



## Measurement of radioactive radon gas concentrations in leaves of trees, University of Mosul, Iraq

Sarwa A.Mohammed 

*Mathematics Department, College of Education for Women, University of Tikrit, Iraq.*

Received: Feb 22, 2023/ Revised: Mar 5, 2023/ Accepted: Mar 9, 2023

(✉) Corresponding Author: [srwa.muhammad@tu.edu.iq](mailto:srwa.muhammad@tu.edu.iq)

### Abstract

In this study, the concentration of radon gas in the leaves of trees at the University of Mosul, was studied using the CR-39 nuclear impact detector. The process lasted for 52 days, and a light microscope calculated the nuclear impact; where the percentages showed the highest rates of radon gas in the College of Dentistry and Computer Center, where the ratio of radiation background ranges between (102.777-158.333) Track/m<sup>2</sup> X 10<sup>6</sup> and the highest concentration of radon gas in the air space in the College of Dentistry and Computer Center by 571.1730) Bq. m<sup>-3</sup> while the highest concentration of radon gas for the sample was about (251.6744) Bq.m<sup>-3</sup>. The reason for this is geological factors as well as air pollution rates and because trees absorb water from the soil leads to the presence of radon gas.

**Keywords:** Leaves of trees, CR-39 , Impact , Radon

### Introduction

Ionizing radiation includes radon. Therefore, exposure is second only to smoking as a risk factor for lung cancer. The natural decay of uranium in soil and water produces radon, an odorless, tasteless, invisible gas. The only human disease linked to radon exposure is lung cancer. When uranium breaks down in soil and water, it produces a radioactive gas called radon. All buildings contain it in the interior and exterior air (Rahimi, 2013). Granite and most of the material in the earth is uranium, the core of which takes a long time to convert into a stable lead. This cycle is called the uranium decay cycle (Macdougall, 2008). Radiative activity is a naturally occurring phenomenon in active radioactive material that naturally emits a specific type of radiation over time; the highest radiation levels come from ionizing radiation sources and nuclear explosions, which can contaminate the environment and have radiological effects on humans. For example, The Hiroshima and Nagasaki atomic explosions in 1945 signalled the start of pollution. Many other events that followed had a widespread impact and polluted large parts of the planet. In addition, these processes include other sources of contamination from using

radioactive materials in manufactured (industrial, agricultural, medical, military, etc.) areas. Therefore, it is necessary to study the effects of radiation, how it is perceived, how pollution levels are perceived and how this pollution is dealt with (Saleh, 2019). All buildings and subterranean areas contain radon, which is known to cause lung cancer. In some situations, radon may be a significant source of radiation at work and is a significant source of radiation for the general population. However, depending on the local geology, building design, ventilation, and human behavior, exposure levels can vary greatly (Clement, 2010). According to a May 2018 report, mattresses from a South Korean company were said to emit radon gas. Monazite, a material that emits radon gas, was found in the bed. Since that news release, many stories have surfaced about the negligent use of monazite in clothing, accessories, masks and building materials, drawing public attention to the health hazards of radon. With this in mind, this study will examine how radon exposure affects people's health (Marsh, 2014). There are many articles examining radon levels in several countries.

In 2015, Asia and others measured radon excess lung risk factor estimates in several households in Fallujah. In addition, the annual effective dose and surplus lung cancer value (ELC) per million people per year were calculated and found to vary from 0.941 to 2.350 mSv.y<sup>-1</sup> with an overall mean of 1.581 mSv.y<sup>-1</sup> and 565 respectively 1410 with an overall average of 948 (Mashhadani, 2015).

In 2019, Gehad M. Saleh et al. Research on the environmental radioactivity and hazards of radon in Hamash gold mine, Egypt. Their results showed that radon concentrations in all samples were above the world limits recommended by ICRP and IAEA (Saleh, 2019).

In 2020, Kleeb et al used the Nuclear Trace Detector CR-39 to calculate the radon concentration in Samara University (IRAK) building. Radon concentrations ranged between 3.8 and 175.9 Bq.m<sup>-3</sup>, averaging 41.4 Bq.m<sup>-3</sup> (Kleeb et al., 2020)

In 2020, Ali et al. measured radon concentrations in powdered milk, Using the Nuclear Track Detector CR-39. Where the radon level ranged between 1371 and 151 Bq.m<sup>-3</sup> with an average value of 577 Bq.m<sup>-3</sup> (Ali, 2020).

Asker et al (2021) Determination Radon Concentration in Urine of Patients with Cancer in Kirkuk. He was found that the concentrations of radon were ranged between 8.9 and 1.5 Bq.m<sup>-3</sup> with an average value of 3.7 Bq.m<sup>-3</sup>.

Al-Ani, et al. (2022) Radon Assessment in Ceratophyllum dimerism Plant Samples was estimated using a passive track detector CR-39. In the Tigris River in Baghdad city - Iraq. The results obtained in this work indicated that the radium content and uranium concentration present in the Ceratophyllum demurs are acceptable and do not pose any risk to the aquatic ecosystem.

## Experimental

This study used the solid-state nuclear tracking detector (SSNTD) method to make extensive indoor radon concentration measurements. This work used the beaker technique. Each cup is 7cm high, 4.5 cm in diameter, and contains a (1\*1cm<sup>2</sup>) CR-39 nuclear tracking detector inside.

Mosul University is a public university in Mosul, Iraq. It is one of the Middle East's most extensive education and research centers and the second largest in Iraq after Baghdad University.

The University of Mosul was established in April 1967 on the basis of Faculty of Medicine under the control of the Ministry of Health. But the actual presence of the University as a local scientific and educational institution dates back to 1 April 1967, the resolution date (14), establishing an Iraqi university under the University of Mosul over the years, the University has expanded its work to include 20 Colleges, (7)

Research Centers, (6) Consulting Offices, 5 Clinics, Hospitals, and 6 Museums, and the University seeks some of the councils and technical and administrative units to achieve the goal of higher education in Iraq, which is to train scientifically qualified national cadres in one hundred scientific disciplines and to support scientific research and the movement of civil servants in the training of cadres. The University of Mosul confers a bachelor's degree in one hundred scientific specializations spread across university departments and different subject areas of the University; even after employment in the national sector, the University accompanies its graduates through successive courses of continuing education programs aimed at restoring and updating graduate information Inform them of the latest scientific discoveries

## Materials and Methods

Techniques to detect radiation and its byproducts and measure their concentrations in materials have evolved to cope with the diversity of their sources. One of these techniques is long-term measurements, mainly based on nuclear reagents (Al-Ataby, 2005).

CR-39 detector has become one of the most famous atom collision detectors because of the above features and specifications. In the absence of previous studies evaluating radioactive radon concentrations, the study in the leaves of trees of the University of Mosul for several possibilities, including the College of Dentistry, behind the Department of Physics and Architecture, the University Press, the College of Physical Education, the Computer Center, Nineveh Medicine, Electrical Engineering and Environmental Sciences.

After carefully removing the detector from the tank and etching it with a 6.25 N NaOH solution at 70 °C for 8 hours and then with distilled water, the sensor was dried and rinsed again with distilled water. Alpha-His traces were then counted under a light microscope with a magnification of 400×, allowing for background (ELFarrash, 2012). The following calculation calculates the radon concentration at (kB.qm<sup>-3</sup>).

## Coefficient

Radon concentration measurements are based on Equation's determination of the diffusion coefficient K (Cox,1984).

where:

$$\rho = K \times C \times T \quad (1)$$

$\rho$  : impact strength TrackT : irradiation time in seconds in equation ( Rejah, 2017)

$$D = \frac{\rho}{T} = K \times C \tag{2}$$

where:

$D$  : the density rate of the effects  $\text{Tr. Cm}^{-2}/\text{h}$

The propagation constant as a function of the propagation chamber geometry can also be calculated according to the relation (Myrick, 1983)

$$K = \frac{1}{4r} \left( 2 \text{Cos } \theta_c - \frac{r}{R_\alpha} \right) \tag{3}$$

where:

$r$ : Tube radius = 2.25 cm

$\theta_c$ : Detector Chamber Angle CR39 = 35°

$R_\alpha$  : number of alpha particles emitted  $\text{Rn}^{222}$  in the air becomes (Mallah,1986)

$$R_\alpha = (5 \times 10^{-3} E_\alpha + 0.285) \times E_\alpha^{3/2} \tag{4}$$

where:

$E_\alpha$ :  $\alpha$  particle energy MeV

When computing the K value from equation 3, the diffusion constant's value in length units is equal because the K value relies on the geometric dimensions of the propagation chamber  $K = 0.6164 \text{ cm}^{-2}$ .

/cm<sup>2</sup>

K: diffusion constant

C: Spatial radon concentration  $\text{Bq.cm}^{-3}$

### Calculate Aerospace Radon Concentration and Sampling

According to this relationship, we can calculate the radon concentration in the headspace of the sealed space in the propagation chamber between the detector sample's surface units  $\text{Bq.cm}^{-3}$  (Mallah, 1986).

$$D_{\text{Rn}^{222}} = \frac{C}{4} r \left( 2 \text{Cos } \theta_c - \frac{r}{R_\alpha} \right) \tag{5}$$

### Calculation of radon concentration in samples

The radon concentration in the sample is given by the following relation [18]

$$C_s = \frac{\lambda_{\text{Rn}} C_\alpha h t}{L} \tag{6}$$

where:

$C_s$ : Radon concentration in the sample  $\text{Bq/m}^3$ .

$C_\alpha$ : Radon concentration in aerospace  $\text{Bq/m}^3$ .

$\lambda_{\text{Rn}}$ :Constant decay radon ( $1.81 \times 10^{-1} \text{ day}^{-1}$ )[19].

$L$ :The sample thickness is approx. = 1.5 cm.

$t$ :Irradiation time in days with a value of 52 days= 4492800 sec.

The nuclear effect of radon gas on the leaves of the trees of the sites has been studied as in the following table (1):

**Table 1 : Location of radon dosimeters**

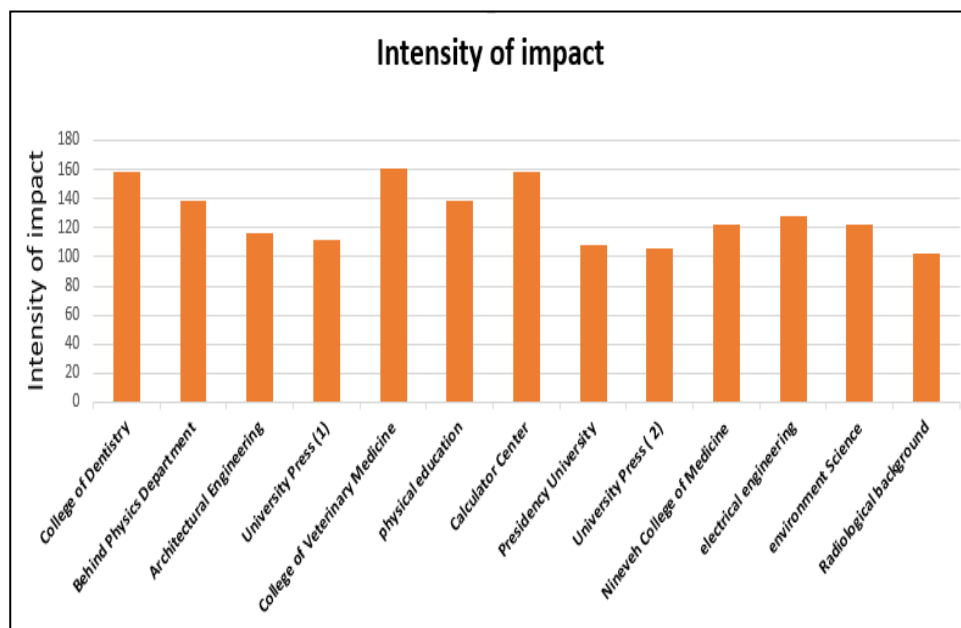
Dosimeter Location	Details
A1	College of Dentistry
A2	Behind Physics Department
A3	Architectural Engineering
A4	University Press (1)
A5	College of Veterinary Medicine
A6	physical education
A7	Calculator Center
A8	Presidency University
A9	University Press ( 2)
A10	Nineveh College of Medicine
A11	electrical engineering
A12	environment Science

This study used nuclear detectors to record radiation activity in the leaves of tree samples from several sites at the University of Mosul. Reagents are placed in a sealed cylindrical diffusion chamber (Sealer Diffusion Chamber). Reagents are placed on the sample to measure its radon concentration. Seal the room Prevent leaks or allow air exchange with surrounding air. after radon is released into the cavity, the  $\alpha$  particles decompose and release. After reaching equilibrium with the body, the detector may be exposed to the sample. At the same time, the radon moves to the progeny wall of the cavity at the experimental working speed [3]

The samples are then ground to obtain a homogeneous, smooth powder sample, ensuring that the radioactive material is evenly distributed throughout each sample, ready for inspection and analysis. The CR-39 detector is used as a technique to detect radioactive contamination. Alpha particle signatures emitted by radon gas are extracted from the sample using long-term measurement techniques.

**Table 2 : The results obtained for the study of radon gas for tree leaves at the University of Mosul**

Sample code	Name a sample	Impact of Rate	Intensity of impact $Tarck/m^2$	Concentration of radon in $\times 10^6$ ospace $Bq.m^{-3}$	Concentration of radon in sample $Bq.m^{-3} \times 10^2$
A1	College of Dentistry	5.7	158.333	5711.73	2516.744
A2	Behind Physics Department	5	138.888	5015.162	2207.661
A3	Architectural Engineering	4.2	116.666	4212.739	1854.436
A4	University Press (1)	4	111.111	4012.151	1766.613
A5	College of Veterinary Medicine	5.8	161.111	5817.621	2560.901
A6	physical education	5	138.888	5015.162	2207.661
A7	Calculator Center	5.7	158.333	5717.621	2516.744
A8	Presidency University	3.9	108.333	3911.839	1721.73
A9	University Press ( 2)	3.8	105.555	3811.527	1677.824
A10	Nineveh College of Medicine	4.4	122.222	4413.363	1942.75
A11	electrical engineering	4.6	127.777	4613.95	2031.048
A12	environment Science	4.4	122.222	4413.363	1942.75
A13	Radiological background	3.7	102.777	3711.215	1633.667



**Fig. 1 Shows The relationship between places and the density ratios of nuclear impact**

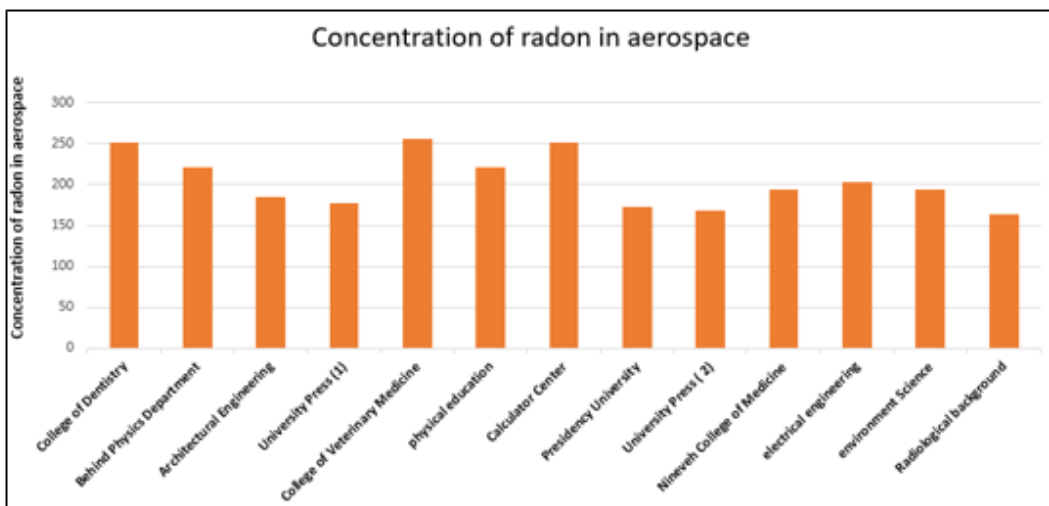


Fig 2. Shows the relationship between places and radon concentration ratios in the air space

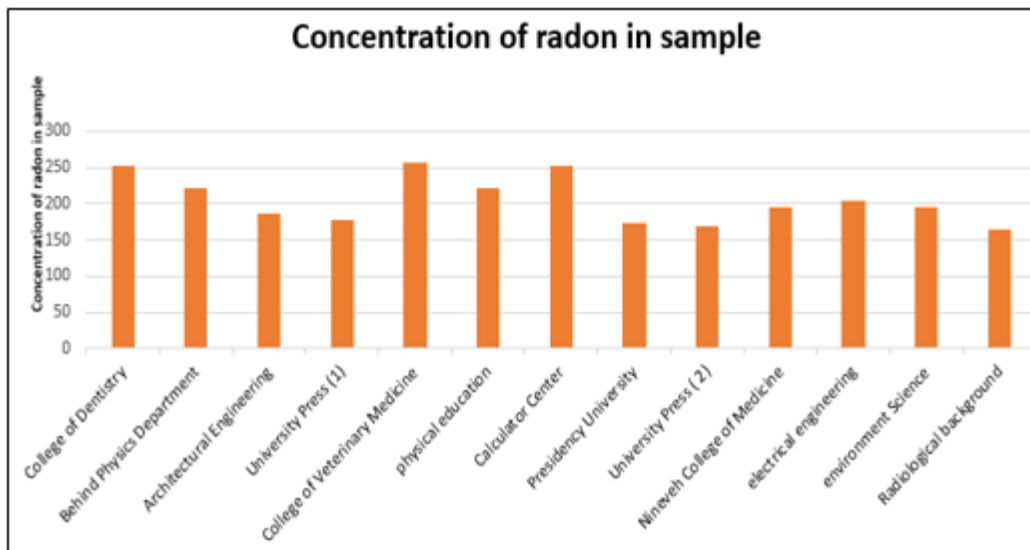


Fig 3. Shows the relationship between places and radon concentration ratios in the sample.

Detector is CR-39, the thickness is 500µm, the size is 30\*30cm<sup>2</sup>, each reagent is 10g, and the detection amount is determined with a 5\*10<sup>-3</sup> sensitive balance. The sample is placed in a cylindrical irradiation chamber with a diameter of 4.5 cm, the so-called expansion chamber.

The room is closed with a rubber stopper, and the distance between the sample surface and the rubber surface is kept at 7 cm. The sample is then left for 52 days to reach an ideal of 98% of radon's isotopic derivatives, and radon is in equilibrium with one another (long-term stability).

To prevent radon from escaping from the room it was propagating in, the rubber was removed and quickly replaced

with another rubber fitted with a CR-39 detector. Before lifting the rubber, reseal it with tape while maintaining the dimension between the probe and the sample face. Reagents are kept in the irradiation chamber for 52 days. All detectors are removed, and solutions up to 98% pure are used to prepare the sample for the chemical etching process. In the final operation, the detector will display the remaining radon level. This procedure involved a temperature of 70 °C and a solution concentration of 2.5 M and included combining 25 grams of molecular weight 40 with 100 milliliters of pure water ( Ali et al., 2020).

After etching with caustic soda for 7.5 hours, Remove samples from solution, rinse thoroughly with distilled water,

dry and finally prepare for examination under an optical microscope, after counting the number of traces left by  $\alpha$  particles (emitted by radon) interacting The detector face facing the sample is used to calculate the radiation background of the CR39 detector. If the detectors are exposed to the sample, one is in a closed tube devoid of samples. Calculating the CR-39 detector's radiation background is the goal.

## Results and discussion

Table (1) shows samples collected at some sites at Mosul University corrected for the impact level of alpha particles and the number of impact levels determined by aerospace radon concentrations, where the radon concentration in the samples was compensated.

The density of the effect ranged between (102.777-158.333) Track/m<sup>2</sup> x 10<sup>6</sup> while the concentration of radon in aerospace ranged between (371.1215-571.1730) Bq. m<sup>-3</sup>x10<sup>1</sup> and the concentration of radon in the sample ranged between (163.3667-251.6744) Bq. m<sup>-3</sup> x 10<sup>3</sup> and was the highest percentage in the College of Dentistry and Computer Center, as shown in the following figures.

## Conclusions

In this study, the concentration of radon gas in the leaves of the trees of the university of Mosul was found in (13) places, including the college of dentistry and physical education, the university press, the department of physics, and the electronic computer center.... etc, where the CR-39 nuclear impact detector with dimensions (1 \* 1cm<sup>2</sup>) and diameter of 4.5cm was used, where the highest percentages of radon gas concentration in the sample were located in the Faculty of dentistry and the computer Center 251.6744).251.6744) Bq. m<sup>-3</sup> x 10<sup>2</sup> .

## Conflict of Interest

The author hereby declares no conflict of interest.

## Consent for publication

The author declares that the work has consent for publication.

## Funding support

The author declares that they have no funding support for this study.

## References

- Al Ani, R. R., Amin, S. A., & Alwan, A. (2022). Radon Assessment in Ceratophyllum demersum Plant Samples. *Iraqi Journal of Science*, 63(12), 5278-5285.
- Al-Ataby, N. A. R. (2005). *Study of Environmental Radioactivity in the Soil of Al-Tuwaiha Zone and its Surrounding Sides* (Doctoral dissertation, Ph. D. Thesis, Baghdad University, College of Science).
- Ali, E. S., Mohammed, S. F., Mohammed, C. N., & Mahmoud, Z. S. (2020, May). Measurement of Radon Radiation Concentration in Imported and Local Powdered Milk using Nuclear Track Detector CR-39. In *Journal of Physics: Conference Series* (Vol. 1530, No. 1, p. 012133). IOP Publishing.
- Al-Mashhadani, A. H., Shafik, S. S., & Saeed, M. A. (2015). Estimating excess of lung risk factor of radon gas for some houses in Al-Fallujah city. *Iraqi Journal of Physics*, 13(26), 160-170.
- Asker, M. M., Ali, E. S., & Mohammed, S. A. (2021). Determination Radon Concentration (Radon Gas) in Urine of Patients with Cancer. *NeuroQuantology*, 19(4), 87-92.
- Clement, C. H., Tirmarche, M., Harrison, J. D., Laurier, D., Paquet, F., Blanchardon, E., & Marsh, J. W. (2010). Lung cancer risk from radon and progeny and statement on radon. *Annals of the ICRP*, 40(1), 1-64.
- Cox, M. E., & Fankhauser, B. L. (1984). Distribution of fallout cesium-137 in Hawaii. *Health Physics*, 46(1), 65-71.
- El-Farrash, A. H., Yousef, H. A., & Hafez, A. F. (2012). Activity concentrations of 238U and 232Th in some soil and fertilizer samples using passive and active techniques. *Radiation Measurements*, 47(8), 644-648.
- Kleeb, R. W., Salah, S. A., & Ali, E. S. (2020). Calculation of Radon Gas Concentration in the Buildings of Samara University Using the Nuclear Track Detector CR-39. *NeuroQuantology*, 18(2), 82-87.
- MacDougall, J. D. (2008). *Nature's clocks: how scientists measure the age of almost everything*. Univ of California Press.
- Marsh, J. W., Harrison, J. D., Laurier, D., Birchall, A., Blanchardon, E., Paquet, F., & Tirmarche, M. (2014). Doses and lung cancer risks from exposure to radon and plutonium. *International Journal of Radiation Biology*, 90(11), 1080-1087.
- Mollah, A. S., Ahmed, G. U., Husain, S. R., & Rahman, M. M. (1986). The natural radioactivity of some building materials used in Bangladesh. *Health physics*, 50(6), 849-851.
- Myrick, T. E., Berven, B. A., & Haywood, F. F. (1983). Determination of concentrations of selected radionuclides in surface soil in the US. *Health physics*, 45(3), 631-642.
- Rahimi, S. A., & Nikpour, B. (2013). Measurement of radon concentration of air samples and estimating radiation dose from radon in Sari province. *Universal Journal of Public Health*, 1(2), 26-31.
- Rejah, B. K., & Ashoor, G. T. (2017). Radon gas concentration measurement in air of Al-Haswaa City in Province of Baghdad. *Iraqi Journal of Science*, 58(2A), 663-668.
- Saleh, G. M., Yousef, H. A., & Mitwalli, M. E. S. (2019). Environmental Radioactivity of Radon and its Hazards in Hamash Gold Mine, Egypt. *Arab Journal of Nuclear Sciences and Applications*, 52(4), 190-196.
- Saleh, S. A. A. M. (2019). Radioactivity of Some Soils in the University of Tikrit, Iraq, college of Education for Girls using Solid-State Nuclear Track Detector type CR-39. *Iraqi Journal of Science*, 2015-2021.

## How to cite this article

Mohammed, S.A. (2023). Measurement of radioactive radon gas concentrations in leaves of trees, University of Mosul, Iraq. *Science Archives*, Vol. 4(1), 39-44. <https://doi.org/10.47587/SA.2023.4107>

This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/)



**Publisher's Note:** MD International Publishing stays neutral about jurisdictional claims in published maps and institutional affiliations.