuously affected by the wind erosion effects with either domestic or foreign origins due to its geographical location and being located on the earth's dry zone (Sohrabi *et al.*, 2017; Moradi *et al*., 2016; Poursadeghiyan *et al*., 2016b). This event has mostly damaged to biological, socio – economic and even cultural

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resources. Although wind erosion event has a long history in our country, but in recent years, due to natural factors such as droughts and climate changes or the human factor effects such as poor management of water and soil resources, vegetation and unsustainable exploitation of land resources, the soil erosion effects have been intensified (Ebrahimi *et al*., 2016; Mirzabeygi *et al*., 2016; Poursadeghiyan *et al*., 2016a). The results of the survey indicate that the main source of recent years dust in Zahedan has generally foreign origin mostly from parts of Pakistan territory. Although this province (Sistan & Baluchistan) is also faced with the phenomenon of dust or dust storms caused by drying of Hamoon wetland. But this is a mostly local phenomenon that involves a relatively short period of time (Ranjbar and Iranmanesh, 2008). Therefore, due to the effects of dust on the atmosphere, changes in temperature, climate, rainfall, drought as well as its ability in transition of metals, pesticides, radioactive substances and organisms including bacteria and viruses and thus its entrance to the respiratory system and adverse effects on humans and other organisms' health, the importance of dust phenomenon is more evident (Zheng *et al.,* 2013; Khandan *et al.,* 2016; Mohammadi *et al*., 2015; Ghio *et al*., 2000). Dust sources exist in climates with negligible precipitation and vegetation (Rashki *et al*., 2013a; Yarmohammadi *et al*., 2016). Dust storm is also common in the northern part of the Indian subcontinent and the surrounding areas. Dust storms frequently occur on the borders of Iran and Afghanistan and Pakistan as well as the Coast of Oman Sea in Iran (Makoran), Sindh plains of Pakistan to the north-west India and indo-gangetic basin (Rashki *et al*., 2013b, Rashki *et al*., 2012, Moradi *et al*., 2016). Dust is one of the important air pollutants that can be emitted into the air whether directly through wind erosion with domestic or foreign origin including man-made and natural activities such as vehicles, industrial and domestic activities, non-asphalt roads erosion and fire or can be created in the form of secondary particles (aerosols) after being released into the environment because of reaction with different compounds such as SO2 gases (sulfur dioxide) and NOx (nitrogen oxides) mostly released from the combustion of fossil fuels, industries and traffic of automobiles. In areas with high soil erosion, dust as a major pollutant factor reduces air quality and endangers humans' health (Janssen *et al*., 2002; Morawska and Zhang, 2002; Barkhordari *et al*., 2011; Biglari *et al*., 2016b). Dust increases diseases such as meningitis, valley fever, asthma, eye infections, viral diseases and damaging to the DNA of the skin and lung cells. In addition, this phenomenon affects the birds' migration and breeding, wildlife habitat conditions and reduction of herbaceous growths and plant diversity. Moreover, the dust reduces water quality and air quality and negatively affects the plants growth and faces the habitat conditions with several challenges (Ostro *et al*., 1999; Hetland *et al*., 2004, Brook *et al*., 2010; Sajjadi *et al*., 2016; Afsharnia *et al*., 2016). The dust particles are usually a mixture of solid particles, solution or both suspended in the air and are able to remain suspended for a long time and even move few kilometers from their original source leading to an increase in the concentration of some other pollutants such as heavy metals with a series of mineral particles released into the atmosphere and can have hazardous effects on humans and other creatures' health (Joksiæ *et al*., 2009; Popescu, 2011; Tasiæ *et al*., 2010). Exposure to heavy metals has caused a wide range of disorders in humans and the ecological dangers (Mohammadi *et al*., 2015). Therefore, it seems vital to severely restrict and control the particles released in the environment because heavy metals are released into the environment in different methods. The airborne emissions are the special concern nowadays. When pollutants are released into the atmosphere, they are able to be transferred to large ecosystems more distant from the main source (Hetland *et al*., 2004; Voutsa *et al*., 1996; Schauer *et al*., 1996). Hazardous substances in the ambient air are identified by different air monitoring networks and the investigations and are considered as the main concerning constituents including: Sulfur dioxide, nitrogen oxide, ozone, particulate matters PM10, PM2.5, soot, VOC (volatile organic compounds), poly Aromatic hydrocarbons, heavy metals (in suspended solids and deposition materials), acid rain, hydrogen fluoride, dioxin, PCB 126 and toxins in the rainwater (Bascom *et al.,* 1996; Brunekreef and Holgate, 2002). Heavy metals are stable metals or stable metalloids with the density greater than 4.5 g/cm^3 (Fu and Wang, 2011). Heavy metals are natural and stable components of the Earth's crust and cannot be damaged or broken down. Thus, they tend to accumulate in soil and sediments and have a long lifetime (Davis *et al.,* 2003; Nan *et al.,* 2002). Accordingly, they remain in food chain and finally lead to neurological and movement disorders in living organisms (Shakya *et al.*, 2014; Mohammadi *et al.,* 2015). However, human's activities have severely changed the biochemical and geological cycles and the balance of some heavy metals. The main sources of man-made heavy metals include industrial point sources such as mines, foundry, metallurgical factories and sources of emission such as combustion, traffic, etc., by-products. Heavy metals are rather volatile and those that attach to airborne particles can be widely dispersed on very large scales (Al-Khashman, 2004; Mainey and William, 1999). Non-ferrous metal industries, fossil fuel, waste and traffic which are from other main sources of heavy metals in the atmosphere that appear in breathable air, suspended particles and sediment particles (Landis *et al.*, 2002). Thus, this study aimed to determine the concentrations of Pb, Cd and Hg in air pollution monitoring stations in Zahedan.

MATERIALS AND METHODS

Teflon and fiberglass filters installed in air quality monitoring station analyzers were taken to atomic absorption lab for the analysis. In these air quality monitoring stations, air samples are directed to gas and particle-measuring analyzers from among sampling probes. Particle-measuring analyzer has a probe separate from that of used for sampling gas-measuring analyzers (Dore *et al.,* 2014).

There are 10 air quality monitoring stations installed in Zahedan including three models Horiba, Ecotec and the Environment S.A. The flow rate of sampling by analyzers is based on Table 1 according to the station model. Teflon filters have been used in gas analyzers, and fiberglass filters have been applied in particles-measuring stations according to Table 2.

Table 1. Analyzers sampling flow rate according to each station

No	Device Model	Analysor	Q sampler
1	Horiba	CO	1.5 L/min
		SO_2	0.8 L/min
		NO_X	0.8 L/min
		O_3	0.8 L/min
		particles	1 m^3/hr
2	Ecotec	CO	1.5 L/min
		SO_2	0.57 L/min
		NO_X	0.57 L/min
		O_3	0.5 L/min
		particles	1 m^3/hr
3	Environment S.A	CO	1.3 L/min
		SO_2	0.45 L/min
		NO_X	0.66 L/min
		O_3	1 L/min
		Vocs	0.07 L/min
		Hcs	1.33 L/min
		particles	1 m^3/hr

Table 2. Analysis method of particle-measuring analyzers

Type of parameters	Method of analysis
Non-Dispersive Infra-Red (NDIR)	CO
UV fluorescence	SO_2
Ozone absorbs	O_3
Chemiluminescence	NOx
gas chromatography	VOCs
Flame ionization	HCs
Reduce the absorption of beta radiation	particles

Air filters digestion

To digest air filters for measuring metals, each Teflon, fiberglass and also raw filter samples (from each of the above filters) were separately digested as control according to the corresponding strategy.

Teflon filter sample digestion method

The samples were digested by microwave (Berghof MWS-2). First, a teflon filter sample was put in special microwave containers and 5 mL nitric acid (65% wb) and 2 mL concentrated fluoridric acid were added to it and then was left at room temperature for 1 hour. After this time, the containers were placed in a microwave according to a specific temperature and time schedule based on Table 3.

After this phase, and after cooling the containers, the samples were taken to the special volumetric dishes containing Boric acid (0.8 g) and were reached to the volume of 50 mL using deionized water. At this stage, the sample was ready to be injected to the device (Danadurai *et al.*, 2011; de Leeuw and Ruyssenaars, 2011).

Fiberglass filter samples digestion method

These samples were digested by microwave

Table 3. Special temperature and time schedule of microwave to digest the air filters sample

Temperature°C	Time	energy % (minutes / seconds)	Program
50	10	100	1
100	10	100	2
200	22	100	3

(Berghof-MWS-2) according to the solution of digesting Teflon filter samples. But with the difference that at least 10 cm of fiberglass filter sample was placed in microwave containers and other steps were taken according to aforementioned solution (Brunekreef and Holgate, 2002).

Measuring metals in digested filter samples

Determination of metals Cd, Ni, Pb in Teflon and fiberglass filters and also control samples after digestion with atomic absorption Varian 240 at wavelengths specific to each metal lamp (cadmium in 228.8 nm and lead in 217 nm) and Hg metal was measured by Mercury analyzer Milestone DMA 80 (Fu and Wang, 2011).

The final computation

Teflon filters samples: After obtaining data on the concentrations of metals in the solution obtained from digestion by atomic absorption spectroscopy, metal concentration in the Teflon filters samples was calculated as follows (the results are represented in Table 4).

$$C = \frac{Gs \times V}{t \times D}$$

C is the metal concentration in air sample (μg / m^3), Gs is the concentration of metal in metallic solution resulted from digestion (mg/L), V is the volumetric dilution (50 mL), t is the time the filter is exposed to air (min), D is the flow rate (L/min).

$$C = \frac{Gs \times V}{t \times D \times P}$$

Fiberglass filters samples: After obtaining data on the concentrations of metals in the solution obtained from digestion by atomic absorption spectroscopy, metal concentration in the Teflon filters samples was calculated as follows as represented in Table 4.

C is the metal concentration in the air sample (μg / m^3), Gs is the concentration of metal in metallic solution resulted from digestion (mg/L), V is the volumetric dilution (50 mL), t is the time the filter is exposed to air (min), D is the flow rate of each point (L/min) and P is the number of points sampled on the fiberglass filter.

RESULTS AND DISCUSSION

In this study, metal absorption by Teflon and fiberglass filters installed in air pollution monitoring stations (exposed to dust and dirt) to determine the concentration of heavy metals cadmium, mercury and lead in the air was studied. After the sampling, preparation and analysis of samples, the results were obtained based on Table (4). Table (4) represents the results of measuring the concentrations of Hg, Pb and Cd in fiberglass and Teflon filters installed in the Zahedan stations in times with most air pollution. Table (5) represents the annual average concentration of metals based on international valid standards EU Target, WHO, California and Federal (Dore *et al.*, 2014; de Leeuw and Ruyssenaars, 2011).

Figures 1 to 3 compare the concentrations of the metals measured in Fiberglass and Teflon filters installed in the studied stations with the international valid standards according to Table 5.

The results obtained in this research showed that lead and mercury levels measured in both types of air filters (Teflon and fiberglass filters) in all stations of Zahedan according to California Air Resources Board standards (1.5 μg/m^3, the 30-day average for lead) and WHO EU Target value standards (0.5 mg/m^3, the annual average for lead and 1 mg/m^3 for mercury) in pollution limits.

The results showed that the concentration of cadmium in fiberglass filters in Zahedan according to available standards WHO and EU Target value are within the permitted values. Figures 1 to 3

Table 4. Analysis results of the metal parameters in fiberglass and Teflon filters, in Zahedan stations

No	Sampling point	Factors assessed (μg m^{-3})		
		Cd	Hg	Pb
1	Weather stations (Filter Faybrglas^{-1})	0.0002	0.0009	0.04
	Weather stations (Teflon filter, gas CO^{-1})	0.001	0.0004	0.01

Table 5. The average concentration of annual standards of metals according to international valid standards

Metals	Standard of EuTarget value	Standard of WHO(μg m^{-3}) (μg m^{-3})	Standards of California & Federal (μg m^{-3})
Cd	0.005	0.005	-
Pb	0.5	0.5	1.5
Hg	1	1	-

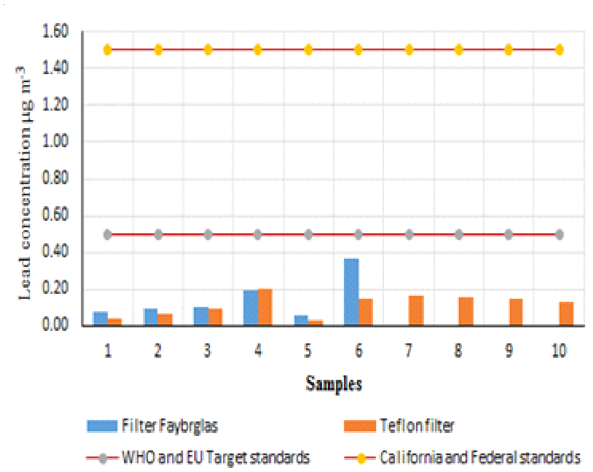

Fig. 1. Comparing the average concentration of lead in fiberglass and Teflon filters with international standards.

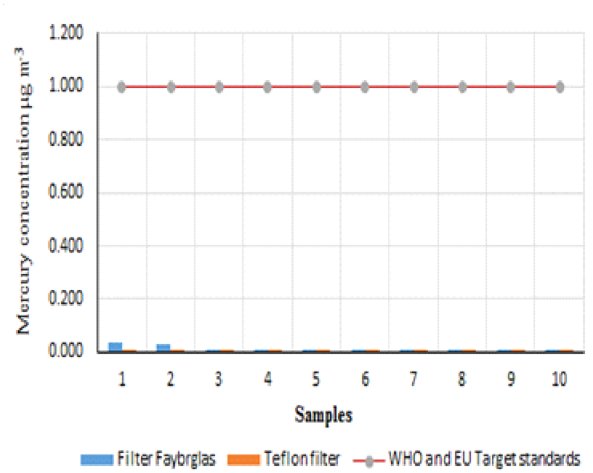

Fig. 2. Comparing the average mercury concentration in fiberglass and Teflon filters with international standards

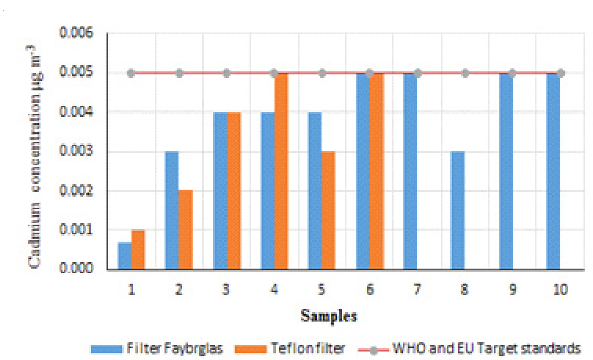

Fig. 3. Comparing the average concentration of cadmium in fiberglass and Teflon filters with international standards

showed that the concentrations of mercury and lead in both Teflon and fiberglass filters are very low compared to international valid standards EU Target¡ WHO¡ CaliforniaandFederal and are within the proposed permissible standards. The above finding is evidence that small amounts of these metals are available in dust.

CONCLUSION

This study aimed to measure the concentration of heavy metals in the air of Zahedan and the results showed that the levels of lead, cadmium and mercury measured in both types of air filters (Teflon and fiberglass) are below the permissible limit of pollution based on the international valid standards EU Target WHO, California. Therefore, despite the phenomenon of concentrated dust in all seasons, there is no concern for the presence of heavy metals of lead, cadmium and mercury.

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