"Nord Cotentin 2000", *in situ* intercomparison measurements

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Abstract. A large-scale international *in situ* intercomparison measurements has been organized in the "Nord-Cotentin" (France) area, in the vicinity of la Hague reprocessing plant and the Nuclear power station of Flamanville. Eleven European countries participated in this event organized at the initiative of the local association "Les Mères en Colère". Two main goals were considered for this event:

- An international *in situ* measurements intercomparison. The general aim of the measurements is to characterise as detailed as possible examined areas regarding their actual radiological standpoint. The basic measurements concerned dose rate, *in situ* gamma ray spectrometry and laboratory analyses on environmental samples.
- A specific aim consisting in providing the local population with an opportunity for direct exchange with international teams.

Both aspects will be reported in this paper.

1. INTRODUCTION

In the frame of the Nord Cotentin radio-ecological study, an *in situ* measurement campaign was done in 1998 in order to examine the contributions to the ambient dose rate of the public in sites selected by a local association "Les mères en colère" ("angry mothers"). This association has taken the initiative to broaden this examination by organising an international *in situ* intercomparison, "Nord Cotentin 2000". The aim of this event was to compare equipments and methods in the environment of nuclear industries under normal conditions. Three major points were clearly identified for this event :

- Determination by *in situ* gamma spectrometry of the activity of gamma emitters and their contribution to the ambient dose.
- Low level radioactivity measurements from environmental samples through *in situ* or laboratory methods
- A specific aim consists in providing the local population with a real opportunity for direct exchange with the participating international teams.

Ten countries have participated to this event. This paper reports mainly on the work done by the French team.

2. *IN SITU* GE GAMMA RAY SPECTROMETRY

In situ Ge gamma ray spectrometry as used in our laboratory is based on ICRU's technical recommendations [1]. The spectrometer is placed at 1 meter height, over a flat field, without any shoulder impeding the photon flux from soil to reach the detector. Hence a 2π solid angle is seen from the detector. However photon fluxes reaching the detector have been diminished by the attenuation of air and soil found on their path. Figure 1 shows the origin of a 661 keV photon flux reaching the detector, for a typical few years old deposition of ^{137}Cs. It is interesting to note that 65% of the impinging photons are emitted from within a 4 meters radius, but also that 15% are coming from a radius greater than 10 meters. Hence, in a single *in situ* Ge measurement, several hundred square meters of soil are being sampled.

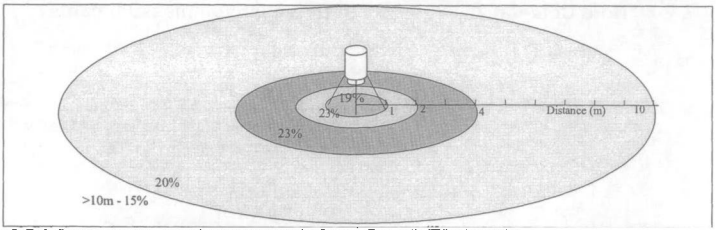

Figure 1: Relative origin of 661 keV photons reaching the detector for an old ^{137}Cs deposition.

The in depth isotope distribution is an important parameter of this technique. Indeed, detector's calibrations are based on theoretical as experimental techniques: efficiencies measured in laboratory are convoluted with photon fluxes impinging on the detector of theoretical isotope distributions on soil. For a majority of field measurements, natural isotopes could be considered as having an homogeneous distribution with depth. Artificial isotopes on the other hand are generally considered as having a decreasing exponential with depth.

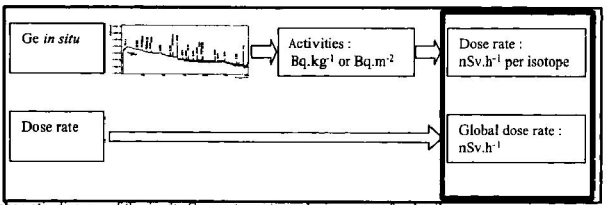

Figure 2: Schematic diagram of the *in situ* Ge spectrometry analysis, see text for details.

Figure 2 presents the schematics of the analysis of *in situ* measurement. From the peaks on the spectrum, gamma emitters are identified. Then, the measured count rate is convoluted with efficiencies and the photon flux of the assumed isotope distribution in order to get the specific activities ($Bq.kg^{-1}$ or $Bq.m^{-2}$ depending of the hypothesis). Then in a latter stage, dose rate per isotope can be extracted. In parallel, a global dose rate measurement is carried out in the same place. The sum of dose components found by Ge gamma spectrometry plus the known dose from cosmic rays at the measurement site should be in agreement with the global dose measurement.

A requirement of the intercomparison organisers was to use the hypothesis of a homogeneous depth distribution of all isotopes, natural as well as artificial. The impact of this hypothesis will be discussed in chapter 4.2.

3. PARTICIPATION OF THE FRENCH TEAM TO THE NORD COTENTIN 2000 INTERCOMPARISON

3.1 Set up

Following the recommendation from the organisers, the French team was composed of the association of IPSN[1] (5 persons) and ACRO[2] (2 persons) teams. The set up used during the event is described in table 1.

[1] Institut de Protection et de Sûreté Nucléaire
[2] Association pour le Contrôle de la Radioactivité dans l'Ouest

Table 1 : Hardware used for *in situ* measurements

	Main material	**Spare**
Ge spectrometer	30% type N (ORTEC)	13% type P (ORTEC)
Acquisition	DART (ORTEC)	INSPECTOR (CANBERRA)
Analysis software	Two laptops with the analysis software Maestro (ORTEC) and Genie2000 (CANBERRA)	
Global dose measurement	NaI SafeSpec (EURISYS)	None

3.2 Unfolding of the event

The event was organised in two steps. In the intercomparison stage, all teams analysed the same sites simultaneously. In a second stage, the "cartography" stage, teams were sent to different sites in order to cover a maximum area during the exercise. A total of 22 sites, 11 marine and 11 terrestrial were analysed in total (figure 3). Any site was analysed by at least two different teams.

Table 2 presents the different sites analysed by the French team. The two first sites (labelled common), were the intercomparison sites.

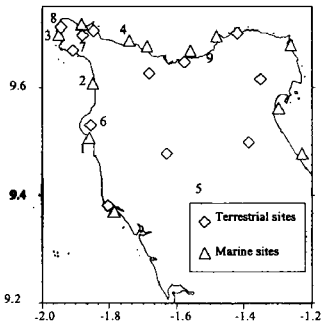

Figure 3: Nord Cotentin peninsula and event measurement sites (terrestrial and marine), the numbers correspond to sites analysed by our team, numbers 5 and 9 are measurements made at our landlady request and at a school, see table 2.

3.3 Complementary measurements

A minimal requirement of the organisers was the sampling by all the teams of the two common sites. However, sampling of any site was encouraged. The aim of this sampling was manifold :

- Check the isotope distribution hypothesis. Core samples were taken to this effect.
- Laboratory intercomparison for the samples of the common sites
- Some samples were taken at the initiative of local inhabitants, as requested by the organisers.
- All these samples will increase the database existing on this region [2].

Table 2 : Sites of the *in situ* measurements made by the French team

Date	time	Site.	Exact localisation			
				Latitude	Longitude	N° in fig.3 &5
10/10/00	10 :00	Marine (common)	Vauville	N49°38,65'	W1°51,400'	2
10/10/00	13 :00	Terrestrial (common)	Flamanville	N49°31,670'	W1°52,283'	6
11/10/00	09 :00	Terrestrial	Jobourg	N49°40,567'	W1°53,450'	7
11/10/00	11 :30	Terrestrial	Goury (Auderville)	N49°42,575'	W1°56'29,6''	8
11/10/00	15 :00	Marine	Ecalgrain	N49°41'23,8''	W1°56'11,9''	3
11/11/00	16 :30	Marine	Urville-Nacqueville	N49°40'45''	W1°43'23''	4
12/10/00	10 : 00	Terrestrial	Tourlaville (school)			9
12/10/00	15 :30	Terrestrial	Tréauville	N49°31'55"	W1°49'01"	5
12/10/00	16 :30	Marine	Sciotot	N49°30'24"	W1°50'60"	1

3.4 Direct exchange between local population and scientific teams

The "Nord Cotentin 2000" event was organised at the initiative of a local mother's association "Les mères en colère". The direct exchange between scientific teams and local population was a major feature of the event, and it was consciously encouraged by the organisers. Some items that could be pointed out :

- all teams were accommodated by inhabitants, that volunteered
- during the week of the event, cultural manifestations were organised

It will be reported of this open-mindedness atmosphere as it was felt by our team :

- discussions with team's landlady, *in situ* measurements in her garden, sampling of her vegetable garden, in-house radon measurement. Results were directly reported to her, with copy to the organisers.
- A whole morning spent in a school, at the headmaster's request. The scientific aims of the intercomparison were presented to pupils. A "hands on" approach was used to present our measurements: small groups were organised in order for them to do their own dose assessment, sample picking, *in situ* Ge measurement...
- Finally, in several sites, open discussion was engaged with passers-by as the event was largely announced in local radio and television. Also, the presence of journalists in the common sites should be noted.

4. RESULTS

4.1 *In situ* Ge spectrometry results

Preliminary intercomparison results were presented in [3]. As an example, figure 4 presents the dose rate assessment by Ge spectrometry from the marine site. The different contributors to the dose rate are shown, the only artificial found being ^{137}Cs. In the graph, it is barely visible as it represents less than 1% of the total dose. Final results of the intercomparison are expected in October 2001.

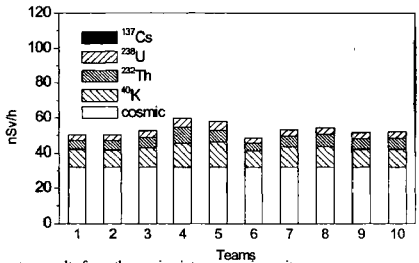

Figure 4: *In situ* Ge spectrometry results from the marine intercomparison site.

Figure 5 presents the *in situ* Ge dose assessments made by our team, during the Nord Cotentin event as well as during some preliminary work. The only artificial radionucleide found was ^{137}Cs with levels ranging from 0.5 to 6 $Bq.kg^{-1}$ assuming a homogeneous distribution hypothesis. In the graph the associated dose rate is barely visible in the Nord Cotentin area and Orsay measurements as it represents less than 1% of the total dose. However in the Mercantour area (South East of France, touched by Chernobyl fallout) it is clearly visible with dose rates of the order of 10% up to 40% for a measurement taken just above a patch of a few cm^2, were radioactivity was highly concentrated due to the morphology of the zone [4].

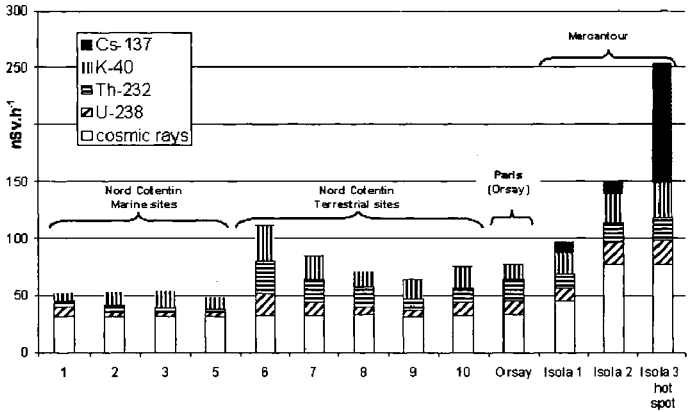

Figure 5: Dose assessment with *in situ* Ge spectrometry done by our team during the Nord Cotentin event and previous work in situ analysis done in 2000.

4.2 Laboratory results

One of the aims of the sampling was to check the hypothesis, imposed by the organisers, of a homogeneous depth distribution of isotopes. Core samples were taken at each of our analysed sites. This hypothesis was found true for most of natural radioactivity. In many cases it was also found true for ^{137}Cs in many sites. An example of a core analysis is shown in figure 6. The activity unit is the $Bq.kg^{-1}$ fresh weight to compare with *in situ* results, depth units are in $g.cm^{-2}$ (layer thickness multiplied by its density).

In this example, the ^{137}Cs distribution was found as not being homogeneous. The *in situ* reported activity was 5.9 +/- 0.7 $Bq.kg^{-1}$ which is in fact the average of the first few centimetres, as it can be noted on the graph. The reported dose rate (homogeneous hypothesis) was 1.0 +/- 0.1 $nSv.h^{-1}$, to be compared to the dose rate calculated with the correct distribution [5,6,7] 1.2 +/- 0.2 $nSv.h^{-1}$.

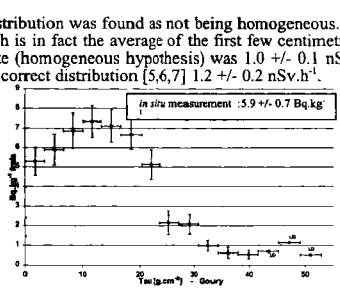

Figure 6: Example of a core analysis. The activity of ^{137}Cs is given in $Bq.kg^{-1}$ fresh weight ."Nord Cotentin 2000"

5. CONCLUSION

The "Nord Cotentin 2000" intercomparison has shown a good agreement between *in situ* gamma spectrometry teams from different countries. It has permitted to strengthen the links between laboratories involved in monitoring environmental radioactivity. This exercise has been organised for the very first time in the framework of an associative request and organisation, allowing the direct exchange between science teams and the local population.

Acknowledgments

The authors are grateful to the Leboisselier family for their kind hospitality during the intercomparison.

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