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- ***Short report***

Instrumental neutron activation analysis of air suspended particles in Rasht city, Iran

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Background: In addition to gas pollutants, many chemicals and air pollutants are in the form of particulate matter. Particulate matter consists of a complex mixture of variable sized particles and physicochemical composition. These particles mainly contain minerals including Fe, Al, Ca, K, Cu, Ti, Mn, Ni, V and their size, chemical composition and concentration are important to assess the extent to which people has been protected. *Materials and Methods:* Instrumental neutron activation analysis (INAA) was employed to determine the composition of elements in material collected on whatman 41 filter using high volume air sampler in Rasht. Conce ntration of elements including Al, Ca, V, Mg, Cu, Ti, K, Ba, Cl, Mn, Na, As, Br, Cr, La, Sb, Co, Fe, Hg, Sc and Zn were determined in samples. *Results:* Results showed that the levels of most air pollutants in Rasht to be lower than those measured in other cities in Iran (Tehran, Esfahan and Shiraz) by the same technique. Compared to other cities in world except for some elements, mean concentration of elements in air in Rasht were lower than those reported for Milan, Pavia and Beijing. *Conclusion:* Although the level of most air pollutants in Rasht are lower than those measured in other cities in Iran, due to considerable differences in element concentrations depending on the day of sample collection, more detailed studies are needed to control the emission of pollutants in this region. **Iran. J. Radiat. Res., 2011; 9(2): 139-143**

Keywords: *Instrumental neutron activation analysis (INAA), air pollutants, particulate matter, Rasht city, toxic elements.*

INTRODUCTION

Air supplies us with oxygen which is essential for our bodies to live. Air is 99.9% nitrogen, oxygen, water vapor and inert gases. One type of air pollution is the particulate matter (PM) in the air. A large number of studies have been carried out on the elemental compositions of particulate and association between human exposure to this type of pollution and occurrence of sever all type of problems (1-3) health.

Another type of pollution is the release of noxious gases, such as sulfur dioxide, carbon monoxide, nitrogen oxides and chemical vapors.

According to WHO (World Health Organization) assessment of the burden of disease due to air pollution, more than 2 million premature death each year can be attributed to the effect of urban outdoor air pollution and indoor air pollution (caused by the burning of solid fuels). More than half of this disease burden is borne by the population of developing countries (4). Recognizing the need of human for clean air, WHO Air quality guidelines have been published since 1987. The guidelines are intended to provide background information and guidance to (inter) national and local authorities to make risk assessment and risk management decisions (5). They also provide a basis for setting standards or limit values for air pollutants. Specific groups at risk should be protected and degree of risk should be considered. National standards may differ from country to country and they might be above or below the respective WHO guideline values. As a part of air quality

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monitoring programs development in order to determine and control the emission of pollutants in different cities in Iran, the main aim of this research was to determine concentration of elements in the air of Rasht city, Guilan province (northwest of Iran) and to compare the obtained results with those measured in other cities.

MATERIALS AND METHODS

Particulate matter was collected at two sampling sites A and B all located in Rasht city, Iran (figure 1). Sampling site A (University of Guilan) which was located in the south of Rasht is more crowded than sampling site B (Golsar). Samples were collected on whatman 41 filter using air sampler operating at $6m^3h^{-1}$ for 12 hours. The collection was carried out during winter -summer 2009 and 100 samples were collected during that period. Instrumental neutron activation analysis was employed to determine the composition of the elements in material collected on the air filter. For elemental analysis, the filters were cut in to four parts. Using pneumatic sample transfer system, one quarter of the filter was irradiated along with standard of elements SN-D-1/2 supplied from IAEA (International Atomic Energy Organization) for 2 minutes at Tehran research reactor. The thermal neutron flux utilized was about 3×10^{13} n $cm^{-2}s^{-1}$. Samples and standard were measured immediately after irradiation to determine V, Al, Ca, Mg, Ti and Cu. After one hour decay time (for decay of short half life radionuclides), the same sample standard and were measured again to determine K, Ba, Cl, Mn and Na.

To determine of Zn, Sc, Sb, As, Br, Cr, Fe, Hg, La and Co second quarter of the same filter and standards were irradiated for 2 h and were measured after one and two weeks decay times.

Measurements were carried out using HPGe detector with 10 percent relative efficiency coupled to gamma ray spectrometer. The quantities of the elements in each sample were calculated through comparative method, the radioisotopes used in these determinations are listed in table 1 (6).

The blank of the filter was also analyzed and considered in these calculations, with the quantity of each element in the filter and having the volume of air suctioned, the concentration of elements in the air was calculated. For verification and evaluation of analytical method, two IAEA's standard

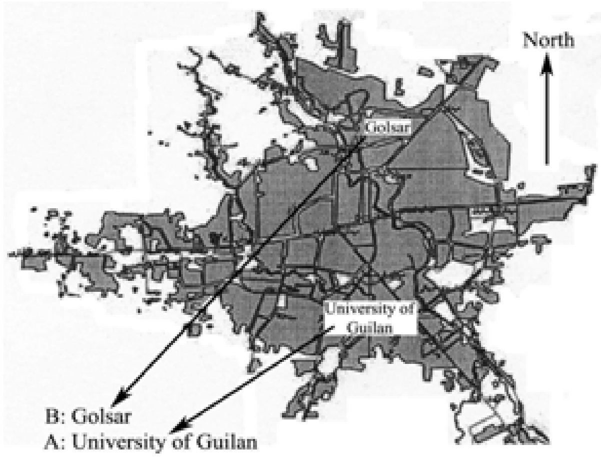

Figure 1. Location of the sampling sites on the Rasht map.

Table 1. Radionuclides, their main photopeak energy and half life.

Element	Radionuclide	Energy (keV)	Half life
Al	^{28}Al	1779	2.24m
As	^{76}As	559	26.30h
Ba	^{139}Ba	166	83.30m
Br	^{82}Br	554	35.40h
Ca	^{49}Ca	3084	8.27m
Cl	^{38}Cl	2168	37.20m
Co	^{60}Co	1173	5.27y
Cr	^{51}Cr	320	27.70d
Cu	^{66}Cu	1039	5.10m
Fe	^{59}Fe	1099	44.50d
Hg	^{203}Hg	279	46.60d
K	^{42}K	1525	12.40h
La	^{140}La	1596	1.68d
Mg	^{27}Mg	1014	9.45m
Mn	^{56}Mn	847	2.58h
Na	^{24}Na	1368	15.00h
Sb	^{122}Sb	564	2.72d
Sc	^{46}Sc	889	83.80d
Ti	^{51}Ti	320	5.76m
V	^{52}V	1434	3.75m
Zn	^{63}Zn	1115	243.00d

reference materials (SL-1 and SD-N-1/2) were chosen and the accuracy and precision of the analytical procedure were estimated by comparison to the certified values. Uncertainty components associated with analytical techniques (including counting statistics, reported standard mass and sampling) were determined and total uncertainty of the measurements were estimated to be within 10-30% in 95% confidence level.

RESULTS AND DISCUSSION

Development of air quality monitoring programs in order to determine and control the emission of pollutants is of great importance. Collected data together with WHO air quality guidelines may be used to assess the extent to which the environment (including people) has been protected from adverse effect of air pollutants. These guidelines also provide basis for setting national ambient quality standards on the limit of toxic elements. As a part of development of air quality monitoring programs in Iran, concentration of elements in the air of Rasht, Guilan province (northwest of Iran) were measured and the following results were obtained.

Table 2 shows the mean concentration of elements in TSP (Total Suspended Particulates) samples collected in Rasht also samples collected in Esfahan [7], Tehran [8], Shiraz [9], Beijing [10], Pavia [11] ,and Milan [12], by other researchers.

INAA of air suspended particles

Table 3 contains WHO guidelines for concentrations (μg m^{-3}) of As, Cd, Cr, Mn, Hg and V in ambient air [5] .A guideline is defined as any kind of recommendation or guidance on the protection of human beings or receptors in the environment from adverse effects of air pollutants. As such, a guideline is not restricted to a numerical value but might also be expressed in a different way, for example as exposure-response information or as a unit risk estimate. A guideline value is a particular form of guideline which provides concentration below which no adverse effects are expected.

As presented in table 2, except for Br, mean concentrations of air pollutants in Rasht were lower than those reported for Esfahan [7]. Besides, only concentrations of Cr and Zn in air of Shiraz [9] are lower than those in Rasht. Compared to Tehran[8], concentrations of most measured elements including Al, As Ba, Br, Ca, Co, Fe, K, La, Mg, MN, Sb, Ti, V and Zn in Rasht were lower than those reported for Tehran[8]. Lower concentrations of air pollutants in Rasht were related to different parameters like the sources of air pollution (transportation, burning of fossil fuels, factories, office buildings, industrial process…) and geography of these cities. Esfahan, Tehran and Shiraz are among most populated cities and are commercial and industrial cities where as, Rasht is turning into industrialized city. Thermal inversion that traps the air pollutants in Esfahan and Tehran is frequently observed (more than 250 days per year) and average annual rainfall in Rasht is at least four times greater than annual rainfall in other under study cities. Compared to other cities in the world concentrations of all measured elements in Rasht were lower than the concentrations obtained from measurements of PM_{10} samples collected in Beijing [10] and only the concentration of Cu, La and Ti in Milan [12] and concentration of As, Co, Cu, La, Sc and Ti in Pavia [11] were less than those measured in Rasht.

In addition, the obtained results indicated that there was a great variability among concentrations of elements in the air of Rasht, depending on the day of sample collection denoted by the standard deviation of the mean concentrations. Therefore, more detailed studies are needed to control the emission of pollutants in this region.

Considering protection of public health and of ecosystems from adverse effect of air pollution, mean concentrations of the measured inorganic pollutants in Rasht were used with WHO air quality guidelines in table 3[5] for risk assessment on the exposed population. Results from this comparison show that mean concentrations of As, Cd, Cr, Hg, V and Mn in Rasht were in agreement with WHO air quality guidelines

Table 2. Comparison of mean concentration of the measured air-pollutants (μg m^{-3}) in Rasht with those reported for other cities.

Element	Rasht Min-Max mean ± SD 2009	Esfahan [7] mean 2008	Tehran [8] Mean 2001	Shiraz[9] mean 2000	Beijing[11] mean 2008	Pavia[11] mean 1999	Milan[12] mean 1998
Al	1.60E–01 – 6.51E+00 1.71E+00 ± 1.24E+00	4.48E+00	2.86E+00	2.56E+00	4.69E+00	–	–
As	9.32E–05 – 5.50E–02 3.52E–03 ± 7.20E–03	3.39E–02	2.92E–02	–	5.82E–02	3.00E–03	4.60E–03
Ba	1.03E–02 – 1.05E–01 3.69E–02 ± 2.70E–02	1.20E–01	–	–	–	5.70E–02	1.12E–01
Br	9.52E–03 – 3.78E–01 3.82E–02 ± 5.70E–02	3.21E–02	2.21E–01	4.13E–01	–	4.15E–02	3.42E–01
Ca	1.15E+00 – 1.11E+01 3.53E+00 ± 1.84E+00	2.02E+01	5.34E+00	1.33+01	1.20E+01	–	–
Cl	1.24E+00 – 6.17E+00 2.66E+00 ± 9.90E–01	6.02E+00	1.42E+00	–	–	–	–
Co	7.67E–04 – 9.31E–03 3.35E–03 ± 2.00E–03	6.37E–03	3.81E–03	–	4.23E–03	1.70E–03	4.30E–03
Cr	5.68E–04 - 9.98E–02 1.94E–02 ± 2.00E–02	3.25E–02	1.07E–02	1.50E–02	2.32E–02	2.50E–02	6.50E–02
Cu	2.32E–02 – 1.93E–01 1.13E–01 ± 4.00E–02	1.56E–01	8.05E–02	1.22E–01	1.57E–01	4.65E–02	6.50E–02
Fe	7.90E–01 – 5.66E+00 2.19E+00 ± 1.28E+00	8.31E+00	2.27E+00	2.62E+00	5.87E+00	2.60E+00	2.70E+00
Hg	1.07E–04 – 1.65E–03 5.58E–04 ± 4.40E–04	2.08E–03	5.29E–04	–	–	8.00E–04	1.70E–03
K	1.00E–01 – 3.60E+00 7.32E–01 ± 6.50E–01	3.68E+00	1.09E+00	–	–	1.05E+00	9.34E–01
La	9.91E–05 – 9.65E–03 1.79E–03 ± 2.00E–03	6.20E–03	2.13E–03	–	–	1.00E–03	1.50E–03
Mg	2.10E–01 – 3.50E+00 7.04E–01 ± 4.80E–01	2.34 E+00	8.60 E–01	–	–	2.96 E+00	3.10E+00
Mn	1.04E–02 – 9.76E–02 3.69E–02 ± 2.00E–02	1.43E–01	5.57E–02	5.30E–02	2.96E–01	5.25 E+00	7.80E–02
Na	4.80E–01 – 3.70E+00 1.23E+00 ± 6.20E–01	3.22 E+00	1.13 E+00	–	–	–	–
Sb	8.91E–04 – 9.97E–03 2.47E–03 ± 1.70E–03	3.90E–03	1.38E-02		4.37E–02	1.20E–02	5.70E–02
Sc	1.01E–04 – 1.97E–03 5.71E–04 ± 4.60E–04	1.84E–03	5.07E–04	8.00E–04	–	5.50E–04	1.00E–03
Ti	2.33E–02 – 4.80E–01 1.44E–01 ± 9.30E–02	7.11E–01	2.23E–01	–	3.37E–01	1.09E–01	7.60E–02
V	1.01E–03 – 1.26E–02 4.01E–03 ± 2.50E–03	2.27E–02	2.43E–02	9.00E–03	1.35E–02	1.68E–02	3.40E–02
Zn	2.04E–02 – 1.80E+00 1.69E–01 ± 2.50E–01	2.14E–01	5.07E–01	8.50E–02	1.09 E+00	2.16E–01	2.39E–01

for inorganic pollutants so, in the case of human health at these concentrations no adverse effects or no nuisance or health significance are expected.

Table 3. WHO air quality guidelines for inorganic pollutants (μg m^{-3}) [(5)].

Element	Guidelines	Access life time risk level
Arsenic	66.0E-03 6.6E-03 5.0E-03	1:10000 1:100000 1:1000000
Cadmium (VI)	5.0E-03	
Chromium	2.5E-03 2.5E-04 2.5E-05	1:10000 1:100000 1:1000000
Mercury *	1.0	
Vanadium **	1.0	
Manganese ***	1.5E-01	

* For inorganic Mercury as an annual average.
** For average time 24 hours.
*** Guideline value.

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