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Investigation on Radon Concentration in the Tehran Subway Stations, in Regard with Environmental Effects

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Abstract: Human beings exposed to many environmental irritative factors through their lives. One of these factors that affect the human body is the radioactive materials and ionizing radiation radon and its radioactive short life decay products, which are considered as a major natural radiation source especially in interior spaces such as homes and underground buildings like mines and subway tunnels. This issue has been focused internationally by the health organizations through out the world. Increasing radon concentration in respiratory gases and also in reparatory tract will cause the related tissues to be exposed to the alpha radiation produced by radon decay and it's products and finally will increase the risk of lung cancer. Hence evaluation and measurement of radon concentration in interior spaces and subway station is of the most importance. The present study was conducted to measure the radon concentration in subway of Tehran. 16 stations were selected randomly from 22 stations and radon concentrations were measured with Alpha GUARD instrument. The radon concentrations have been measured in some European cities. For example radon concentration of 12.36 Bq m^{-3} was reported in the subways stations of Prague. Result showed that the radon concentration is 14.19 Bq m^{-3} in subway stations of Tehran which is almost equal to the amount measured in subway of Prague. As the threshold radon concentration is 148 Bq m^{-3}, the quantity measured in Tehran is below the admissible dosage.

Key words: Radon concentration, radon measurement, subway stations

INTRODUCTION

Human body is surrounded by natural radioactive sources. In this regard, bodily tissues are susceptible to the hazardous radiation from the environment (Eisenbud, 1987). The sources of Radon gas in the buildings such as houses and offices includes the soil underneath the foundation of the buildings, building materials, fossil fuels applied for natural gas and consuming water. The level of importance of these resources in releasing Radon, relates to the situation of the building, concentration of the gas and its origin (Radium 226) in the mentioned sources. It is obvious that with more concentration of Radon gas or Radium 226 in the mentioned sources and in the case of closer contact between house or office and the ground, higher concentrations of this gas and the relevant bio-scattering will occur inside the space of the buildings; thus the residents will be encountered with higher doses of this gas through breathing process (Lubin and Boice, 1989). It is obvious that the buildings located in lower floors are exposed much more to radon (Henriksenst, 2003), hence radon is named soil gas. According to the studies, radon content in underground mines is several times more them the ground level (Henriksenst, 2003). Accordingly people who are residues of lower level of buildings or indoor spaces and travel of them in places like subway stations, maybe more exposed. In a similar study which was performed by Sabol (1995) the more radon content in Prague subway stations was reported to 12.4 Bq m^{-3}. In the studies performed in Prague and Helsinki subway stations the radon content was less then permissible dose is 148 Bq m^{-3} (EPA, 1998). One of the high-risk places for cancer with high concentration of radon gas is the underground subway stations. Due to daily subway application, determination of Radon concentration is of high importance.

MATERIALS AND METHODS

This research was accomplished through a descriptive method in Tehran Subway Stations. This descriptive

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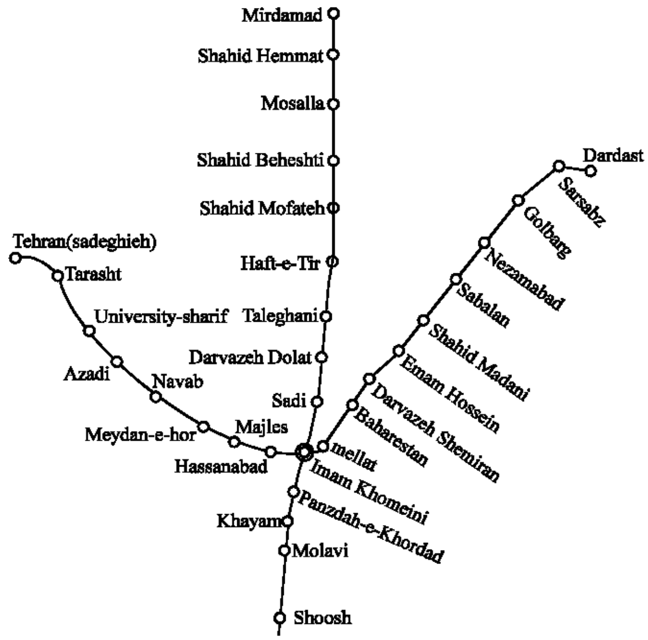

Fig. 1: Line 1 and Line 2 of Tehran Subway (Subway Development Office, 2002)

study was performed to evaluate and measure the radon gas content in two lines of Tehran's subway stations were under taken in autumn/winter 2005. With the cooperation of Iran Atomic organization and after obtaining the authorization of Tehran and environs Rail road company, 16 stations were randomly selected among 22 current underground stations and the ratio of radon were determined in them by ALPHA Guard Instrument. This Instrument is built by Genitron Instruments GmbH of Germany (4). Analysis of the data is conducted through *A*lpha Expert software (Genitron Instruments, 1994). In this regard, one station has been assessed per day. At the beginning the measurement instrument was placed in the arrival part and then in the middle part of the station and finally in the terminal part of station for an hour. In each location the rate of measured Radon was determined by the mentioned instrument in the period of 10 min continuously. Among 16 determined stations, 8 stations from line 1 of the subway and 8 stations from line 2 of subway were selected. Accordingly, Imam Khomeini station which is placed at the cross-section of line 1 and line 2 collectively, a number of 8 stations from line 1 including Mir Damad, Mosalla, Mofatteh, Haft-e-Tir, Darvaseh Dollat, Saadi, 15th of Khordad, Molavi and 8 stations from line 2 including Imam Khomeini station, Hasan Abad, Parlement, Sharif, Navvab, Hor, Tarasht were accurately assessed. In each station due to the time limitations, between 13 to 18 measurements in various days and hours were repeated through out the year (Subway Development Office, 2002) (Fig. 1).

RESULTS

The measurements of the Radon concentration in Tehran subway stations were conducted in 2005. At the moment, there are 22 underground stations operating in Tehran. Among which, 16 stations were selected randomly and the ratio of Radon was assessed in each station separately. The average concentration of radon gas in the mentioned stations was determined as 14.19±5.68 Bq m^{-3}. The results of the mentioned measurements are presented in Table 1.

The mean radon content in Helsinki subway has been estimated to be 100Bq m^{-3} and the same content in Prague station has been measured as 12.4 Bq m^{-3}. In the present study no significant difference was shown between the radon content and the depth of subway stations ($p<0.678$) and Pearson correlation coefficient is Table 2 and Fig. 2.

DISCUSSION

The result of the measurements in subway station reveals that mean radon content in Tehran's various stations are 14.19±5.68 Bq m^{-3} which is much lower than the threshold dose (148 Bq m^{-3}) and is permissible (EPA, 1998). In another study accomplished by Cohen (1986) in 453 indoor location 42 states of US, the radon content was estimated to be 60 Bq m^{-3}, once again the results of Tehran's subway stations reveals a much lower quality (Cohen, 1986). In studies performed by Sohrabi *et a*l., in

Table 1: The average concentration of radon in line 1 and 2 of Tehran's subway stations

Stations of line 2			Stations of line 1		
No.	Station	Radon concentration on (Bq m^{-3})	No.	Station	Radon concentration on (Bq m^{-3})
1	Emam Khomeini	17	1	Mirdamad	8
2	Hasan Abad	14	2	Mosala	21
3	Majles	16	3	Mofateh	25
4	Hor	10	4	Hafte tir	24
5	Navab	10	5	Darvazeh Dolat	14
6	Azadi	25	6	Saadi	16
7	Sharif	10	7	Emam Khomeini	17
8	Tarasht	9	8	Panzdahe khordad	10
			9	Molavi	10

Table 2: Comparison between ratios of radon gas concentrations, depth of stations and surface level of underground water

		Depth	Rn-Bq	Water level
Depth	Pearson correlation	1	0.102	-0.0202
	Sig. (2-tailed)	0	0.678	0.406
	N	19	19	19
Rn-Bq	Pearson correlation	0.102	1	0.610**
	Sig. (2-tailed)	0.678	0	0.006
	N	19	43	19
Water level	Pearson correlation	-0.202	0.610**	1
	Sig.(2-tailed)	0.406	0.006	0
	N	19	19	19

19** Correlation is significant at the 0.01 level (2-tailed)

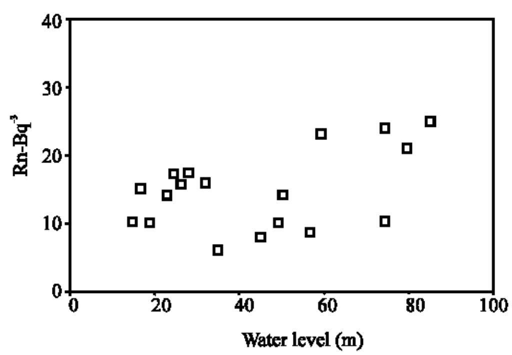

Fig. 2: Comparison of ratio of scattering radon gas concentration and the depth of underground water (Subway Development Office, 2002)

Ramsar/Iran in 1990 ' measurement were undertaken in 350 focal spots and 160 school and 58 rooms of Ramsar Hotel. This study was accomplished with the active method. Some figures of the afore mentioned results are 615 Bq m^{-3} in Chabokasar, 246 and 111 Bq m^{-3} in Ramsar city and in 50 Bq m^{-3} Sadatmahalel and katalem, 49 Bq m^{-3} in Tonekabon and 83.5 Bq m^{-3} in Ramsar old hotel and 50 Bq m^{-3} in Ramsars new hotel. Comparing the results of this study with the above quantities reveals much louver radon content in Tehran's subway stations, which is due to high level of radioactive radon in Ramsar region (Sohrabi *et al.*, 1990). In the study performed by Sabol in Prague's subway station the radon content was 12.4 Bq m^{-3} which has not a significant difference with the reported quality in Tehran ($p>0.242$). These are shown in

Table 3: The comparison between Radon gas in Tehran Subway and Prague Subway

Group statistics					
	City	N	Mean	Std. devetion	Std. error mean
Rn-Bq	Tehran	16	14.1875	5.68294	1.42074
	Prague	24	12.3667	2.47609	0.50543

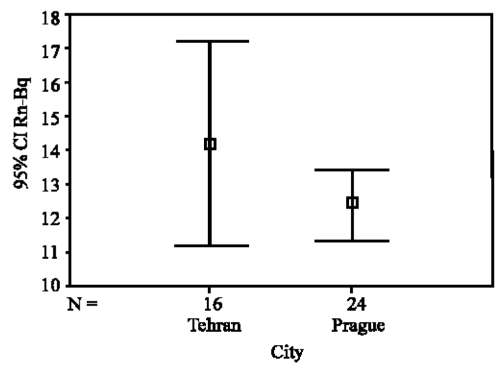

Fig. 3: Comparison of Radon concentration in Tehran Subway and Prague Subway

Table 3 and Fig. 3. In Annamaki's study which was accomplished in Helsinki's subway stations the radon content was measured as 1000 Bq m^{-3} compared to the related amounts in Tehran = 14.19 Bq m^{-3} and in Prague = 12.4 Bq m^{-3}. This difference can be interpreted by the soil mineral content in the cities and the proper ventilation in Prague's and Tehran's subways stations. The ventilation of the underground parts of Tehran metro is maintained by the piston effect of the moving trains. Along the tunnels there are 24 pressure balancing shafts through which the air is exchanged. The shafts can be closed during wintertime to prevent the icing of the concrete lining. At the same time, however, the ventilation decreases.

In the Fig. 4 and 5, a comparison between Radon in various stations of the line 1 and 2 of Tehran Subway and the depth of the stations are shown. This issue is probable due to the bedrock of Azadi Station that it mainly consists of Calcite. Calcite is a metamorphic stone

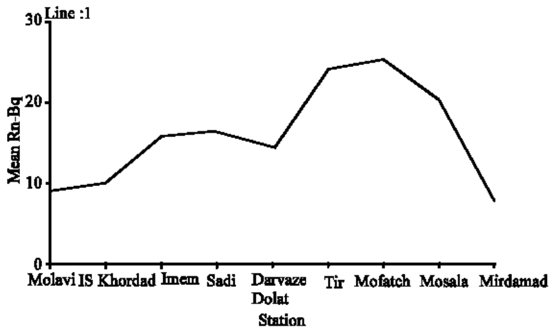

Fig. 4: Average concentration of Radon in various stations of the Line 1 of Tehran Subway

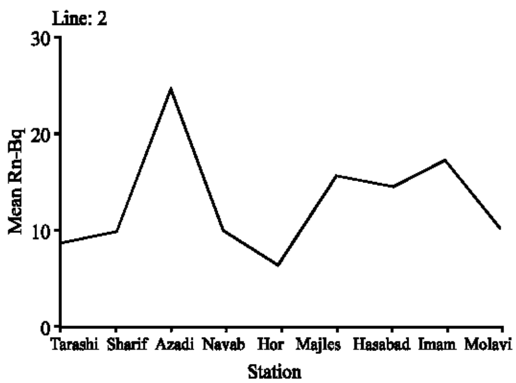

Fig. 5: Average concentration of Radon in various stations of the Line 2 of Tehran Subway

and is created by the heat and pressure of the igneous stones and the rate of Radon is higher in comparison with sedimentary stones (Asikinen, 1982). As a rule, the ratio of Radon gas in a closed place increases due to decline of air ventilation. The ratio of this gas in an open place depends on the type of soil and rock in that region. According to the report of Alter and Oswald (1989) the concentration of Radon in the air of USA with normal building ground soil is approximately 9 Bq m^{-3}.

Considering the average concentration of radon Gas in Tehran Subway Station that is equal to 4.19±5.68 Bq m^{-3} as well as its comparison with radon concentration in Hawaii and 42 states of USA and some parts of Ramsar in a separate study, it has been shown that the rate of radon in Tehran Subway station is smaller than the threshold level because of the appropriate air-condition system.

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