Monitoring of gross alpha around some industrial regions in Egypt

By

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Abstract

Air quality monitoring could potentially improve exposure estimates use in epidemiological studies. Air quality was investigated by monitoring concentrations of ^{222}Rn near the ground at 1 m height and particulate matter (PM) with an aerodynamic diameter less than or equal to 10 µm (PM10) and 2.5 µm (PM2.5). In this study, radon activity outdoor air and total alpha emitters in the atmosphere and its behavior in the environment have been investigated using CR-39 nuclear track detector. Measurements of radon and total alpha were evaluated in five locations of delta Egypt. It was measured continuously by collecting air samples at a height of 1m above the ground level using a high pump with known air flow rate.

The mean estimated value of radon activity was 85 Bq/m^3 which varies from 20 to 190 Bq/m^3 in air 1 m above the ground surface. The highest radon activities were observed in the industrial zones. The total alpha emitters were ranged from 144.1 Bq/m^3 to 513.2 Bq/m^3 with an average 209 Bq/m^3. The calculated average annual effective dose to the general public was calculated and ranged from1.23 mSv/y to1.45 mSv/y.

This work was the first nation-wide outdoor radon survey, while previous outdoor measurements were concerning mining and milling sites.

Key Words: Dosimeters / CR-39 /ICRP / Aerosol, Particulate Matter and outdoor.

INTRODUCTION

Atmospheric aerosols affect the Earth's radiation budget directly by scattering and/or absorbing solar and infrared radiation, and indirectly as cloud condensation and ice nuclei. While the impacts of aerosols are often pronounced downwind of mid-latitude industrial complexes [1], high latitude regions are also sensitive to variations in aerosol concentrations. Radon is one of the most significant, silent, unseen environmental health risks we face. Radon (^{222}Rn), a radioactive gas with a half-life of 3.82 days, part of the ^{238}U decay chain, is continuously produced in soil, rocks and water by natural radioactive decay of ^{226}Ra. ^{222}Rn is released from the ground into the atmosphere (exhalation), where it is transported mainly by turbulent diffusion or convection. Its potential accumulation in caves, underground mines, basements, dwellings represents a human health risk [2]. Radon exhalation mainly depends on geological formation, soil characteristics (radium content, permeability and porosity), and meteorological parameters. Outdoor radon may contribute to radon levels in houses, because in some parts of the country radon levels outdoors are higher than indoors. Outdoor air usually acts as a diluting factor, due to its normally low radon concentration, but in some cases, as in high rise apartments built with materials having very low radium content, it can act as a real source. The radon concentration in outdoor air is mainly related to atmospheric pressure, and (in case of non-perturbative

weather) it shows a typical oscillating time pattern, with higher values during night [3].

Until a few years ago the average level of radon gas concentration in the atmosphere at ground level was usually assumed to be of the order of few Bq/m^3~~Bq/m^{-3}~~-:e.g in the range of 4 to 15 Bq/m^3 ~~Bq/m^{-3}~~-in /USAm [4], but more recent measurements seems to indicate higher values, reaching some tens of Bq/m^3 [5,6]. Quite high radon concentrations in the outdoor air have been reported near substantial radon sources, such as mine tailings [7], or in the case of particular weather conditions, such as thermal inversion or very low precipitation [8].

Sampling and analysis of atmospheric aerosol particles are particularly difficult tasks. An aerosol is a suspension of a solid or liquid particle in the air. For health purposes, aerosol or particulate matter (PM) is typically defined by size, with the smaller particles having more health impact. Commonly quoted values for PM are total particulate matter (TPM) or total suspended particles (TSP) [9]; particles with a diameter <10 µm (PM10); and particles with a diameter <2.5 µm (PM2.5). Particulate matter represents a complex mixture of organic and inorganic substances [10]. The large diversity of particle types, sources, and processes that regulates the physical and chemical properties of atmospheric particles makes their environmental monitoring a challenging task.

This study was carried out to monitor the diurnal variations of the outdoor ^{222}Ra and its progeny in different locations in Delta Egypt as shown in figure 1. ~~Two kinds of particulate were collected namely: total suspended particulate (TSP), refers to all particles in the atmosphere, and particulate matter with aerodynamic diameter of 10 µm (PM10), has been performed using the so-called high-volume sampling systems (Hi-Vol), which allowed the collection of particles up to 100 µm with no clear upper size limit. Total suspended particulate matter is the sum of all solid and liquid particles suspended in air, many of which are hazardous. This complex mixture contains for instance dust, pollen, soot, smoke, and liquid droplets. These particles vary greatly in size, composition, and origin. Particulate matter represents a complex mixture of organic and inorganic substances. A qualitative explanation based on Solid State Nuclear Tack Detectors (SSNTDs) has been investigated~~.

Experimental Work

A- Sample collections

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~~Two kinds of particulate were collected : total suspended~~The two p-articulates (TSP) matter and particulate~~s~~ with aerodynamic diameter of 10 µm (PM10)were sampled using the so-called high-volume samplers (General Metal Works, Model

GMWL-2000 H) operating at a flow of about 78 m^3/h by pumping 540 m^3 of air through Whatman 41 cellulose filters of 18 x 25 cm in size. The normal frequency of filter change is every 8 hours. Filters were mounted in plastic filter holders and the sampling head (made of commercial PVC) was separated from the high-volume samples by means of flexible PVC tubing 15 m in length and with a 4 cm internal diameter, to avoid contamination by the electric motor. One filter blank per week was used as recommended.

Weather parameters such as temperature, wind speed, wind direction, relative humidity and pressure were registered from the weather station. These were read prior to and after the air collection and their means were calculated from the two readings.

According to the above consideration, samples were collected from industrial areas close to some factories and from populated areas close to industrial ones (Alexandria, El-Mansoura, Tanta City, Great Cairo region and Sinai). Samples were collected daily within the four different months selected for sampling; December 2006, May 2007, July 2007 and September 2007.

B- Total Alpha and Radon Measurements

The radon daughters were collected in filters mounted onto the suction pump. The variability of outdoor radon concentrations against background weather conditions was analyzed. The daily courses of the differences in urban and rural radon levels were compared. Annual and seasonal mean of 24-hour patterns of ^{222}Ra concentration were analyzed. Radon activity concentration in outdoor air was measured by exposing CR-39 detectors with surface area 1.2 cm x 1.5 cm and 1mm thickness for 30 days (to reach secular equilibrium). After exposure, the CR-39 detectors were etched in 6.25 Normal NaOH at 70°C for 6 h and the track density was counted using the optical microscope. Using this technique, the efficiency of etching CR-39 using alcohol/water solutions of sodium-hydroxide was examined. Two CR-39 detectors are used for each sample, one is set very close to the filter material for counting the total α activity emitted from the sample and the other is set 9 cm apart from the sample for counting the radon concentration. The annual effective dose (D) was calculated from the following relation [11].

$$1\ Bq/m^3 = 0.0172\ mSv/yr$$

$$D = C \times 0.0172\ mSv/yr$$

Where C is the radon concentration
and D is the annual effective dose

C- Gamma Measurements

The filter samples were prepared by dissolving it in a diluted acid (HCl) and transferred to a standard Marinelli beakers, this was kept to equilibrate and then analyzed using the HpGe. The HpGe detector has a relative efficiency of 40% and full-width-at-half maximum (FWHM) of 1.95 keV for ^{60}Co gamma energy line at 1332 keV [12].

Quality Assurance was carried out by analysis IAEA-381 and IAEA- 426 reference materials with known concentration of natural radioactivity.

RESULTS AND DISCUSSION

The average concentration values of TSP in Cairo, Mansoura, Tanta, Alexandria and Sinai were measured and the averages were found to be (275.0, 214.0, 288.0,

702.8 and 236.1)μg/m^3). On the other hand, the average values of (PM10) in Cairo, Mansoura, Tanta, Alexandria and Sinai were (277, 225, 230, 494.2 and 374.3)μg/m^3) respectively. Figure 2, 3 represented the average concentration of TSP and PM10 in each location. The average ratios of PM10 to TSP in Cairo, Mansoura, Tanta, Alexandria and Sinai were calculated and it was 1.1, 1.1, 0.8, 0.7, and 1.6, respectively.

It was clear that the TSP and MP10 in Alexandria was higher than the other cities, so, more intensive study was carried out and evaluated in winter, spring, summer and autum. The monthly averages (PM10) were 319.0, 321.0, 371.4, and 441.2μg/m3. Figure 4 represents the (PM10) concentration values in Alexandria. The data obtained showed that, the summer and autumn seasons have higher average values than spring and winter seasons. Daily average (PM10) concentration levels were evaluated and were found to range from 718.0 -112.0 in winter, 817.0 -132.0 in spring, 883.0 - 112.0 in summer and 851.0 to 170.0 in autumn with the unit μg/m^3.

Analysis of the meteorological data of summer and autumn revealed the percent of unstable conditions of these periods were relatively higher than May and December months. Also it was found that the summer season has the highest (PM10) concentration which may be attributed to higher motor vehicle because of the existence of high population during this season.

Radon activity concentration in Cairo (Maadi, Shoubra and Heliopolis), Tanta, Mansoura, Sinai and Alexandia for 12 months of the year was recorded as shown in Figure 5. Minimum and maximum average radon concentration was ranged from 20 - 190 Bq/m^3 Bq m^{-3} while the recommended ICRP value ranged from 200-600 Bq/m^3 Bq/ m^3 **(ICRP 2007).** Also, outdoor mean 222Rn concentration was 6.1 Bqm^{-3} in Japan [13].

The annual effective dose D was calculated for radon were 1.26, 1.29, 1.34, 0.82 and 1.53 mSv/y in Alexandria, Mansora, Tanta, Cairo and Sinai respectively for PM10. From the data obtained, the annual effective dose to the general public was found to vary from 0.6 to 1.53 mSv/y. These results represent a data base for Rn concentration in north Egypt.

GAMMA SPECTROMETRIC ANALYSIS

The gamma ray spectra of the different filter samples were accumulated for at least twenty four hours each, and were analyzed to detect the gamma ray energies due to uranium, thorium and their daughters, and due to potassium. The counting rate for each gamma transition was determined and compared with that obtained for the blank filter. The results revealed that the activity concentrations of the natural radionuclide were within the back ground limit.

CONCLUSION

Air quality monitoring could potentially improve exposure estimates for use in epidemiological studies. MAir quality by monitoring concentrations of ^{222}Rn near the ground and particulate of TSP and matter (PM) with an aerodynamic diameter less than or equal to 10 μm (PM10) were investigated in this study. Minimum detectable concentrations for these samples were presented to show the effect of different climate-logical operating environments.

The highest concentration of TSP and PM10 was found in industrial area. The annual effective dose to the general public was found to vary from 0.6 to 1.53 mSv/y. These results indicated that measures should be taken to abate this increase in concentrationmore concern should be taken around the industrial areas. The results

represent a data base for Rn concentration in north Egypt and are the first nation-wide outdoor radon survey.

To provide further adequate requirements for monitoring of atmospheric radon and natural radioactivity at the Egyptian national locations, it is necessary to develop modern methods and equipment for operational sampling and radiometry under the special project in the frame of Egyptian Regulatory Authority.

REFERENCES

1. Charlson, R.J., S.E. Schwartz, J.M. Hales, R.D. Cess, J.A. Coakley, J.E., Hansen, and D.J. Hofmann, Climate forcing by anthropogenic aerosols, *Science, 255*, 423-420, 1992.
2. Portsendorfer J, Butterweck G., Reineking A. 1991, Diurnal variation of concentration of radon and its short-lived daughters in the atmosphere near the ground, Atmospheric Environment, 25, 709-713.
3. 2002 International Radon Symposium Proceedings, "ABOVE NORMAL OUTDOOR RADON LEVELS IN CENTRAL FLORIDA: A PRELIMINARY REPORT OF SAMPLING RESULTS", Donald M. Phillips, Clark Eldredge, Walter Klein.
4. Bodhaine, B.A. (1992).~~,~~ The U.S. aerosol monitoring program in Antarctica, Proceedings, 4th Workshop Italian, Research on Antarctic Atmosphere, Porano IV, Italy, October 21-23, 1991, Italian Physical Society,Bologna, Italy, 15-25,~~ 1992 .~~
5. GRASTY, R.L. (1991): A cross Canada radon survey, in Proceedings of the Fifth International Symposium on the Natural Radiation Environment, Salzburg Austria.
6. Mansour H., Perkl dar S., Abdulla H. Y., Muhamad N. Q., M. M. Othman M. M and Qader S.(2005).~~ ,~~Journal of Radia. Measu. 40, 544-547 ~~(2005).~~
7. Boubel R.W., Fox, D.L., Turner, D.B. and Stern. A.C., Fundamentals of Air Pollution. Academic Press Inc., San Diego (1994).
8. Saeed Durrani and Radomir Ilic., Radon measurement by etched track detectors, world scientific, UK, 1997.
9. Kishimoto K., Matsumra K., Kataoka Y., Morii H. and Watanabe Y., Neuroscience Research, 31,135, (1998).
10. Chan S.W., Lee C.W., and Tsui K.C., Journal of Environmental Radioactivity 101, 494:503, 2010.
11. ICRP Publication 103 The 2007 Recommendations of the International Commission on Radiological Protection. Annals of the ICRP 37/2-4.
12. El-Tahawy, M.S., Farouk, M.A., Hammad, F.H. and Ibrahiem., N.M. (1992): “Natural Potassium as a Standard Source for the Absolute Efficiency Calibration of Ge Detectors ”, Nucl. Sci. J.,29 361-363.
13. Oikawa S, Kanno N, Sanada T, Ohashi N, Uesugi M, Sato K, Abukawa J, Higuchi H., “A nationwide survey of outdoor radon concentration in Japan”, J Environ Radioact. 2003;65(2):203-13.

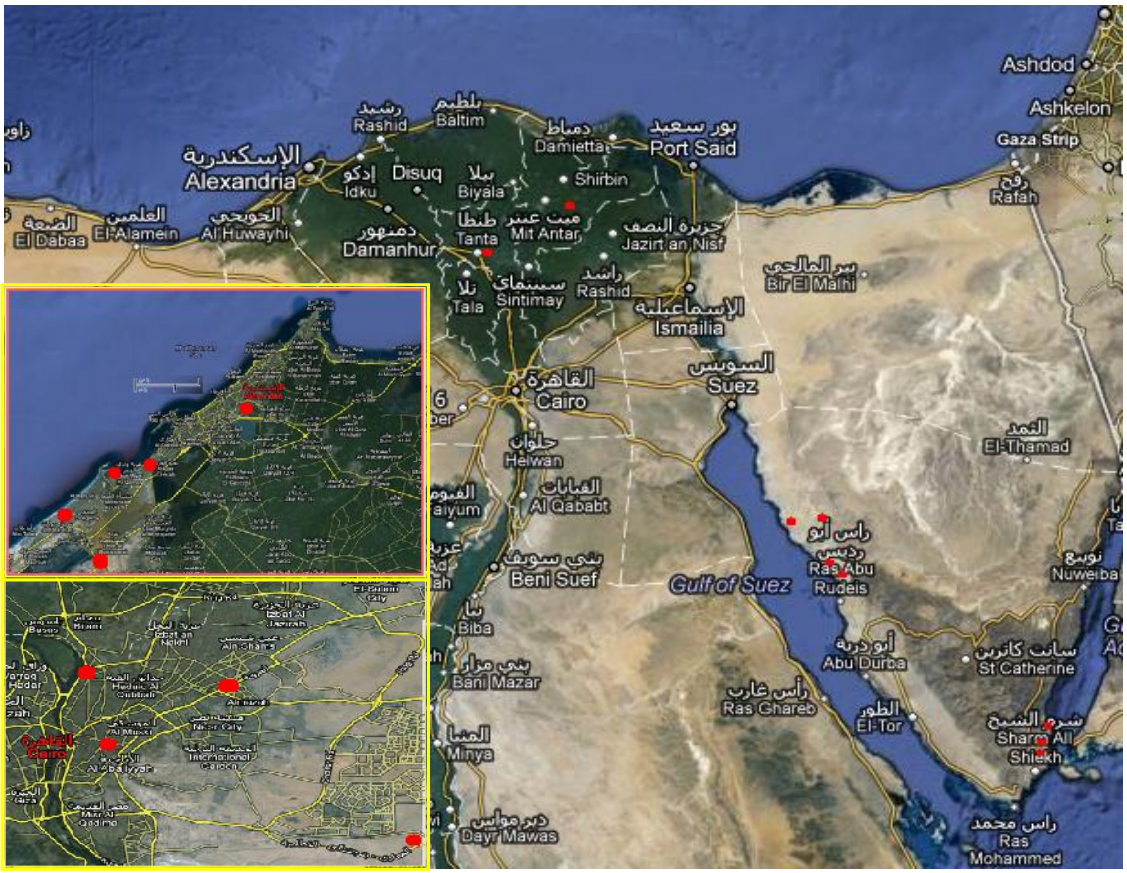

Fig. (1): Sample locations

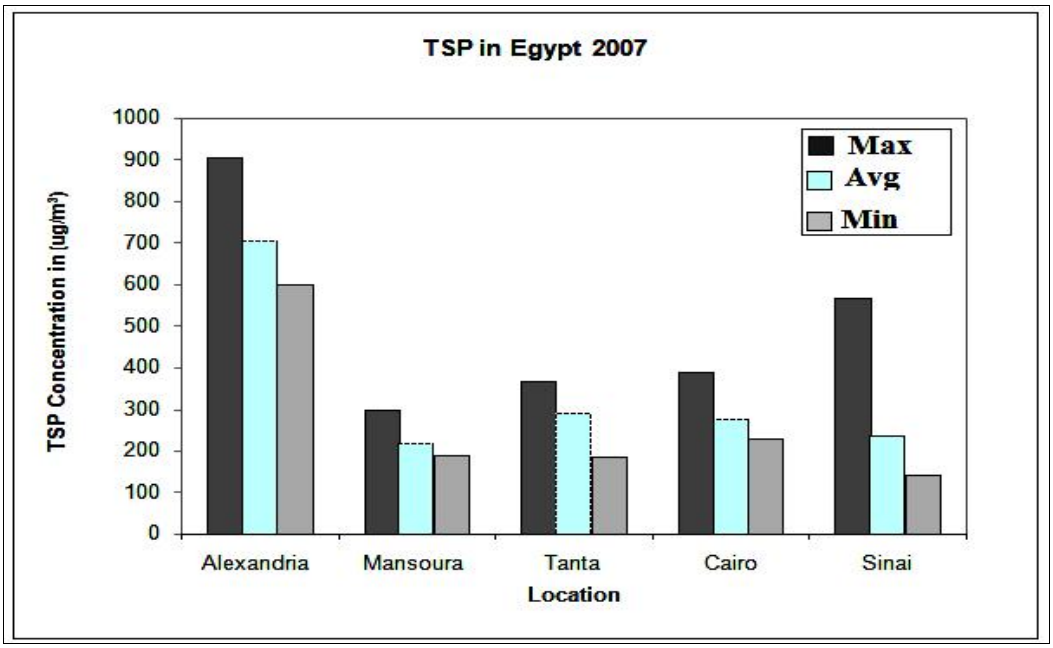

Fig. (2): Minimum, Maximum and average concentrations of TSP (µg/m^3) in different locations in Egypt.

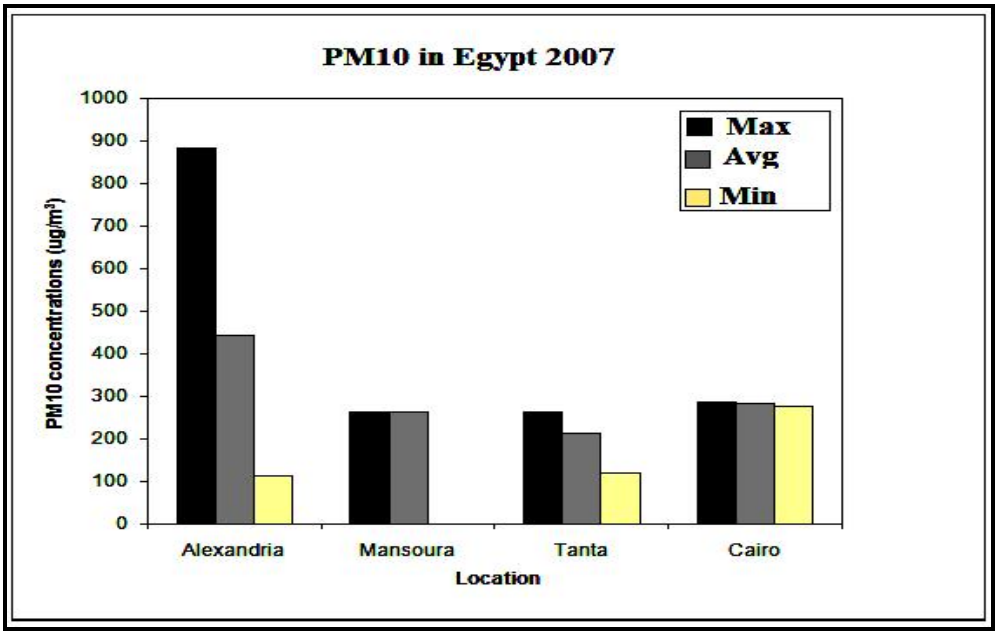

Fig. (3): Minimum, Maximum and average concentrations of PM10 (µg/m^3) in different locations in Egypt.

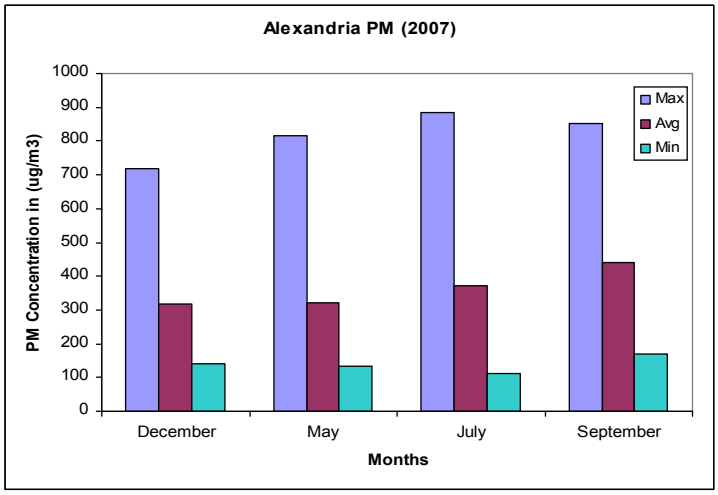

Fig. (4): The concentrations of PM10 (µg/m^3) in Alexandria

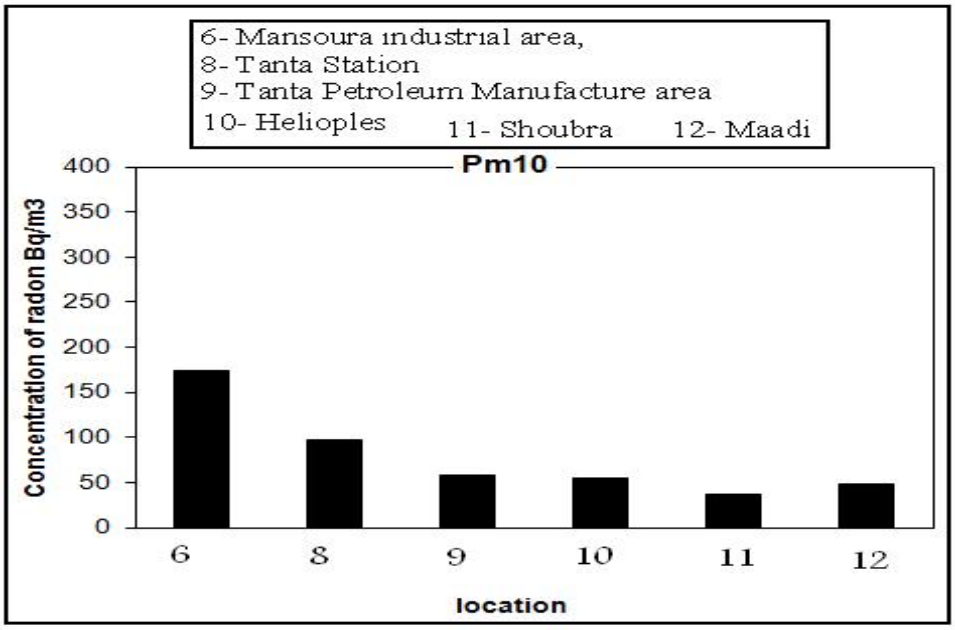

Fig. (5): Variation in outdoor radon concentration in different location in Egypt