A comparative study of $PM_{2.5}$ and PM_{10} concentrations between Iran and Australia and identification of their sources in Iran

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Abstract

This paper aimed to compare particulate matter (PM) concentration between Iran and Australia and then addressed the causes of the quantified differences in PM concentrations between these two countries. In addition, we reviewed the sources of PM in Iran and potential controlling methods. High level of PM, in particular, PM_{10} and $PM_{2.5,}$ has negative impact on the air quality, soil resource management, crop productivity, human health and climate. We collected annual average $PM_{2.5}$ and PM_{10} concentration data from world health organization (WHO) database for all cities in these two countries from 2010 to 2014and conducted a comparative data analysis. The results showed that the annual averaged $PM_{2.5}$ and PM_{10} concentrations in Iran were 80 ± 10 and 100 ± 20 $\mu g/m^3$ respectively, which was 10 times higher than Australia. The main causes of high PM value in Iran, especially in Ahvaz and Zabol, are draught, water deficiency, climatic changes, long-range transport and divert water. In order to control high level of PM concentrations especially for dust stabilization in Iran, many studies applied different methods, including biopolymer, chemical polymer, planting in salinity and draught soil. However, but the results were not satisfactory. It is suggested that different control strategies should be targeted in different regions of Iran considering local/regional emission sources and meteorological condition. In addition, the government should provide more funds to conduct suitable urban planning management research for the water and soil resources management in Iran to minimize the negative impact of dust storms.

Keywords: Aggregate Stability, Dust, Iran, Australia, Particular Matter

1. Introduction

Particulate matter (PM) is a term used to describe the mixture of solid particles and liquid droplets in the air. It can be either human-made or naturally occurring. Dust, ash and sea-spray are very common form of PM. PM varies in size, a few nanometers to couple of micrometer. PM's mass concentrations are generally $PM_{2.5}$ (particle mass of less than 2.5µm in diameter) and PM_{10} ((particle mass of less than 10µm in diameter).

Inhalation of particulate pollution can have adverse effect on human health, and the recent studies suggest that there is no safe threshold of PM. Exposure to high concentrations of PM (e.g. during short-term pollution episodes) can also exacerbate lung and heart conditions, significantly affecting quality of life, and increase deaths and hospital admissions. Both the children and elderly as well as those with predisposed respiratory and cardiovascular disease are known to be more susceptible to the health impacts from air pollution (Organization, 2006) . Human-made sources of PM are more important than natural sources, which make only a small contribution to the total concentration. Within towns and cities in Iran, the major

emission sources of PM are road traffic, degradation of soil, and the mismanagement of lands (Organization, 2006). Consequently, levels of PM_{10} close to eastern Iran border are often much higher than those in central locations. In recent years, extreme PM concentrations especially dust are a major concern for the governments in Iran as the PM concentrations exceeded World Health Organization (WHO) guideline in all cities, which leads to adverse health effects.

In this context, this paper analyzes PM concentration data collected from WHO database (updated 2016) in whole Iran and Australia cities. We used WHO PM database for $PM_{2.5}$ and PM_{10} from 2010 to 2014. The database contains annual mean for $PM_{2.5}$ and PM_{10} concentrations for all major cities in Iran and Australia. In case of Iran, a major challenge for assessments of $PM_{2.5}$ and PM_{10} associated health impacts due to the lack of ground-based monitoring networks and representative exposure estimates. This paper aimed to compare annual mean PM concentration between Australia and Iran and highlights the level of PM pollution in Iran compared to Australia which is considered one of the clean ambient air qualities. Following this we will discuss the sources of PM pollution in Iran and the difficulties in improving air quality.

2. Results and discussion

2.1 $PM_{2.5}$ and PM_{10} concentration

The results found that the annual averaged concentrations $PM_{2.5}$ and PM_{10} were 80 ± 10 and 100 ± 20 $\mu g/m^3$, respectively for Iran which is about 10 times higher than Australia (Figure 1).PM_{10} concentrations were generally higher in Ahvaz and Zabol compared to other cities in Iran (Figure 2). The dispersion of soil fine particles are the major cause of high PM concentration in these two cities. PM concentrations are generally higher in the cities located on the east of Iran than on the north due to relatively large dust emissions rate and unfavorable meteorological conditions for pollution dispersion (Figure 2). This suggests that different control strategies should be targeted in different regions of Iran considering local/regional emissions and meteorology. PM concentrations were higher in the summer seasons due to the significant contributions of PM to dust particles in Iran. In addition, we observed that the lowest and highest $PM_{2.5}$ often occurs in the rainy and dry days, respectively (Figure 3).

In this study, all statistical analysis was performed in statistical analysis software (SAS). Tukey honest significant difference (HSD) test was used to determine if significant differences occurred between the dry and rainy days at 0.05 levels. Figure 3 shows that PM_{10} and $PM_{2.5}$ concentrations are significantly different between rainy days (days with more than 0.1mm of rain) and dry days (days with less than 0.1 mm of rain) at the 0.01($P<0.001$) and at the 0.05 ($P<0.036$) level, respectively.

2.2 PM sources in Iran

As mention in section 2.1, the dispersion of fine soil particles are the major cause of high PM concentration in the cities located on the east of Iran. Wind erosion and dust storm generated soil particles which was then undergone subsequent deposition. Wind erosion is a geological and climatic phenomenon which happens over long periods of time in arid and semi-arid regions where the ground surface typically lacks a continuous vegetation cover (Shao, 2008). When the wind blows over loosely held particles increases, sand particles first start vibrating and then to saltation. As they repeatedly strike the ground, they loosen and break off smaller particles of dust, which then begin to travel in suspension (Burri, 2011). At wind speeds above that, which causes the smallest to suspend, there will be a population of

dust grains moving by a range of mechanisms: suspension, saltation and creep. Wind erosion can also produce dust storms and shifting sand dunes. Large amounts of minerals and organic matter are carried with the dust particles and redistributed in the continental scale.

Particles suspended in the atmosphere play an important role in the climate system, as they influence the atmospheric radiation balance directly, through scattering and absorbing various radiation components, and indirectly, through modifying the optical properties and lifetime of clouds (Shao, 2008). The global dust emission is estimated to amount to 3000 Mt yr^{-1}, with estimates varying between 1000 and 10000Mt yr^{-1} (Duce et al., 1991). Human activities such as excessive clearing of native vegetation, overgrazing and inadequate agricultural practices can substantially increase soil erosion. Such human activities have caused profound impact on soils and vegetation, resulting in increased frequency and intensity of wind erosion in many parts of the world with adverse effects on soil resources, crop productivity, human health, and climate (Lal, 1994 ;Montgomery, 2012).

2.3 Major causes of dust storms and its effects

Dust storms are the results of much interdependent factors across several regional countries in Middle East. Several major causes of dust pollution include years of inappropriate farming practice, mismanagement of water resources and climate change continue to contribute to reduced vegetation coverage, desertification and droughts. Droughts and arid conditions favor the dissolution of soil particles, and wind contributes to the production of dust. Considering these negative impacts of droughts on environmental and human health, land degradation in drylands is identified as one of the major environmental issues of the 21 century (UNEP, 1995).

The draught and increase in ambient temperature have caused disintegration of the top soil layer, and the absence of the vegetation increased dust pollution. Besides the natural factors, several anthropogenic factors accelerate disintegration of the top soil layer, such as, haphazard driving, military actions, constructions of roads, water mismanagement, and abandoning of the agricultural lands due to economic impact on the social life:, in particular the farmers. (Varoujan K et al., 2013).

The impact of the dust and dust storms has a profound impact on all human activities. Dust effects on health, social life, economics, transportation, and many other activities. They reduce visibility, deposited on skin and clothes, infiltrate buildings and find their way into food and drinking water, leaving an irritating sandy feeling in human mouth. Dust has a negative impact on agriculture sectors in many way, including (i) reducing crop yields by burial of seedlings under sand deposits, (ii) the loss of plant tissue and reduced photosynthetic activity as a result of sandblasting, (iii) delaying plant development, (iv) increasing end-of-season drought risk, (v) causing injury and reduced productivity of livestock, (vi) increasing soil erosion and accelerating the process of land degradation and desertification, (vii) filling up irrigation canals with sediments, (viii) covering transportation routes, (ix) affecting water quality of rivers and streams, and (x) affecting overall air quality.

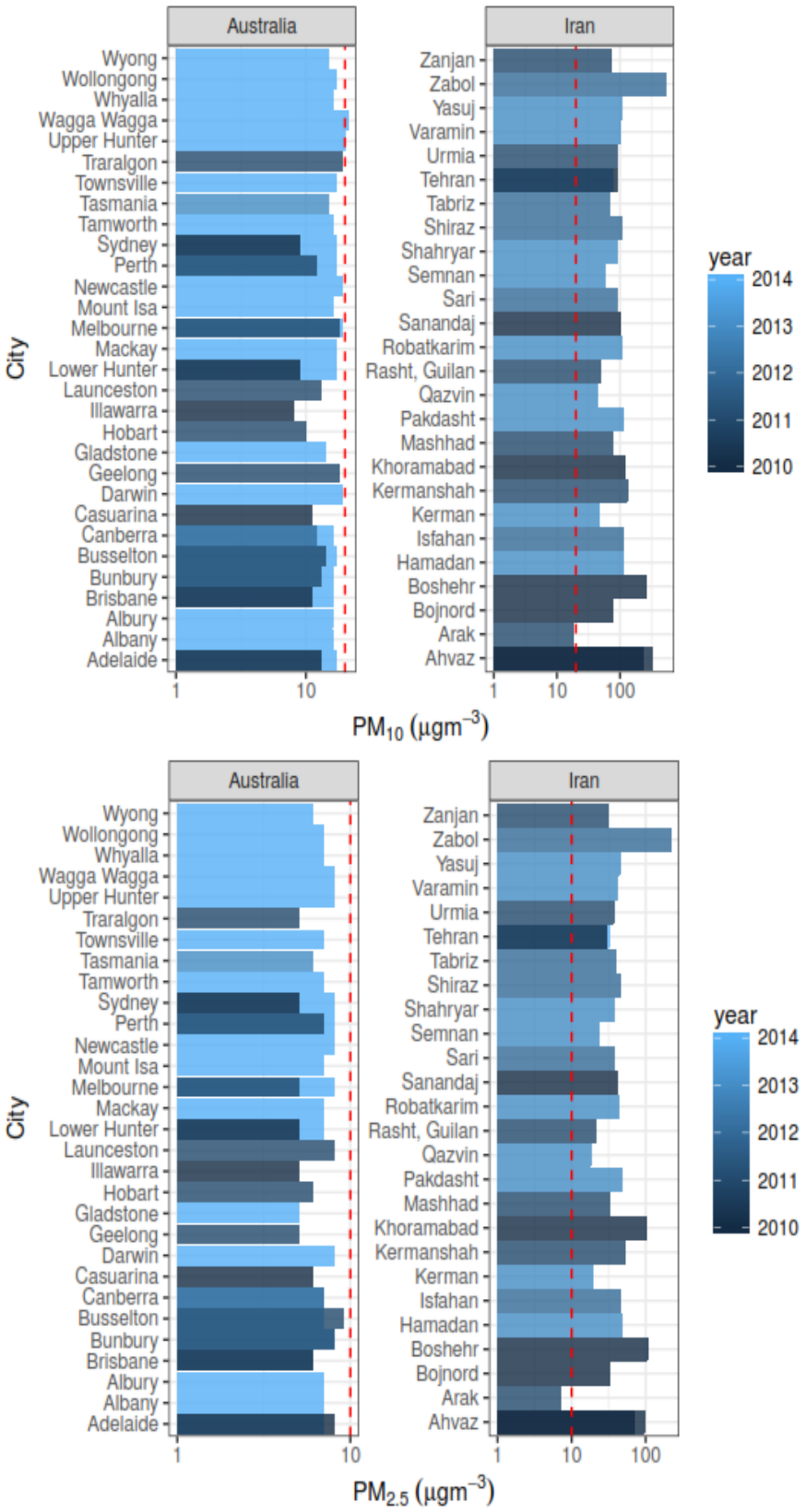

Figure 1 PM Level for whole cities In Aus and Iran in the period 2010-2014

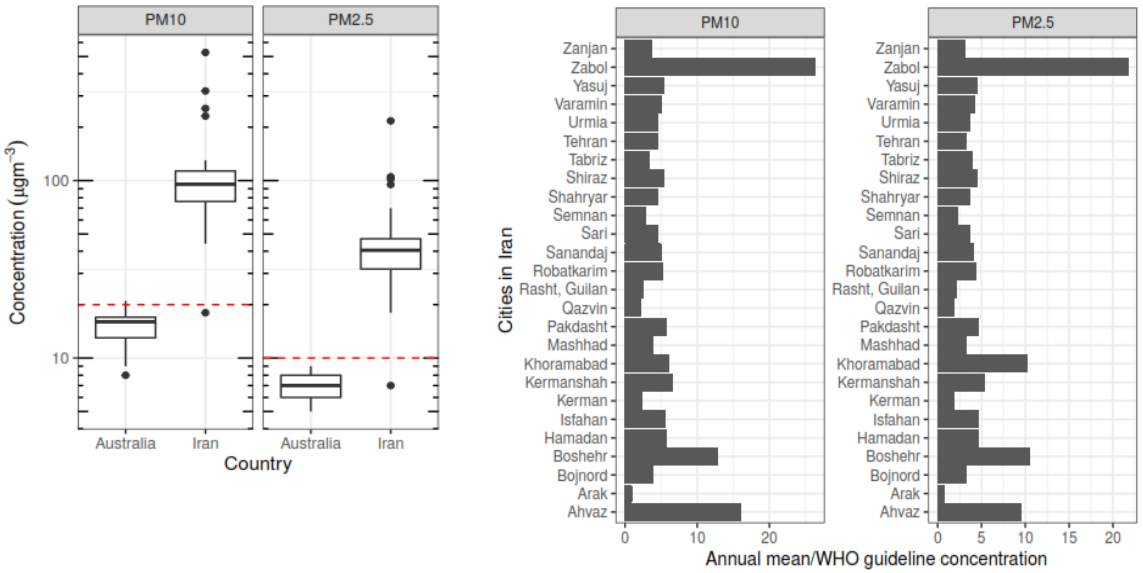

Figure 2 PM_{10} and $PM_{2.5}$ according to WHO guideline concentration

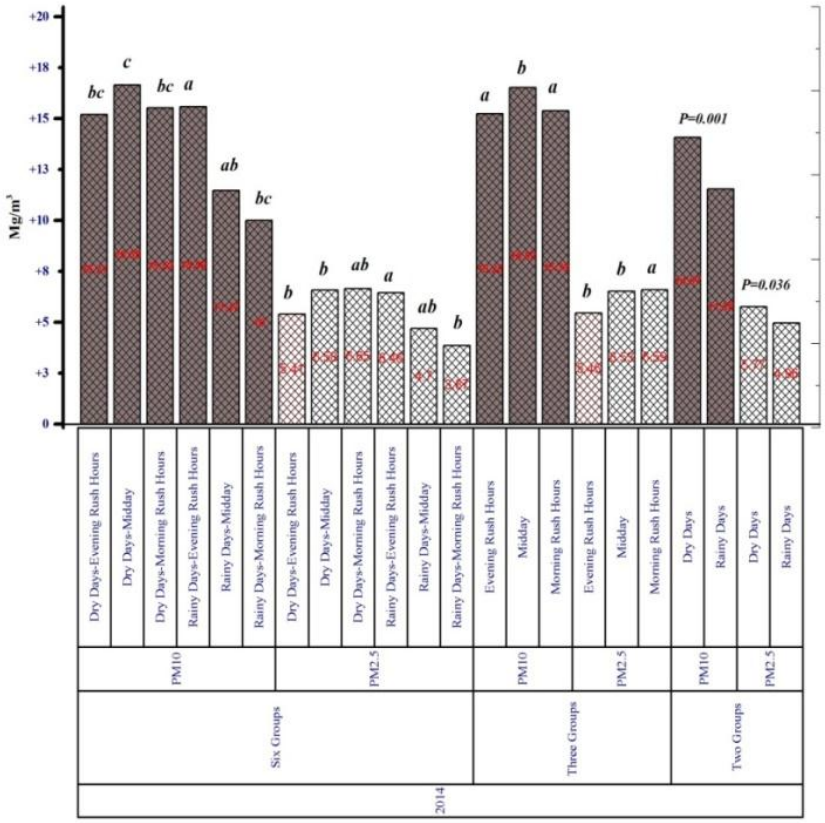

Figure 3 Tukey HSD[a], T-test analysis with Subset for alpha = 0.05, 0.01
Variables with the same letter in the top of each column are not statistically different at the 0.05 level

Overall results and recommendation

1. $PM_{2.5}$ measurements can directly be linked to human health risks.
2. In high-income countries, like Australia PM concentrations are regularly monitored performed but in developing countries like Iran PM data are not monitored regularly. Therefore, governments need to take initiative to establish department of monitoring of environmental air quality database.
3. Iran needs much more effective policies and research that could mitigate complex PM pollutions, reduces dust concentration, and achieves sustainable development.
4. The main reason for increasing of the regional dust and dust storms is draught, mismanagement of water.
5. The main reasons for increasing of local dust occurrences are haphazard driving, military actions, and construction of roads (Varoujan K et al., 2013).
6. The dust and dust storms have negative impact on the humans health, economy, transportation, and other social events (Varoujan K et al., 2013)
7. To minimize the dust storms, the government should prudently manage the water resources of Iran. With mismanagement of the water for example in Isfahan and Chaharmahl and Bakhtiari provinces due to divert water, many of the greatest rivers are shrinking and drying up also groundwater wells for local people are being affected. The overuse and diversion of the water is largely to blame. With this condition we would not be surprised in future to hear that one of the major dust sources is in the Chaharmahal and Bakhtiari province.
8. The government should provide more funds to conduct suitable urban planning management research for the water and soil resources management in Iran to minimize the negative impact of dust storms.

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