

Radiological Assessment of Radon and Thoron Concentration and their Radionuclides Daughters of the Smoke Hookah using RAD-7 and Estimation of their Health Risks

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Abstract: The concentration of Radon and Thoron and their radionuclide progenies have been evaluated from the smoke of Hookah inside a fabricated chamber using a passive detector of RAD-7. The results showed that the radionuclides of radon and thoron gases increase with the relative density of smoke. The accumulated alpha particles emitted from the radionuclides of both radioactive gases variable with the rate of indoor air moving (ventilation rate). So, high deposition of alpha particles on the trachea and lungs causes high radiation tissue damage for the exposed people.

Keywords: Radon; Thoron; Hookah; RAD-7; Po-218

1. Introduction

Radon and thoron are the radioactive gases, and they are produced from the decay of Radium (Ra-226) and thorium (Th-232) chains, respectively [1]. Both gases decay by emitting a heavy particle (Alpha particles) to produce some radionuclides (their daughters) (Po-218, Po-214, Po10, Po-216) by emitting alpha particles (2). Risks of the inhalation of radon and thoron gases are from the accumulation of their daughters in the trachea and lungs during the inhalation due to the high energy of the alpha particles of the daughters. The radioactive gases are variable in indoor air (3-5), soil (6-8), water (9-11), tobacco (12-14), and also building materials [15-18].

Today, hookah smoke is inhaled extensively by young people and for long periods of time, without considering its dangers. Inhaling smoke has caused damage to the community environment in general (the person sitting with the smoker is also considered to be inhaling smoke) [19]. The ventilation rate (air moving) has highly impact on radon and thoron concentration indoors, so it is considered an important factor to estimate its risks to human health. Inhaling both gases leads to lung cancer as a result of the alpha particles (emitted by the nuclides of these gases) being accumulated on the tissues at high energies and penetrating.

The research aims to evaluation of radon / thoron concentration and its radionuclide daughters from the smoke of hookah using radon detector type RAD-7- The procedures based on how the concentration of alpha particles effects by variable of ventilation (air moving) during a fabricated exposure chamber.

2. Research Methods

2.1 Materials and Equipment

2.1.1 Hookah, hookah pump, and exposure chamber

The system is held airtight with grommets to ensure proper airflow, and some setups include a diffuser at the end of the stem to further smooth the smoke as it passes through the water. First thing we bring a water pipe bottle, add some water, bring a cup, fill the top of the cup with tobacco, provided the holes in the top of the cup are open, after that we will pack the cup with aluminum foil, Then drill the aluminum foil with a needle and place the cup on the glass bottle, by an electric heater that in the fig. (1). The hookah pump has been used to withdraw the tobacco smoke through the pipe put it in the box (fig.2).



Figure 1: Stature of the used of hookah



Figure 2: The electric hookah pump

Smoke exposure consists of a square glass box $60 \times 60 \times 65$ cm in size. It is equipped with a thermometer and a humidity meter. Two holes on the top of the box exchange air with the outside of the box. Two pipes on the top of the box connect the device Rad 7. An air hole on one side of the box allows smoke to enter (Fig.3).



Figure 3: Fabricated smoke exposure chamber

2.1.2 RAD-7

RAD7 (Fig.4) is an accurate sniffer that can be used for both short-term and long-term measurements. The instrument is based on a semiconductor detector that measures radon daughters collected with a strong electric field. RAD7 is capable of dissolving the energy of various radon isotopes, radon, and thoron



Figure 4: Equipment of RAD-7

3. Experimental procedures

A hookah pipe prepared for smoking is the charcoal tray beneath the bowl, used to catch ash from the burning charcoal. The stem connects the bowl to the base, a water-filled container that cools and filters the smoke. Attached to the stem is the hose, a flexible tube through which the smoker inhales. The hose is fitted with a mouthpiece for hygiene and comfort. A purge valve is often included to allow stale smoke to be expelled. The system is held airtight with grommets to ensure proper airflow, and some setups include a diffuser at the end of the stem to further smooth the smoke as it passes through the water. First thing we bring a water pipe bottle, add some water, bring a cup, fill the top of the cup with tobacco, provided the holes in the top of the cup are open, after that we will pack the cup with aluminum foil, Then drill the aluminum foil with a needle and place the cup on the glass bottle, by an electric heater, we will Heat the charcoal pieces until redness. Place the charcoal pieces on a circular shisha grid on the cup, then use a Hookah Pump to withdraw the tobacco smoke through the pipe, and put it in the box. The electric fan provided the air moving inside the chamber.

Measures of radon/ thoron and their radionuclide progenies have been measured using RAD-7 (for 1 hr: repeated 3 times). The measurement is based on the quantity of smoke inside the chamber (smoke density) and the concentration of the radionuclides. The smoke pumped by using a smoke pumper for 5 minutes is considered equivalent to (5kg/m³) (Fig.5). A formaldehyde detector, also known as an HCHO gas meter, is key equipment for detecting and monitoring formaldehyde gas concentrations in the air. These specialist gas detecting devices are necessary for human safety in areas where hazardous formaldehyde gas might be present. The temperature, humidity, land pressure levels are monitored and controlled during the experiments (Table 1)

Table (1): The temperature, humidity and pressure levels monitored and controlled during the experiments

Density of smoking	Temperature (C°)	Humidity%	Pressure (Cm-Hg)
Zero	28.7±0.05	39±1	79.4±0
5	28.4±0.06	45±1	79.2±0.06
10	28.4±0.06	57±1	78.9±0.06
15	26.8±0.06	63±0.5	78.9±0.06
20	25.8±0.06	64±0.5	78.9±0
25	24.5±0.015	69±1	78.8±0.06



Figure 5: Prepared an exposure hookah smoke

4. Results and Discussion

The results proved that the average radon concentrations vary with the smoke density and relativity. The variation of the radon concentration depended on the rate of air moving inside the chamber (the electric fan provided the air moving). Figure 6 shows the average radon concentration inside the closed chamber, with fan operation changes exponentially with the density of smoke.

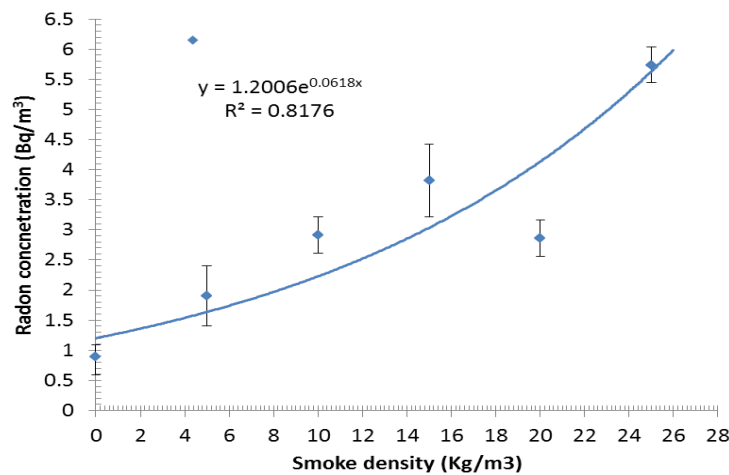


Figure 6: Average radon concentration with ventilation inside the chamber

Without the operation of the fan inside the chamber, radon concentration is distributed randomly due to the random decay of radionuclides and bad passing to the pipe of RAD-7. The radio nuclide concentration (Po=218, Po-216, Po-214, and Po-210) for both states without fan operation inside the chamber is listed in Table 2. Accumulation of the radionuclides on the base of the chamber due to low density recorded by the RAD-7

Table 2: The radionuclides concentration with fan operation in close chamber

Smoke density (kg/m ³)	218po(c/m)	214po(c/m)	216po(c/m)	212po(c/m)
0	0.036 ± 0.01	0.046 ± 0.01	0.026 ± 0.01	0.00 ± 0.00
5	0.023 ± 0.01	0.0066 ± 0.01	0.0133 ± 0.01	0.00 ± 0.00
10	0.036 ± 0.01	0.02 ± 0.001	0.03 ± 0.01	0.02 ± 0.01
15	0.02 ± 0.01	0.02 ± 0.001	0.006 ± 0.001	0.04 ± 0.01
20	0.02 ± 0.01	0.00 ± 0.00	0.0133 ± 0.01	0.00 ± 0.00
25	0.026 ± 0.01	0.023 ± 0.001	0.00 ± 0.00	0.02 ± 0.001

Table 3 shows the effects of shisha smoke on the radionuclide's concentration inside a close chamber with fan operation.

Table 3: The radionuclides concentration without fan operation in close chamber

Smoke density (kg/m ³)	218po(c/m)	214po(c/m)	216po(c/m)	212po(c/m)
0	0.02 ± 0.01	0.04 ± 0.01	0.03 ± 0.01	0.00 ± 0.00
5	0.04 ± 0.01	0.020 ± 0.01	0.02 ± 0.01	0.04 ± 0.00
10	0.04 ± 0.01	0.04 ± 0.001	0.04 ± 0.01	0.04 ± 0.01
15	0.04 ± 0.01	0.02 ± 0.001	0.02 ± 0.001	0.02 ± 0.01
20	0.04 ± 0.01	0.02 ± 0.00	0.04 ± 0.01	0.05 ± 0.00
25	0.07 ± 0.01	0.02 ± 0.001	0.02 ± 0.00	0.02 ± 0.001

The mentioned results of the radon and its radio nuclides during the tables (1 and 2) consider inhalation during one hour exposure, so the risks are more dependent on the inhalation time per day, and per year. So, sniffing of hookah per day increases the rate of accumulation of alpha particles in the human trachea and lungs

5. Conclusions

Radiological assessment of radon and thoron concentration and their radionuclide daughters in the smoke of Hookah was investigated using RAD-7. Smoke of Hookah contains a variety of radioactive nuclei (Po-218, Po-216, Po-214, and Po-212). The longer the smoke is inhaled, the more alpha particles are accumulated, resulting from the decay of radon and thoron gases. The ventilation rate impacts the rate of accumulation of alpha particles relatively. So, high deposition of alpha particles on the trachea and lungs causes high radiation tissue damage for the exposed people

Author's Contribution:

I confirm that all named authors have read and approved the manuscript. We also confirm that each author has the same contribution to the paper. We further confirm that all authors have approved the order of authors listed in the manuscript."

Conflict of Interest

Authors declare there are no potential conflicts of interest.

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References

- [1] Ismail AH, Jaafar MS (2010), Indoor Radon Concentration and Its Health Risks in Selected Locations in Iraqi Kurdistan Using CR-39 NTDS. , " 2010 4th International Conference on Bioinformatics and Biomedical Engineering, Chengdu, China, 2010, pp. 1-8, <https://doi.org/10.1109/ICBBE.2010.5514794>.
- [2] Ismail AH, Jaafar MS (2010) Relationship between radon concentration, ventilation rate and male infertility: A Case study in Iraqi Kurdistan. *Int J of Low Radiation* 7: 175-187. <https://doi.org/10.1504/IJLR.2010.034591>
- [3] Ismail AH, Jaafar MS (2011) Design and construct optimum dosimeter to detect airborne radon and thoron gas: Experimental study. *Nuclear Instruments and Methods in Physics Research B* 269: 437-439. <https://doi.org/10.1109/IST.2011.5962165>
- [4] Ebrahim M.M., Ramazan M., Mohammad R. A., Samaneh K., The Effects of Water Pipe Smoking on Hematological Parameters in Rats, *IJHOSCR* 8(3) - ijhoscr.tums.ac.ir – July 1, 2014. [PMCID: PMC4305380](https://pubmed.ncbi.nlm.nih.gov/2716233/).
- [5] Funck C., Mathilde R., Michel L., Arnould J., Verstuyft C., Martine L., et al. Effects of type of smoking (pipe, cigars or cigarettes) on biological indices of tobacco exposure and toxicity. *Lung Cancer*. 2006;54: 11–8. <https://doi.org/10.1016/j.lungcan.2006.06.016>.
- [6] Aurelio, L. Biochemical markers of cardiovascular damage from tobacco smoke. *Curr. Pharm. Des.* 2005;11: 2190–208. <http://dx.doi.org/10.2174/1381612054367391>
- [7] Lubin J.H., Alavanja M.C., Caporaso N, Brown L.M., Brownson R.C., Field R.W., et al. Cigarette smoking and cancer risk: modeling total exposure and intensity. *Am J Epidemiol*. 2007;166(4): 479-89. <https://doi.org/10.1093/aje/kwm089>
- [8] Yeh, C., Graham B, Powell C., Mesia-Vela S., Wang Y., Hamade N., et al. Effect of cigarette smoking dose on oxidized plasma proteins. *Environ. Res.*2008; 106: 219–25. <https://doi.org/10.1016/j.envres.2007.09.008>
- [9] Asgary S, Naderi G, Ghannady A. Effects of cigarette smoke, nicotine and cotinine on red blood cell hemolysis and their -SH capacity. *Exp Clin Cardiol* 2005;10(2):116-9. [PMCID: PMC2716233](https://pubmed.ncbi.nlm.nih.gov/2716233/)
- [10] Roethig HJ, Koval T, Muhammad-Kah R, et al. Short term effects of reduced exposure to cigarette smoke on white blood cells, platelets and red blood cells in adult cigarette smokers. *Regul Toxicol Pharmacol* 2010;57(2-3):333 <https://doi.org/10.1016/j.yrtph.2010.04.005>
- [11] Fouad FM, Rastam S, Al Moustafa AE. Involvement of water pipe smoking in the development of human pancrea) c cancer. *Int J Cancer* 2010;127(2):497-8. <https://doi.org/10.1002/ijc.25061>
- [12] Ismail A. H., Detection of radioactivity for some materials that used in construction and for some area that was exposed to the weapons of depleted uranium and estimating its health risks, *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, Volume 1016,2021,165729. <https://doi.org/10.1016/j.nima.2021.165729>
- [13] Funck C., Mathilde R., Michel L., Arnould J., Verstuyft C., Martine L., et al. Effects of type of smoking (pipe, cigars or cigarettes) on biological indices of tobacco exposure and toxicity. *Lung Cancer*. 2006;54: 11–8. [10.1016/j.lungcan.2006.06.016](https://doi.org/10.1016/j.lungcan.2006.06.016)
- [14] Aurelio, L. Biochemical markers of cardiovascular damage from tobacco smoke. *Curr. Pharm. Des.* 2005;11: 2190–208. DOI: <http://dx.doi.org/10.2174/1381612054367391>
- [15] Lubin J.H., Alavanja M.C., Caporaso N, Brown L.M., Brownson R.C., Field R.W., et al. Cigarette smoking and cancer risk: modeling total exposure and intensity. *Am J Epidemiol*. 2007;166(4): 479-89. <https://doi.org/10.1093/aje/kwm089>

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- [16] Yeh, C., Graham B, Powell C., Mesia-Vela S., Wang Y., Hamade N., et al. Effect of cigarette smoking dose on oxidized plasma proteins. *Environ. Res.*2008; 106: 219–25. <https://doi.org/10.1016/j.envres.2007.09.008>
- [17] Asgary S, Naderi G, Ghannady A. Effects of cigarette smoke, nicotine and cotinine on red blood cell hemolysis and their -SH capacity. *Exp Clin Cardiol* 2005;10(2):116-9: [19641671](https://doi.org/10.1016/j.ery.2005.02.001).
- [18] Roethig HJ, Koval T, Muhammad-Kah R, et al. Short term effects of reduced exposure to cigarette smoke on white blood cells, platelets and red blood cells in adult cigarette smokers. *Regul Toxicol Pharmacol* 2010;57(2-3):333-7. <https://doi.org/10.1016/j.yrtph.2010.04.005>
- [19] Fouad FM, Rastam S, Al Moustafa AE. Involvement of water pipe smoking in the development of human pancreatic cancer. *Int J Cancer* 2010;127(2):497-8. [25642307](https://doi.org/10.1002/ijc.21307)
- [20] Mfoumou E, Li Z, Al Moustafa AE. Current tobacco and water-pipe smoking enhance human cancer invasion and metastasis. *Int J Cancer*;132(4):990-1. <https://doi.org/10.1002/ijc.27744>
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