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Valence, 28 January 2010.

CRIIRAD report N°. 10-07

Analyses of atmospheric radon 222 / canisters exposed by Greenpeace in Niger (Arlit/Akokan sector)

1 / Context

The companies SOMAIR and COMINAK, subsidiaries of the AREVA group, are mining uranium deposits in northern Niger.

In the course of a field mission carried out in November 2009, a Greenpeace International team deposited detectors (canisters of activated charcoal) to measure radon 222, a radioactive gas formed by the decay of the radium 226 present in the uranium ore.

This report includes the results of the analysis of the activated charcoal canisters conducted in CRIIRAD's laboratory, and a brief commentary on the interpretation of the results.

2 / Collection of the samples

Preparations for the mission

The sampling procedures and radioprotection instructions were discussed during a preliminary meeting at the CRIIRAD laboratory on **7 October 2009**, between Dr. Rianne Teule (chemist, Greenpeace International) and Dr. Bruno Chareyron (nuclear physics engineer in charge of the CRIIRAD laboratory).

The CRIIRAD laboratory provided Greenpeace with activated charcoal detectors (canisters) along with the equipment for setting them up. These detectors are intended to be installed in the environment, either indoors or outdoors.

Once the airtight cover is removed from the casing, radon 222 present in the ambient air is absorbed by the activated charcoal in the receptacle. After the nominal exposure period of 48 hours, the detectors are sealed and returned to the laboratory as quickly as possible. Since radon 222 has a half-life of 3.8 days, the concentration in the canisters will halve every 3.8 days as a result of its radioactive decay.

It was planned that the Greenpeace team would install the radon detectors mostly near to the main sources of radon (the air vents of COMINAK's mine tunnels, SOMAIR's and COMINAK's radon-bearing radioactive waste stores, etc) and at a range of distances from these sources, so as to study the transfer of radon into the environment and evaluate the danger to the population (radon is a radioactive gas and carcinogenic to humans).

In preparation for the mission, CRIIRAD had recommended that Greenpeace obtain from AREVA a plan of the air vents and a list of the levels of radioactive gas emitted to the atmosphere by each (see Annex 2). Greenpeace made this request to AREVA in August 2009.

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As a result of approaches made in **2004**, CRIIRAD had received the following information from AREVA: *"The concentrations of radon emitted from the air vents (ventilation is mandatory under article 32 of the regulation of 8/01/2001, which also defines maximum radon concentrations acceptable in the workplace) are very variable, depending on:*

- *the nature of the zone being mined*
- *the ventilation of the zone (airflow after it has been mined)*
- *weather conditions.*

*The concentrations measured range from **3,600 to 18,000 Bq/m^3** with an average of **10,000 Bq/m^3** at the level of the outlet itself. The impact of this ventilation is reflected in the measurement of added doses and has no effect on the population."*

Unfortunately, AREVA did not provide Greenpeace with any specific documentation on the actual emissions of the various air vents.

Air sampling was therefore carried out by Greenpeace near to vent GT 238, chosen at random, without knowing whether it was actually connected to a sector at risk.

Implementation of the on-site measures and sampling

The canisters were put in place by Greenpeace between **5 and 6 November 2009**.

They were removed 48 hours later, following the procedure set out by CRIIRAD.

The canisters were set up at between 1m and 2.5m above the ground.

As a result of the constraints of weather and security, the team was not able to carry out the sampling as originally planned.

In practice, it was possible to install only two detectors close to an air vent for the COMINAK mines (air vent no. GT 238 – see photo below), without prior confirmation from AREVA as to whether the radon emitted by this vent was representative of the emissions from the other vents.

In addition, Greenpeace installed six further detectors at Akokan and Arlit. Contrary to the original plan, it was not possible to locate detectors in control areas unaffected by mining activities.

The locations of the eight sampling stations, along with site descriptions and the dates and times of installation and removal, are shown in the first six columns of table T1 on the next pages. This information is provided by Greenpeace (Dr Rianne Teule).

Air vent N°GT 238 / Photo Greenpeace

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3 / Analysis at the CRIIRAD laboratory

Processing of the samples

The eight canisters were returned to CRIIRAD (B Chareyron) on 12 November 2009 by Dr Teule (Greenpeace).

Upon being received by the CRIIRAD laboratory, the samples were weighed so as to determine the uptake of water by subtracting the original mass. This parameter is used to correct, where necessary, the coefficient of radon capture by the activated charcoal.

For the eight canisters analysed, the water uptake remained below the threshold at which an adjustment has to be made to take account of the capture rate.

Results of gamma spectrometry analysis

Gamma spectrometry analysis was carried out at the CRIIRAD laboratory directly upon receipt of the canisters on **12 November 2009**, six days after exposure. The CRIIRAD laboratory's authorisation from France's Nuclear Safety Authority (Autorité de Sûreté Nucléaire) is reproduced as Annex 1.

The activity of the radon 222 contained in the canisters is determined from that of its gamma-emitting decay products (lead 214 and bismuth 214). The spectrum processing was carried out by Stéphane Patrigeon, measurement technician at the CRIIRAD laboratory.

The activity obtained (Bq per canister) is assigned to the date corresponding to the middle of the exposure period, after correction for radioactive decay.

The activity is converted into Bq/m^3 by means of a custom calibration factor. The quality of calibration is verified in-house by comparison with other methods of determining the radon 222 activity by volume (Kodalpha passive dosimeters and Alphaguard monitor).

The measurement of radon 222 activity by volume and the margin of uncertainty of each measurement are shown in the last two columns of table T1 on the next page.

Commentary

The radon 222 activity by volume at seven of the eight stations was between **19 Bq/m^3** and **44 Bq/m^3**.

These values are appreciably higher than the mean radon 222 activity in outdoor air at the earth's surface estimated by UNSCEAR[1] as typically **10 Bq/m^3**, but the values can vary naturally due to the nature of the soil and the meteorological conditions.

Therefore, it is not possible in the context of this fieldwork to determine the proportion of radon attributable to uranium extraction activities. This would have required numerous control measurements in the environment far from Arlit and Akokan, in order to establish through comparison the level added by mining activity.

It should be noted here that the use of the radon activity measured at the customs office of ARLIT to estimate the "natural", as COMINAK and SOMAÏR do, is highly questionable. In fact this sector is close to the areas of uranium mining and may be subject to its impact.

[1] United Nations Scientific Committee on the Effects of Atomic Radiation

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Table T1 / Results of measurements of activity concentration of radon 222 / CRIIRAD laboratory

N°canister	Location	GPS coordinates	Description	Time&date installation	Time&date removal	Radon (Bq/m3)	+/-	Uncertainty
607	Bouche d'aérage (Vent A)	N18°38.373' E7°18.651'	10 meter north of air vent COMINAK N°. GT238, Afasto sector	5/11/09 14H50	7/11/09 14H50	37,7	+/-	8,3
614	Bouche d'aérage (Vent A1)	N18°38.467' E7°18.654'	About 110 meters north of monitor 607	5/11/09 15H37	7/11/09 14H55	43,8	+/-	9,6
622	Jardin Akokan	N18°42.074' E7°20.644'	Garden located at south side of Akokan, NE of COMINAK mines	5/11/09 17H00	7/11/09 15H47	25,6	+/-	5,6
612	Gendarmerie Akokan	N18°42.157' E7°19.802'	Gendarmerie, located outside village on main road to COMINAK mine. Monitor installed 2 m from official monitoring station.	6/11/09 8H00	8/11/09 7H45	130,9	+/-	28,8
619	Maison Arlit	N18°44.418' E7°23.309'	House of Mr. H.L. in ARLIT / Garden surrounded by walls of mud / Height 2.1 meter.	6/11/09 15H40	8/11/09 15H50	25,1	+/-	5,5
617	Maison Akokan	N18°42.653' E7°20.147'	House of Mr. T. in AKOKAN / small garden surrounded by walls of mud	6/11/09 16H55	8/11/09 16H47	41,0	+/-	9,0
610	SOMAIR Containers	N18°44.208' E7°22.614'	Containers SOMAIR, north-west part of ARLIT / height 2.5 m / no houses nearby	6/11/09 17H55	8/11/09 18H30	19,0	+/-	4,2
620	SOMAIR Containers	N18°44.208' E7°22.614'	Containers SOMAIR, north-west part of ARLIT / height 1 m	6/11/09 17H58	8/11/09 18H30	25,4	+/-	5,6

It will be noted that the value measured at the **Akokan gendarmerie (131 Bq/m^3)** is well above normal. This result is actually **three to seven times** as high as those recorded over the same period in four other sectors of Arlit and Akokan (between 19 Bq/m^3 and 41 Bq/m^3).

Assuming that radon 222 is in equilibrium with its decay products, this corresponds to a potential alpha energy (PAE) of 728 nJ/m^3. In outdoor air, the equilibrium factor between radon and its short-lived decay products is customarily of the order of 0.4, giving an estimated PAE of 291 nJ/m^3. This result is consistent with the data provided by AREVA.

It is in fact stated in COMINAK's Radioprotection 2008 report (see extract E1 on the next page) that in 2008 the PAE of radon 222 at the Akokan gendarmerie averaged 216 nJ/m^3, or 2.4 times the level recorded at the Arlit customs house at the same time (88 nJ/m^3).

This concentration of radon could be linked to mining activity, and in particular to radioactive atmospheric emissions from the COMINAK mine, some of whose air vents are near to the town of Akokan.

In the hope of clarifying this point, in August 2009 a copy of the studies of atmospheric transfer and dispersal of radon in the Arlit and Akokan area was requested from AREVA (see Annex 2). These documents have not yet been received.

This is a crucial issue, however, since on the basis of AREVA's own measurements it can be seen that some population groups in the mining area are currently subject to a radiation exposure markedly above the maximum permitted annual dose of one millisievert a year, chiefly as a result of inhaling radon 222 in the outdoor air.

This is the case for the population group designated "Akokan gendarmerie", for whom the 2008 COMINAK report estimates an annual added dose of 1.36 millisieverts, 90% of which is due to radon 222 (see extract below).

Written by Bruno Chareyron, nuclear physics engineer in charge of the CRIIRAD laboratory.

Approved by Corinne Castanier, director of CRIIRAD.

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Extract E1 (page 5) from the 2008 COMINAK radioprotection report

Le tableau ci-dessous présente l'évolution des moyennes annuelles en EAP Rn222 depuis 2001.

Stations de surveillance	Niveau moyen annuel en nJ.m^{-3}								
	Zone Urbaine Akokan NCC	Zone Urbaine Gendarmerie	Zone Urbaine COFITEC	Z.I. Poste de Garde	Z.I. extérieur	Aguelal	AFASTO	COMI 16	Niveau Naturel Douanes Arlit
	EAP Rn222	EAP Rn222	EAP Rn222	EAP Rn222	EAP Rn222	EAP Rn222	EAP Rn222	EAP Rn222	EAP Rn222
2008	92	216	178	203	328			163	88
2007	88	187	135	279	173		185	131	91
2006	119	159	163	411	153	92	185	103	84
2005	128	199	138	606	220	81	190	201	102
2004	91	155			274	110			103
2003	96	184			257	136			98
2002	140	154			322	135			51
2001	134	192			340				

Extract E2 from the 2008 COMINAK radioprotection report: results of the monitoring of effective annual added doses (Annex 5)

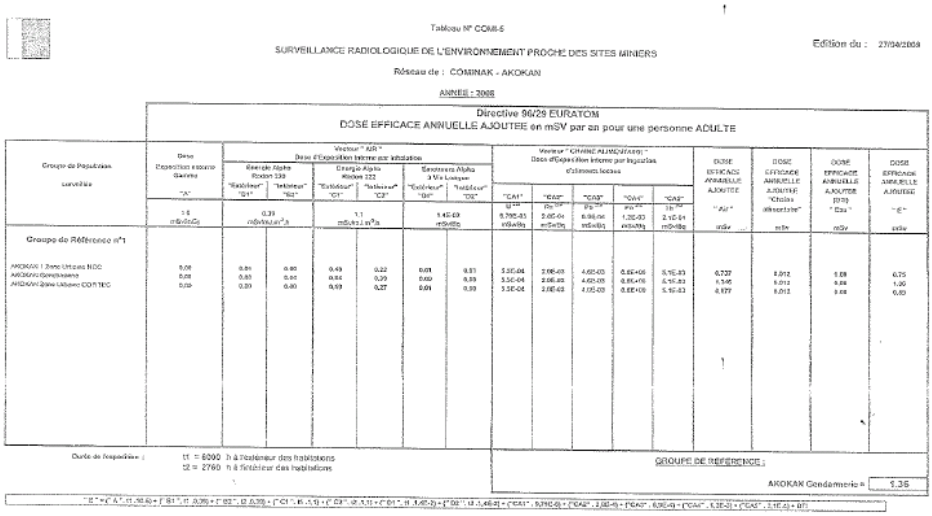

Tableau N° COMI-5

SURVEILLANCE RADIOLOGIQUE DE L'ENVIRONNEMENT PROCHE DES SITES MINIERS

Edition du : 27/04/2009

Réseau de : COMINAK - AKOKAN

ANNEE : 2008

Directive 96/29 EURATOM

DOSE EFFICACE ANNUELLE AJOUTEE en mSV par an pour une personne ADULTE

GROUPE DE REFERENCE :

AKOKAN Gendarmerie = 1,36

ANNEX 1 / Agreements CRIIRAD laboratory

Le laboratoire de la CRIIRAD est agréé par l'Autorité de sûreté nucléaire pour les mesures de radioactivité de l'environnement. La portée détaillée de l'agrément est disponible sur le site internet de l'Autorité de sûreté nucléaire.

Une liste actualisée[2] est présentée ci-dessous :

1 / Matrice **eaux** : émetteurs gamma d'énergie inférieure à 100 keV et d'énergie supérieure à 100 keV (agrément valable jusqu'au 01/08/2010) et tritium (agrément valable jusqu'au 30/06/2014).

2 / Matrice **sols** : émetteurs gamma d'énergie supérieure à 100 keV (agrément valable jusqu'au 10/7/2011), uranium et descendants, thorium et descendants, Ra 226 et descendants, Ra 228 et descendants (agrément valable jusqu'au 01/08/2010).

3 / Matrices **biologiques** : émetteurs gamma d'énergie inférieure à 100 keV et d'énergie supérieure à 100 keV (agrément valable jusqu'au 30/06/2014).

4 / Matrices **gaz** : émetteurs gamma d'énergie inférieure à 100 keV et d'énergie supérieure à 100 keV et gaz halogénés (agrément valable jusqu'au 01/02/2012).

En outre, le laboratoire de la CRIIRAD est agréé pour la mesure du radon dans les lieux ouverts au public (niveaux 1 et 2 ; validité jusqu'au 15 septembre 2011).

Le responsable du laboratoire
Bruno CHAREYRON
Ingénieur en physique nucléaire

[2] Décision n°DEP-DEU-0705-2009 du 8 décembre 2009 de l'Autorité de sûreté nucléaire portant prorogation d'agrément de laboratoires de mesures de la radioactivité de l'environnement et Décision n°DEP-DEU-0704-2009 du 8 décembre 2009 de l'Autorité de sûreté nucléaire portant agrément de laboratoires de mesures de la radioactivité de l'environnement.

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ANNEX 2 / Documents requested by GREENPEACE and CRIIRAD to AREVA before the mission in November 2009

ANNEX I – LIST OF REQUESTED DOCUMENTS AND INFORMATION

GREENPEACE mission to Niger
Analysis of the radiological impact of uranium mining at Arlit and Akokan, 2009
List as suggested by CRIIRAD (list no. BC 090807 / B Chareyron)

- Installation plan of air vents for COMINAK's underground galleries, with indication of the vents functional in 2009.
- For each air vent, results of the measurements of extraction rate, radon activity concentration and radon emission flux.
- Evaluation of the dispersion of radon and radioactive dust from COMINAK's air vents, the heaps of crude ore alongside the SOMAIR and COMINAK plants, and SOMAIR's and COMINAK's static and/or dynamic leaching waste heaps.
- Evaluation of the radon- and dust-associated dosimetric impact on the populations of Arlit and Akokan (methodology and results for the period 2006-08).
- Installation plan for the on-site dosimeters (measurement of the ambient gamma radiation dose rate, measurement of dust activity concentration, measurement of radon activity concentration), and 2006, 2007 and 2008 measurement results.
- Installation plan for the wells, piezometers and boreholes enabling monitoring of the radiological and chemical quality of the groundwater.
- Detailed results of the radiological and chemical analyses conducted between 2006 and 2008 on the wells, piezometers and boreholes.
- Description of the modifications effected since 2003 in the supply of drinking water (for employees and the population). Creation and closure of wells, volumes extracted, results of the radiological and chemical analyses.
- Description of the strategy for monitoring the radiological and chemical impact of SOMAIR's and COMINAK's activities on the food chain at Arlit and Akokan (methodology and results 2006-2008).
- Annual radiological protection reports for SOMAÏR and COMINAK for 2006, 2007 and 2008 (results of environmental monitoring and monitoring of radiological protection of employees).
- Results of aerial mapping of the gamma radiation level above the Arlit and Akokan zones.
- List of the sectors accessible to the public at Arlit and Akokan where radioactive waste rock originating from SOMAIR and COMINAK mines has been reused. Results of the radiation measurements conducted on these sectors. List of sectors decontaminated.
- Summary of the radiation monitoring operations carried out on scrap metal, plastics and geotextiles originating from SOMAIR and COMINAK mines and uranium extraction plants and reused in the public domain (2006 to 2008). Description of the method of radiation monitoring, results of the monitoring, number of radioactive items recovered. Estimate of the dosimetric impact on the individuals concerned.

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