



Radon-risk Mapping and Protection in Mining and High Potential Mining Areas of Cameroon

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Outline

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Introduction

- Radon measurements indoors started ten years ago in Cameroon with focus on mining and ore bearing areas. Various techniques were used: Electret Ionization Chambers, RADUET, RADTRAK, DRPS and DTSP.
- Up to date, radon measured in about 3000 houses
- Radon in soil measured since 2021 in about 500 points in five regions
- Most of measurements carried out in the mining and high potential mining areas
- Regulation on radon exposure drafted in 2019-2020
- A national radon action plan (RAP) established in 2020 within IAEA TC project CMR9009
- A follow-up project CMR9010 to run the RAP from 2022.



Study areas

Number	Study area
1	Uranium bearing area of Poli
2	Uranium deposit of Kitongo (inside two exploratory galleries)
3	Uranium and thorium bearing area of Lolodorf
4	Gold mining area of Bétaré Oya
5	Bauxite bearing area of southern Adamawa
6	Bauxite bearing area of Fongo-Tongo
7	Nickel and cobalt bearing area of Nkamouna-Kongo
8	Rutile bearing area of Akonolinga
9	Diamond bearing area of Mobilong
10	Radon prone area of Ngaoundéré city

Uranium-238 and thorium-232 series

	²³²Th	10 ¹⁰ y	
α	²²⁸Ra	6 y	
β	²²⁸Ac	6 h	γ
β	²²⁸Th	2 y	(γ)
α	²²⁴Ra	4 d	(γ)
α	²²⁰Rn	1 min	(γ)
α	²¹⁶Po	0.1 s	
α	²¹²Pb	11 h	γ
β	²¹²Bi	1 h	γ
β/α	²¹²Po & ²⁰⁸Tl	0.3 μs & 3 min	γ
α&β	²⁰⁸Pb	stable	

	²³⁸U	4.5×10 ⁹ y	
α	²³⁴Th	27 d	(γ)
β	^{224m}Pa	1 min	
β	²³⁴U	2.5×10 ⁵ y	
α	²³⁰Th	75 y	
α	²²⁶Ra	1600 y	(γ)
α	²²²Rn	4 d	
α	²¹⁸Po	3 min	
β	²¹⁴Pb	27 min	γ
β	²¹⁴Bi	20 min	γ
β	²¹⁴Po	0.2 ms	
α	²¹⁰Pb	22 y	(γ)
β	²¹⁰Bi	5 d	
β	²¹⁰Po	140 d	
α	²⁰⁶Pb	stable	

Radon-222: Radon

Radon-220: Thoron

Only radon is considered in the IAEA BSS, ICRP 115, ICRP 126, etc.

Up-to-date thoron is not taken into account in radon regulation.

^{222}Rn , ^{220}Rn and progeny indoors

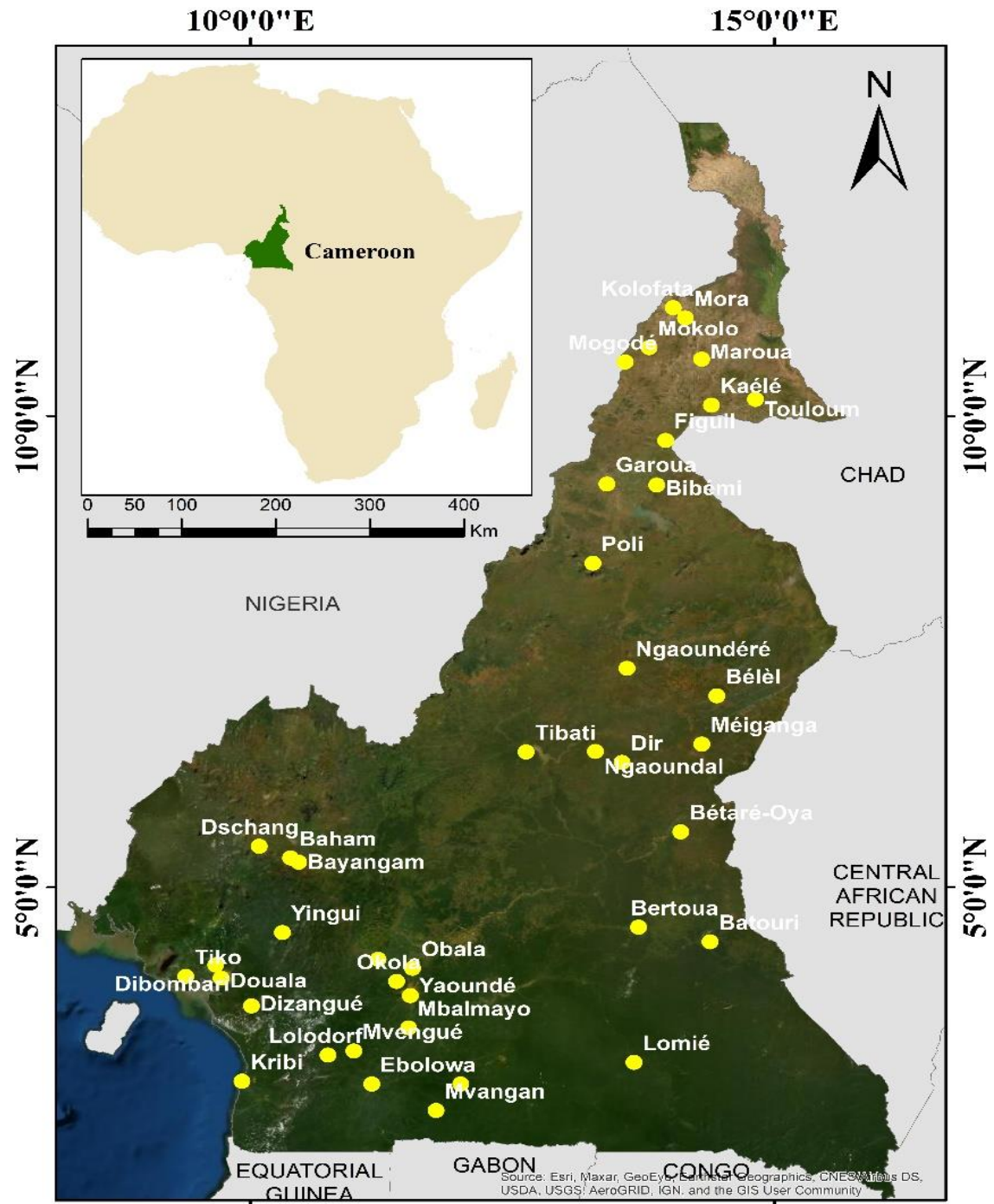
- 450 RADUET and 350 TnP monitors were deployed for 2 months in the houses of some regions (ES, LT, NO, and SU) with highlight on mining and ore bearing areas.
- Detectors were analyzed at Hirosaki University, Japan.
- DRPS and DTSPS were deployed in 500 houses
- Analysis at Bhabha Atomic Research Centre, Mumbai, India



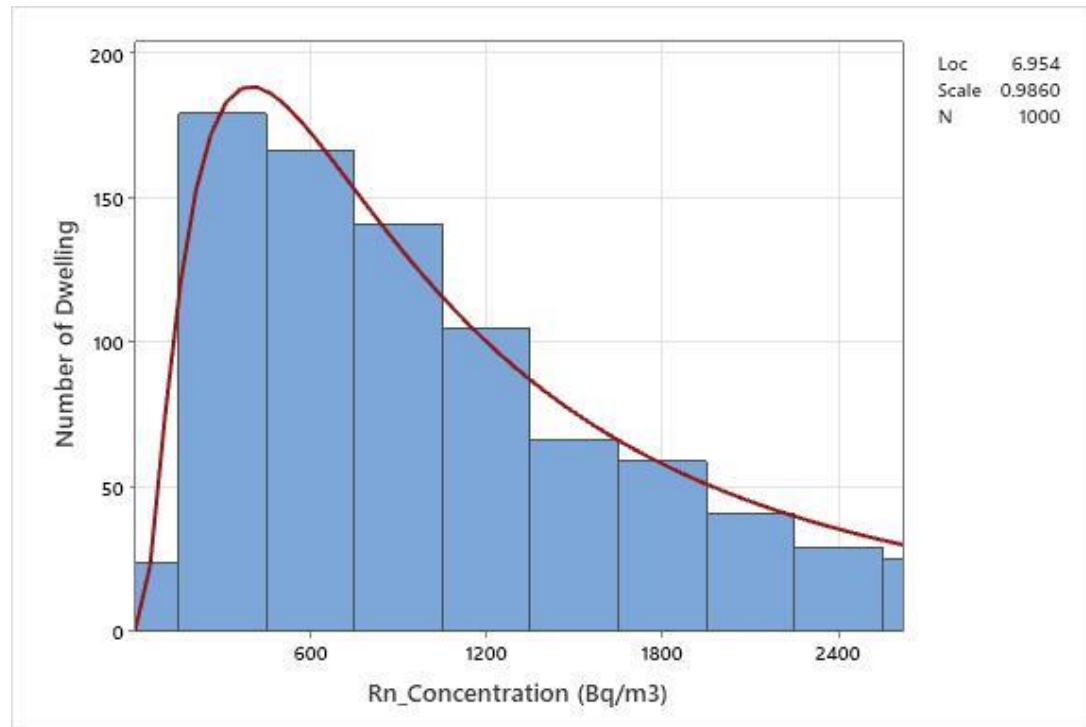
^{222}Rn measurements indoors

- A total of 1500 RADTRAK detectors were deployed in the houses for two months in the whole country.
- Detectors were analyzed at RADONOVA Laboratories in Uppsala, Sweden.





Radon distribution indoors



Radon distribution indoors follows the lognormal law.

Indoor radon, thoron and thoron progeny concentrations

Region	Arithmetic mean (Bq.m ⁻³)			Range (Bq.m ⁻³)		
	²²² Rn	²²⁰ Rn	TnP	²²² Rn	²²⁰ Rn	TnP
Uranium area of Poli	82	94	6.4	46-143	24-238	4-9
Uranium deposit of Kitongo	486			416-523		-
Uranium and thorium area of Lolodorf	97	160	10.3	27-937	6-700	0.4-36
Gold mining area of Betare Oya	133	92	6	88-282	4-383	0.6-19
Bauxite area of Southern Adamawa	107	-	-	43-270	-	-
Bauxite area of Fongo-Tongo	173	-	-	98-410	-	-
Nickel-cobalt area of Nkamouna-Kongo	78	-	-	21-304	-	-
Rutile area of Akonolinga	-	-	-	-	-	-
Diamond area of Mobilong	-	-	-	-	-	-
Radon prone area of Ngaoundere city	241	-	-	102-538	-	-

- The corresponding arithmetic means are 103 Bq.m⁻³, 107 Bq.m⁻³ and 6.8 Bq.m⁻³.
- Arithmetic mean of Rn is well above the world average value of 40 Bq.m⁻³ given by UNSCEAR.
- 49%, 9%, and 2% of all surveyed houses have ²²²Rn concentrations above 100, 200 and 300 Bq.m⁻³ respectively.
- The city of Ngaoundéré is the most Rn-exposed area with 28% of houses having Rn above 300 Bq.m⁻³.

It clearly appears the importance to put in place Radon Regulation and Radon Action Plan in Cameroon.

Inhalation dose due to radon and thoron indoors

Region	Mean dose (mSv.yr ⁻¹)		Range (mSv.yr ⁻¹)	
	²²² Rn	²²⁰ Rn	²²² Rn	²²⁰ Rn
Uranium area of Poli	1.5	1.8	0.9-2.6	0.34-6.2
Uranium deposit of Kitongo	3.2		2.8-3.5	
Uranium and thorium area of Lolodorf	2	2.2	0.5-18.5	0.08-8
Gold mining area of Betare Oya	2.5	2	1.7-5.3	0.13-4
Bauxite area of Southern Adamawa	2.1	-	0.8-5.0	-
Bauxite area of Fongo-Tongo	3	-	1.6-8.1	-
Nickel-cobalt area of Nkamouna-Kongo	2.5	-	0.4-5.8	-
Rutile area of Akonolinga	-	-	-	-
Diamond area of Mobilong	-	-	-	-
Radon prone area of Ngaoundere city	5.6		2-10.2	

- The mean value for ²²²Rn is 2.8 mSv.yr⁻¹ higher than the world average value of 1.2 mSv.yr⁻¹ (0.2-10 mSv.yr⁻¹) given by UNSCEAR.
- The mean value of inhalation dose due to Tn exposure indoors is 2 mSv.yr⁻¹.
- Ngaoundere city, the first identified radon prone area of Cameroon has the average dose of 5.6 mSv.yr⁻¹.

Inhalation dose due to radon and thoron indoors

- The contribution of Tn to inhalation dose due to Rn and Tn exposure ranges between 12–67, 3–80, 7–70 and 7–60% in the North, South, East and Littoral regions respectively.
- The corresponding average values are 49, 53, 31 and 26% respectively.
- It clearly highlights the importance to consider Tn in inhalation dose assessment of Rn.

Radon in soil

Study area	²²² Rn arithmetic mean (kBq.m ⁻³)	Range (kBq.m ⁻³)
Uranium bearing area of Poli	-	-
Uranium and thorium bearing area of Lolodorf	13.2	4.8- 57.3
Bauxite bearing area of southern Adamawa	-	-
Bauxite bearing area of Fongo-Tongo	69	35- 202
Nickel and cobalt bearing area of Nkamouna-Kongo	26	3.6- 54
Rutile bearing area of of Akonolinga	24.3	5.4- 75.5
Diamond bearing area of Mobilong	16.5	6.6- 38.7
Radon prone area of Ngaoundéré city	79	73- 166

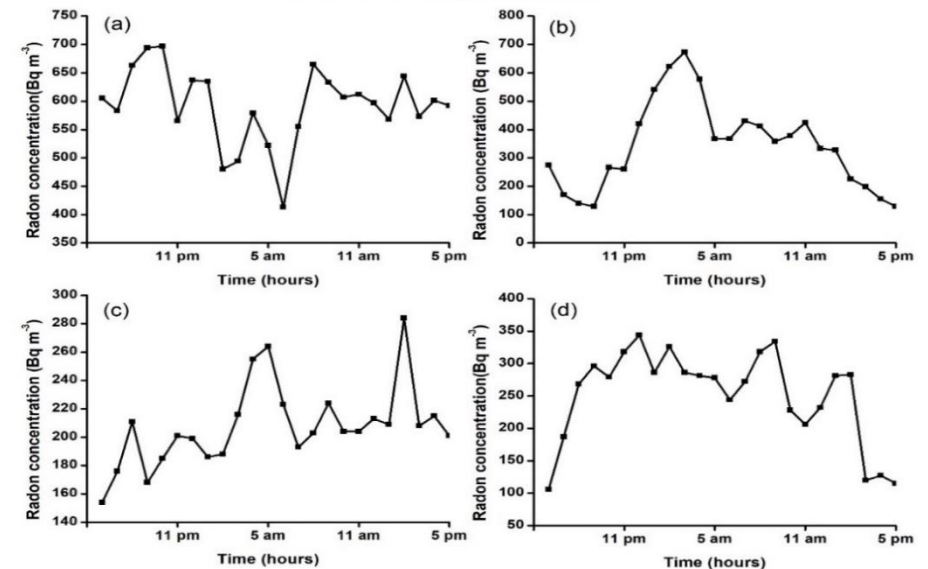


Radon in soil

- According to Sweden Criteria, radon in soil measuring points ranging between 10 and 50 kBq.m⁻³ are considered “normal risk,” and those presenting concentrations greater than 50 kBq.m⁻³ are classified as “High Risk” areas.
- The average radon concentrations in soil of the bauxite bearing area of Fongo-Tongo and the radon prone area of Ngaoundéré city are well above 50 kBq.m⁻³ making them high risk areas.

Radon at workplaces

- The reference level for workplaces is 1000 Bq m⁻³ (WHO, ICRP, IAEA BSS GSR Part 3)
- ICRP recommends using the same upper value of 300 Bq m⁻³ in mixed-use buildings, which are used by both members of the public and workers (ICRP 126).
- New dose coefficients for workers (ICRP 137).
- Emphasis on radon at workplaces from 2023.



Radon regulation and national radon action plan

The collected data on Rn using EICs and RADUET detectors helped to build a Technical Cooperation Project with IAEA on *Establishing a national Rn plan for controlling public exposure due to Rn indoors* implemented from 2018 to 2020.

- Equipment ;
- Expert missions ;
- Scientific visits ;
- Fellowships ;
- Workshops and National Training Courses.



Radon Regulation and RAP

- Regulation on Rn was drafted by the regulatory body from 2019-2020 and the process to adopt it is still ongoing.
- RAP was validated during a national workshop in October 2020 involving all the national stakeholders.
- To efficiently implement the young RAP, mitigation of high Rn levels in houses and workplaces, Rn prevention, capacity building on Rn risk communication, Rn regulation should be strengthened or taken into account.
- A follow-up project on *Strengthening National RAP to Mitigate Public Exposure to Rn in Dwellings and at Workplaces in Cameroon* has started in 2022 within the framework of 2022-2023 IAEA TC Cycle.

Conclusion and perspectives

- Rn measured in about 3000 houses at the national scale.
- Collected data brought out the importance to develop Rn regulation and RAP.
- Regulation on Rn drafted and the validation process is ongoing.
- RAP validated during a national workshop in 2020 involving all the national stakeholders.
- RAP and Rn regulation emphasizing on Rn-risk communication, Rn mitigation, integration of radon issue in building codes and training of building professionals.
- Rn-risk mapping ongoing to locate the Rn prone areas for radiological protection of the public. Rn at workplaces will be considered.
- Rn-risk mapping extended to other Central African Countries.
- At the international level there is requirement to take into consideration Tn exposure in the regulation of Rn.
- Unified approach between UNSCEAR and ICRP recommended for Rn and Tn dosimetry.



<https://www.researchgate.net/profile/Saidou-2>

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