Assessment of Radiological Air Contamination for Selected Places at Al-Tuwaitha Nuclear Site during Winter and Spring

Naheel Abbas Mohammed Salih1, Yousif Muhsin Zayir AL-Bakhat2
Altaj Abd Ulmajeed Al-Rahmani1, Omar Mahmood Murbar3
Nadia Abdulhameed Majed2

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Abstract:
This study presents the results of atmospheric particulates sampling using high volume air sampler for selected places at Al Tuwaitha nuclear site. The collected samples were analyzed for gross alpha /beta radioactivity using Ludlum model 3030 and measurement particles activity in Al Tuwaitha nuclear site and the surrounding areas for the period from 28/12/2016 to 13/4/2017.The measurement of activity concentrations ranged from (0.42±0.03 to 4.18±0.13) Bq/m3 for alpha particles and from(0.93±0.06 to 9.21±0.26) Bq/m3 for beta particles. The activity concentration of nuclides inversely proportional with air temperature and wind speed while humidity is directly proportional with it. Highest value of activity concentration has been found at(Near nuclear and radiation safety directorate/ In the center of planning department/T9)while the lowest value has been found at (the right side of Nuclear application and researches directorate / building 61/T42). The results of this study show that the region has natural nuclides which are the daughters of the two decay series, namely the thorium and the uranium series. In both cases, it is a radioactive Radon isotope which can escape from the soil and ascend into the air.

Keywords: Air radioactivity concentration, Hi Vol3000, Ludlum model 3030, Tuwaitha Nuclear site.

Introduction:
Radiological contamination is the deposition of, or presence of radioactive substances on surfaces or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable. Such contamination presents a hazard because of the radioactive decay of the contaminants which emit harmful ionizing radiation (1).

Airborne radioactive particles may emit alpha, beta, gamma or neutron radiation, depending on the radioisotope present. The most dangerous of these is alpha particles, since they have high energy (>4 MeV for most alpha-emitting isotopes), leading to large localized radiation doses when inhaled or ingested, compared to betas, gammas and neutrons. For an airborne radioactivity detection system, it is the most important to be able to detect alpha particles and their energies, for radioisotope identification and risk evaluation (2). Atmospheric radioactivity is a matter of concern because the inhalation pathway is a major avenue for the entry of contaminants into the body.

We take in a larger mass of air than either food or water; the daily intakes by a reference person are only 1.9 kg of food and 2.2 kg of water, but 26 kg of air. Additionally, the area of interface in the lungs between the body’s internal milieu and the outside atmosphere is 50–100 m². This large interface facilitates the transfer of noxious agents from the inhaled air into the body fluids. Therefore, if the quantity of radioactivity being handled is great enough to pose a significant inhalation hazard, in case of an accidental release of the radioactivity to the air (3).

In 2012, Clemenza et al. (4) studied the presence of air borne 131I, 134Cs, and 137Cs in air particulate due to accident of Fukushima reactors that have been detected and measured in the Low Radioactivity Laboratory operating in the Department of Environmental Sciences of the University of Milano-Bicocca. The sensitivity of the detecting apparatus is of 0.2 μBq/m³ of air. Concentration and time distribution of these radionuclides were determined and some correlations with the original reactor releases were found. Radioactive contaminations ranging from a few to 400 μBq/m³ for the 131I and of a few tens of
μBq/m³ for the 137Cs and 134Cs have been detected(4).

In 2016, Mann et al.(5) showed that the radon and thoron at ground levels from Hisar district varied from 11 to 112 and 11 to 80 Bq m⁻³, while for Fatehabad district from 5 to 24 and 59 to 105 Bq m⁻³, respectively, in summer season. In winter season, indoor radon and thoron levels from Hisar district varied from 15 to 43 and 32 to 102 Bq m⁻³, while for Fatehabad district from 18 to 31 and 11 to 80 Bq m⁻³, respectively. The radon levels of 95% locations lie well below the limit recommended by International Commission of Radiation Protection, 2011. The radon mass exhalation rate varied from 6 to 56 mBq kg⁻¹ h⁻¹.

The radon mass exhalation rates from the soil samples were lower than the worldwide average, i.e. 56 mBq kg⁻¹ h⁻¹. There exists a poor correlation between indoor radon and exhalation rates. More investigations of measurement of radionuclide contents from rock and stone of study area can improve the understanding (5).

In 2017, Hague and Ferdous (6) measured the radioactivity levels of naturally occurring radionuclides ²²⁶Ra, ²²⁸Ra and ⁴⁰K in eighteen water and eight air samples, collected from Savar Atomic Energy Center Bangladesh, were determined using gamma ray spectrometry system using a High Purity Germanium (HPGe) detector of 40% relative efficiency. The air samples had activity concentrations of ²²⁶Ra, ²²⁸Ra and ⁴⁰K varied from 1.49±0.00 to 613.56±0.01, 0.00±0.01 to 79.90±0.02 and from 19.70±0.05 to 206.82±0.00 mBq/m³ respectively. They calculated average activity(6).

In 2017, Karkoush et al.(7) measured the activity of airborne radon in the outdoor air environment near contaminated zones at two scrap yards at Al-Tuwaitha Nuclear Site and they recorded using RAD7 electronic radon detector. Outdoor air-borne radon activity ranged from 5.9 to 11.84 Bq/m³ for the first zone and from below detection limit (<4 Bq/m³) to 17.76 Bq/m³ for second zone, which were less than the International Atomic Energy Agency (IAEA) prescribed action level (1000 Bq/m³) for workplaces(7).

In 2016, Rejah determined the activity of natural radionuclides ²²⁶Ra, ²³²Th and ⁴⁰K by sodium iodide and assessed the annual effective dose in Dielac1,2 and Nactalia 1and 2for children. The activity was in the range of allowed levels globally(8).

Materials and Methods:

Areas of the Study

A number of sites in Iraq has some degree of radiological contamination and require decommissioning and remediation in order to ensure radiological safety. Many of these sites in Iraq are located at the nuclear research center at Al Tuwaitha. The International Atomic Energy Agency (IAEA) Board of Governors has approved a project to assist the Government of Iraq in the evaluation and decommissioning of former facilities that used radioactive materials (10). In this study, 50 locations were covered, many of them are inside Al Tuwaitha site and the other located outside are background areas as shown in Table (1) and Fig. 1.
### Table 1. Sample Locations:

| No. | sample Location                                                                 | ID    | GPS coordinates      |
|-----|--------------------------------------------------------------------------------|-------|----------------------|
| 1   | In the center of nuclear and radiation safety directorate                       | T1    | N 33.20680 E 044.51370 |
| 2   | Near library                                                                    | T2    | N33.20917 E044.51562 |
| 3   | Near internal check point                                                       | T3    | N33.20631 E044.51874 |
| 4   | Near the center of nuclear application and researches directorate / building 61 | T4    | N33.20572 E044.50954 |
| 5   | Outer check point/Dyala bridge                                                  | T5    | N33.21860 E044.52541 |
| 6   | In the right side of nuclear and radiation safety directorate                  | T6    | N33.20693 E044.51362 |
| 7   | Al Rafidain bank -Dyala bridge                                                  | T7    | N33.22712 E044.52054 |
| 8   | Ishtar area near Al-Taachi primary school                                        | T8    | N33.19226 E044.53194 |
| 9   | Near nuclear and radiation safety directorate/ In the center of planning department | T9    | N33.20813 E044.51268 |
| 10  | In the left side of nuclear and radiation safety directorate                   | T10   | N33.20705 E044.51375 |
| 11  | Near outer transport overland                                                  | T11   | N33.20866 E044.51490 |
| 12  | Behind nuclear and radiation safety directorate                                | T12   | N33.20699 E044.51308 |
| 13  | Near agriculture & air condition storages                                      | T13   | N33.20693 E044.51370 |
| 14  | In the center of radiochemistry lab. building                                  | T14   | N33.20589 E044.51554 |
| 15  | In the right side of dispensary directorate                                     | T15   | N33.20613 E044.51648 |
| 16  | In front of Radioactive waste management directorate building                  | T16   | N33.20501 E044.51759 |
| 17  | Near decommissioning building                                                   | T17   | N33.20693 E044.51370 |
| 18  | In the center of nuclear application building                                  | T18   | N33.20693 E044.51370 |
| 19  | Near radioactive waste treatment system (RWTS)                                 | T19   | N33.20144 E044.51816 |
| 20  | In the right side of radiochemistry lab. building                              | T20   | N33.20142 E044.51584 |
| 21  | Near radioactive waste silo                                                    | T21   | N33.20221 E044.51708 |
| 22  | In the left side of radiochemistry lab. building                               | T22   | N33.20524 E044.51583 |
| 23  | In the left side of nuclear application and researches directorate / building 61 | T23   | N33.20572 E044.50954 |
| 24  | Near fuel fabrication facility                                                  | T24   | N33.20034 E044.51251 |
| 25  | In front of restaurant                                                         | T25   | N33.20509 E044.51770 |
| 26  | Behind waste building RWTS &in front of radioactive waste storage              | T26   | N33.20148 E044.51766 |
| 27  | In front of Tammuz-2 reactor                                                   | T27   | N33.20341 E044.51746 |
| 28  | In front of playground behind agricultural directorate                         | T28   | N33.20760 E044.51640 |
| 29  | Near Al Elwiat region                                                          | T29   | N33.22059 E044.50797 |
| 30  | Beside waste station /opposite side of old waste storage facility              | T30   | N33.20196 E044.51830 |
| 31  | Behind Central labs building                                                    | T31   | N33.20738 E044.51193 |
| 32  | Near middle check point opposite refuge                                        | T32   | N33.20808 E044.52279 |
| 33  | Near park opposite Tammuz-2 reactor                                            | T33   | N33.20567 E044.51940 |
| 34  | Near old production directorate                                                | T34   | N33.20575 E044.51516 |
| 35  | Behind restaurant opposite Lama&Tammoz2reactor                                 | T35   | N33.20544 E044.51878 |
| 36  | In the left side of dispensary directorate                                     | T36   | N33.20918 E044.51180 |
| 37  | Near Monitory &internal audit directorate                                      | T37   | N33.20733 E044.51752 |
| 38  | Near 14 Tammuz reactor/IRT-5000                                               | T38   | N33.20467 E044.51547 |
| 39  | Near extinguish center                                                         | T39   | N33.20340 E044.52219 |
| 40  | In front of second Decommissioning building                                   | T40   | N33.20674 E044.51859 |
| 41  | In the left side of nuclear application building                               | T41   | N33.20748 E044.51374 |
| 42  | the right side of Nuclear application and researches directorate / building 61 | T42   | N33.20576 E044.50926 |
| 43  | Near transport building opposite production building                            | T43   | N33.20662 E044.51491 |
| 44  | Near Salman Pack entrance check point opposite Al Salman bridge                | T44   | N33.20746 E044.54850 |
| 45  | Western Al-Tuwaitha – near Al Masudy school                                    | T45   | N33.18438 E044.48763 |
| 46  | On the top of earthen berms                                                    | T46   | N33.20883 E044.50990 |
| 47  | Near nuclear application building/ in front of green houses                    | T47   | N33.20751 E044.51376 |
| 48  | In front of nuclear and radiation safety directorate/ towards production building | T48   | N33.20672 E044.51367 |
| 49  | Near nuclear and radiation safety directorate/ In the left side of planning department | T49   | N33.20813 E044.51276 |
| 50  | Near radioisotopes production facility                                         | T50   | N33.20651 E044.51414 |
Collection of samples:
The method was based on the collection of aerosols, using high volume air sampling (High Volume 3000) sampler Particulate from Australia. This devise is used for outdoor sampling, with air flow rate (10-15) m³/hr. The measurement was done by putting the devise 20 meter far from the building and within established periods of time, usually an hour. The total volume of air can be calculated from the flow-rate multiplied by the sampling time (11). The aspiration was done through an air filter, type No.37030, glass fiber with diameter 5.5 cm, with collection efficiency 99% (3). The samples was collected from many locations at Al-Tuwaitha Nuclear Site and the surrounding areas. The atmospheric parameters are: temperature range 15 -30 °C; pressure: 750.64-769.60mmHg; wind speed; wind direction and humidity are shown in Table (2).

Measurement of activity:
Almost all the air contaminants are alpha, beta, gamma emitters; in this study the measurements of air filters are performed by the measurement of alpha and beta particles using Ludlum 3030 alpha / beta sample counter from USA which have dual-channel counters designed for simultaneous alpha and beta sample measurements and scintillation detector type ZnS(Ag) with a shielded chamber and chrome-plated brass sample tray that can accept a maximum sample size of 5.1 cm (2 inches) in diameter. The Ludlum 3030 is powered by main supply of 95-250 Vac. The instrument was calibrated daily (prior to use) using standard sources supplied by the manufacturer to be used that day, every Twenty-four hours QC must be done. This feature ensures that the instrument is tested daily and that measurements are valid (12).

Measurement of activity concentration in air:
The measurement of alpha and beta activity was made by the use of the Alpha-Beta counter Ludlum 3030, having the background counting rates 3cpm or less for alpha, and 50cpm or less for beta radiations. The method consists of the following: after the expiry of the aspiration time (1 hour), the filter is removed from the aspiration motor and put in Ludlum 3030 devise and counted for 1 minute then repeat. The measurement was repeated 3 times. The average for the three values was estimated. The following equation was applied for estimating the alpha and beta activity concentration in air (13)

\[ A = \frac{\text{Activity net}}{V \times E_f} \]  

where: \( A \) is radioactive concentrations (activity densities) expressed in units Bq.m⁻³, \( V \) is the air total volume (m³), \( E_f \) the filter efficiency=99% (4). The instrument subtracts the back ground automatically. One Becquerel (Bq) is equal to one disintegration per second. 1 Becquerel (Bq) is equal to 60 DPM (14). Activity \( \text{net} \) (Bq)=\( \text{DPM}_\text{ins} - \text{DPM}_{B.G} \)/60, where DPM is disintegration per minute, \( \text{DPM}_\text{ins} \) is instant disintegration per minute, \( \text{DPM}_{B.G} \) is background disintegration per minute.

Results and Discussion:
In this study, the outdoor alpha and beta concentrations were measured in 50 locations at Al-Tuwaitha nuclear site and some surrounding locations in winter and spring. Table (2) shows the concentrations of alpha and beta in many locations at Al-Tuwaitha.

Table (3) shows the concentrations of alpha and beta in many locations out of Al-Tuwaitha and the effect of weather factors (which represents background levels) (15). The highest value of activity concentration is (4.18±0.13Bq/m³ for alpha and 9.21±0.26 Bq/m³ for beta) which has been found at (Near nuclear and radiation safety directorate/ In the center of planning department/T9) while the lowest value (0.42±0.03Bq/m³ for alpha and 0.93±0.06Bq/m³ for beta) has been found at (the right side of Nuclear application and researches directorate / building 61/T42). The variation in the activity of alpha and beta particles are due to many reasons including: the air temperature, humidity, pressure, wind speed and rains.

To define the relation between different metrological parameters related to activity concentration, we evaluate the correlation factor (R). The value of (R) lay between (1, -1), the maximum positive value (+1) refers to strong directly relation between any two parameters, the minimum negative value (-1) refers to strong inversely relation, if the value of (R) approach to (0) from the left side, it means weak inversely relation, but if the value of (R) approach to (0) from the right side, it means weak directly relation, also if (R=0) that means no relation as shown in Table (4). The alpha and beta concentration was lower in spring than in winter as shown in Table (2) because the temperature became higher and that caused atmospheric disturbance and then diluted and diffused the airborne radioactivity.

Alpha concentrations are always lower than beta concentrations as shown in Tables (2 and 3) because Alpha particle has small range and small penetration then investigating it became a very difficult in the laboratory.

Some sites out of Al-Tuwaitha were chosen as background (T5, T7, T8, T44 and T45) where the average alpha activity concentration was
Radioactive waste management directorate building T16) Fig. 5 when the measurement is repeated after (30 minutes). Or (Near radioative waste silo T21) Fig. 6, (In front of playground behind agricultural directorate T28) Fig. 7, (Beside waste station opposite side of old waste storage facility T30) Fig. 8, (Near Al Elwiat region T29) Fig. 9, (In front of Tammuz-2 reactor T27) Fig. 10, (Behind waste building RWTS and in front of radioactive waste storage T26) Fig. 11, (Near radioactive waste treatment system (RWTS) T19) Fig. 12 and (In the right side of dispensary directorate T15) Fig. 13 when the measurement is repeated after (10 minutes).

Table 2. Atmospheric parameters and the concentrations of alpha and beta in many locations at Al-Tuwaihia.

| No. | ID | date    | Starting Time | End time | Wind Speed (km/h) | Wind Direction | Temperature °C | Humidity % | Pressure mmHg | Alpha Activity concentration Bq/m³ | Beta Activity concentration Bq/m³ |
|-----|----|---------|---------------|----------|-------------------|----------------|----------------|------------|--------------|-----------------------------------|----------------------------------|
| 1   | T1 | 28/12/2016 | 09:40 | 10:40 | 10.8 | NW | 16.52 | 77 | 758.64 | 3.34±0.03 | 7.81±1.63 |
| 2   | T2 | 2/1/2017   | 10:04 | 11:04 | 10.8 | N  | 17.35 | 70 | 760.64 | 1.50±0.16 | 2.98±0.67 |
| 3   | T3 | 5/1/2017   | 10:50 | 11:50 | 14.4 | N  | 18.7 | 52 | 759.67 | 0.63±0.11 | 1.36±0.27 |
| 4   | T4 | 8/1/2017   | 09:50 | 10:50 | 11   | NW | 18.5 | 73 | 765.5 | 2.84±0.18 | 6.30±0.29 |
| 5   | T5 | 12/1/2017  | 09:50 | 10:50 | 14.4 | NW | 15.5 | 48 | 750.64 | 2.94±0.19 | 6.18±0.34 |
| 6   | T6 | 9/1/2017   | 09:15 | 10:15 | 3.7  | NW | 15.5 | 79 | 763.93 | 4.18±0.13 | 9.21±0.26 |
| 7   | T7 | 22/1/2017  | 9:30  | 10:30 | 14.4 | NW | 16.2 | 87 | 761.93 | 1.97±0.14 | 4.57±0.39 |
| 8   | T8 | 24/1/2017  | 9:49  | 10:49 | 11   | NW | 16   | 83 | 765.17 | 2.63±0.31 | 5.76±0.30 |
| 9   | T9 | 29/1/2017  | 09:10 | 10:10 | 14.4 | W  | 16.2 | 82 | 763.15 | 1.97±0.08 | 4.68±0.07 |
| 10  | T10| 29/1/2017 | 10:35 | 11:35 | 18   | NW | 18.33 | 69 | 765.23 | 1.43±0.06 | 3.37±0.16 |
| 11  | T11| 31/1/2017 | 09:59 | 10:59 | 7.2  | E   | 15.00 | 43 | 758.64 | 3.05±0.08 | 6.69±0.10 |

(1.26±0.09) Bq/m³for alpha and (2.79±0.20) Bq/m³ for beta while the average measurement of alpha activity concentration was (1.84±0.11) Bq/m³ for alpha and (4.07±0.24) Bq/m³ for beta at the studied areas which were considered within the background (less than twice the background level).

The alpha and beta radiations at Al-Tuwaihia site are from natural isotopes because of the fast disintegration for nuclides with time. This means that the nuclides have short half-life from natural decay series the thorium and the uranium series. As shown (In the left side of nuclear and radiation safety directorate T10) Fig. 2, (Near outer transport overland T11) Fig. 3, (Near agriculture and air condition storages T13) Fig. 4 and (In front of

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Table 3. Atmospheric parameters and the concentrations of alpha and beta in many locations out of Al-Tuwaitha.

| #  | ID | date       | Starting Time | End time | Wind Speed (km/h) | Wind Direction | Temperature °C | Humidity % | Pressure mmHg | Alpha Activity concentration Bq/m³ | Beta Activity concentration Bq/m³ |
|----|----|------------|---------------|----------|------------------|----------------|----------------|-------------|--------------|-----------------------------------|----------------------------------|
| 1  | T5 | 8/1/2017   | 11:20         | 12:20    | 10.8             | S              | 16.31          | 44          | 758.64       | 1.70±0.09                         | 3.64±0.29                        |
| 2  | T7 | 16/1/2017  | 10:45         | 11:45    | 18               | NW             | 17.50          | 67          | 765.23       | 1.58±0.08                         | 3.35±0.32                        |
| 3  | T8 | 17/1/2017  | 9:47          | 10:47    | 14.4             | NW             | 16.90          | 72          | 765.23       | 1.37±0.14                         | 2.81±0.03                        |
| 4  | T44| 14/3/2017  | 10:25         | 11:25    | 14.4             | N              | 26.5           | 40          | 759.80       | 0.70±0.03                         | 1.65±0.07                        |
| 5  | T45| 15/3/2017  | 10:30         | 11:30    | 14.4             | SW             | 26             | 53          | 758.64       | 1.15±0.09                         | 2.51±0.27                        |

αAVR 1.26±0.09
βAVR 2.79±0.20

Table 4. The behavior of different parameters.

| Parameter 1                        | Parameter 2          | proportional | R   |
|------------------------------------|----------------------|--------------|-----|
| Alpha Activity concentration       | temperature          | Weak inversely | -0.45|
| Alpha Activity concentration       | Wind speed           | Weak inversely | -0.45|
| Alpha Activity concentration       | humidity              | Weak directly | 0.18|
| Beta Activity concentration        | temperature          | Weak inversely | -0.47|
| Beta Activity concentration        | Wind speed           | Weak inversely | -0.47|
| Beta Activity concentration        | humidity              | Weak directly | 0.19|

Figure 2. Fast decay for nuclides with time after repeat the measurements each 30 minute

Figure 3. Fast decay for nuclides with time after repeat the measurements each 30 minute

Figure 4. Fast decay for nuclides with time after repeat the measurements each 30 minute

Figure 5. Fast decay for nuclides with time after repeat the measurement each 30 minute
Figure 6. Fast decay for nuclides with time after repeat the measurement each 10 minutes.

Figure 7. Fast decay for nuclides with time after repeat the measurement each 10 minutes.

Figure 8. Fast decay for nuclides with time after repeat the measurement each 10 minutes.

Figure 9. Fast decay for nuclides with time after repeat the measurement each 10 minutes.

Figure 10. Fast decay for nuclides with time after repeat the measurement each 10 minutes.

Figure 11. Fast decay for nuclides with time after repeat the measurement each 10 minutes.
It was noticed that the activity concentration of nuclides decreased for same locations with existing of rain for sample T10. The activity concentration of T10 (1.97±0.14 Bq/m$^3$ for alpha and 4.57±0.39 Bq/m$^3$ for beta) is less than the activity concentration of sample T1(3.34±0.63 Bq/m$^3$ for alpha and 7.81±1.63 Bq/m$^3$ for beta) which is measured on a sunny day as shown in Table (2). This result can be found also for sample T9 where the activity concentration was (4.18±0.13 Bq/m$^3$ for alpha and 9.21±0.26 Bq/m$^3$ for beta) for a sunny day and T49 where the activity concentration is (2.10±0.10 Bq/m$^3$ for alpha and 4.57±0.34 Bq/m$^3$ for beta) for a rainy day. This behavior has revealed the effect of rain on airborne radionuclides. Since the Radon and the aerosols dissolve in the rain, the radioactivity will decrease on the rainy day.

Conflicts of Interest: None.

Conclusion:
This study involves evaluation of airborne radioactivity levels for selected places at Al-Tuwaitha Nuclear Site during winter and spring. In general, the estimated airborne activities in winter were slightly higher than in spring because of the effect of the meteorological parameters on the activity concentration of nuclides. The airborne activities were slightly higher than the mean background level, indicating that there is no abnormal airborne radiological contamination at the studied areas. Also, it is found that the weather conditions have a mean factor on the radioactivity concentration in air. It is inverse proportional with the rain, temperature and wind speed and direct proportional with the humidity.
تقييم التلوث الإشعاعي للهواء لمناطق مختارة في موقع التويثة النووي خلال فصلي الشتاء والربيع

نهيل عباس محمد صالح1
يوسف محسن زاير البخات2
نادية عبد الحميد مجيد2
نور علم هاشم امين2
عمرو محمود مريط2

1 قسم الفيزياء، كلية العلوم للبنات، جامعة بغداد، بغداد، العراق.  
2 وزارة العلوم والتكنولوجيا، مديرية السلامة الإشعاعية والنووية.

الخلاصة:
تم في الدراسة الحالية تجميع الجسيمات العالقة في الهواء الجوي في موقع التويثة النووي والمناطق المحيطة بها على مرشحات هواء باستخدام جهاز سحب الهواء للفترة من 28/12/2016 إلى 13/4/2017. وقد قياس تركيز النشاط الإشعاعي للجسيمات العالقة لأشعة الفا وبيتا باستخدام جهاز لودلم 3030. وقد تراوحت قيمة النشاط الإشعاعي لأشعة الفا من (0.03±0.42 إلى 0.13±0.18) بكريل لكل متر مكعب. أما جسيمات بيتا فقد تراوح تركيز النشاط الإشعاعي لها من (0.06±0.93 إلى 0.26±0.21) بكريل لكل متر مكعب. حيث أن هذه التراكيز تتناسب عكسياً مع درجة الحرارة وسرعة الريح وطريقة مع الرطوبة النسبية. وان أعلى تركيز وجد قرب مديرية السلامة الإشعاعية والنووية – مركز قسم التخطيط النموذج T9 - بينما أقل تركيز وجد قرب دائرة البحوث والتطبيقات النووية، المبنى 61 نموذج T42. 

خلال هذه الدراسة ان النويدات المشعة هي طبيعية ناتجة من سلاسل انحلال اليورانيوم والثوريوم والتي تنتمي ضمن سلاسلها الرادون المشع الموجود في التربة والذي ينتشر الى الهواء الجوي.

الكلمات المفتاحية: تركيز النشاط الإشعاعي للهواء، جهاز سحب الهواء Hi Vol3000، موقع التويثة النووي.