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Observations of Fallout from the Fukushima Reactor Accident in Cienfuegos, Cuba

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Abstract Following the recent accident at the Fukushima Daiichi nuclear power plant in Japan, radioactive contamination was observed near the reactor site. As a contribution towards the understanding of the worldwide impact of the accident, we collected fallout samples in Cienfuegos, Cuba, and examined them for the presence of above normal amounts of radioactivity. Gamma ray spectra measured from these samples showed clear evidence of fission products ^{131}I and ^{137}Cs. However, the fallout levels measured for these isotopes (135 ± 4.78 mBq m^{-2} day^{-1} for ^{131}I and 10.7 ± 0.38 mBq m^{-2} day^{-1}for ^{137}Cs) were very low and posed no health risk to the public. The doses received as consequence to the Fukushima fallout by the Cienfuegos population's (0.002 mSv per year) don't overcome the limit of dose (1 mSv per year) fixed for the public in Cuba.

Keywords Fallout · Cs-137 · I-131 · Fukushima accident · Cuba

On the 11th of March 2011, at around 08:15 CET, an earthquake of magnitude 8.9 on the Richter scale occurred near the east coast of Honsu, Japan, and was followed by a tsunami. The tsunami hit the Fukushima Daiichi nuclear power plant, disrupting its functioning and causing the release into the atmosphere of elevated quantities of fission products. Since the following day, the 12th of March, the French ISRN (ISRN 2011), carried out simulations of the atmospheric dispersion of the radioactive plume formed by releases from Fukushima (Fig. 1). According to these simulations the plume moved over the Pacific Ocean and could arrive in Cuba on the 23rd of March.

The monitoring of environmental radioactivity in Cuba is carried out by the Environmental Radiological Surveillance Network (RNVRA), which was established in 1990 with the support of the International Atomic Energy Agency (IAEA). The main aim of the network is to detect possible alterations of the environmental levels of radioactivity as a consequence of local, regional or global contamination. The RNVRA provides relevant information on radioactivity levels in all compartments of the biosphere to ensure that concentrations of radioactive materials do not constitute a risk to humans or the environment. The Environmental Studies Centre of Cienfuegos (CEAC) represents one of the monitoring sites, belonging to the network, where fallout is recorded (Fig. 2). Here, previous studies were carried out to determine levels of background environmental radioactivity in Cienfuegos (Alonso-Hernández et al. 2002, 2004, 2006; Hernández et al. 1998). Since 1990, a database of monthly concentrations of gamma emitter isotopes in the fallout is available. So far, only ^{137}Cs was identified as artificial radionuclide, showing fluxes of 1.5 mBq m^{-2} day^{-1}.

The aim of the study was to measure the radioactivity levels from Fukushima accident in total atmospheric deposition in Cienfuegos, Cuba.

Methods

Starting from the 15th of March, weekly fallout samples were collected at CEAC (22° 03′ N, 80° 29′ W) using a plastic open surface collector with a surface area of

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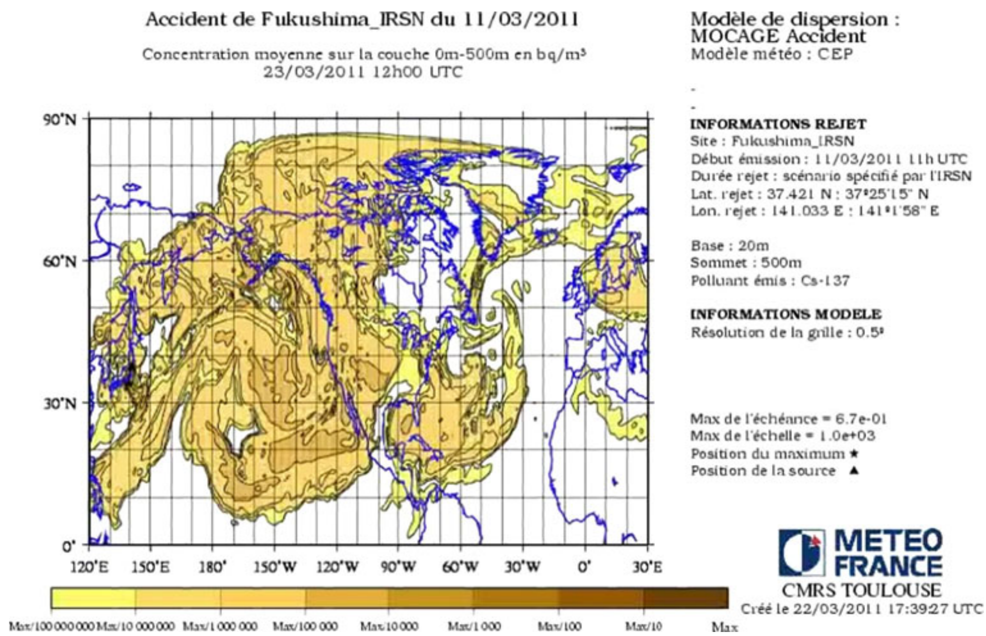

Fig. 1 Simulation of atmospheric dispersion of the radioactive plume formed by releases from the Fukushima Daiichi nuclear power plant (ISRN2011)

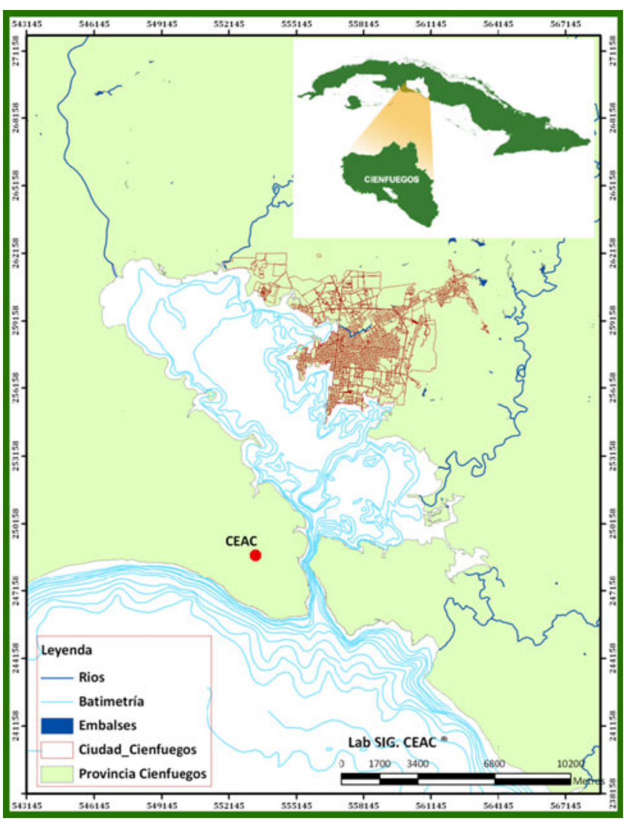

Fig. 2 Location of CEAC, Cienfuegos (Cuba), where monitoring was carried out

0.25 m^2. The container was regularly checked to verify the presence of an appropriate amount of water necessary to collect wet and dry depositions. Every week, the collected water was evaporated to dryness, without bringing it to boil, to obtain residual samples which were then put in a calibrated geometry and analyzed by gamma spectrometry.

Fallout samples were measured in a low level gamma spectrometric system with HPGe well detector (EGPC100 P-15, CAMBERRA), 11.1% relative efficiency, resolution of 1.86 keV at 1.33 MeV of 60 Co and a 2048 channel MCA. An iron shield (30 cm thick) covered the active zone of the detector. The typical measurement time was 250,000 s. The activity concentration and its uncertainty were calculated using equations provided in the literature. The uncertainty was calculated as the result of the uncertainty propagation process using the net peak area, the detector efficiency and the mass uncertainties, and in all calculations resulted to be less than 20%. This procedure was accredited by the National Office for Normalisation for ISO-NC-17025 and it is recognized by the International Atomic Energy Agency through the ARCAL XXVI IAEA Regional Project. Since 2005, CEAC belongs to the IAEA-Network “Analytical Laboratories for the Measurement of Environmental Radioactivity” (ALMERA), and participates in intercomparison exercises organised by IAEA.

Results

The radioiodine and radiocesium levels recorded in the fallout are reported in Table 1. ^{131}I was quantified in the fallout of Cienfuegos between the 23rd of March and the 15th of April; after this date no isotopes of Iodine were detected. The maximum flux of ^{131}I was recorded for the

Table 1 Radioiodine and radiocesium, in fallout (mBq m^{-2} day^{-1}) at Cienfuegos (Cuba) for the period 23 March 2011–3 May 2011

Date	^{131}I	^{137}Cs
15 March–23 March	ND	<1.26
23 March–1 April	135 ± 4.78	10.7 ± 0.38
1–8 April	57.2 ± 6.8	<1.26
8–15 April	3.57 ± 0.21	<2.13
15–22 April	ND	<1.95
22 April–3 May	ND	<1.77

ND not detected

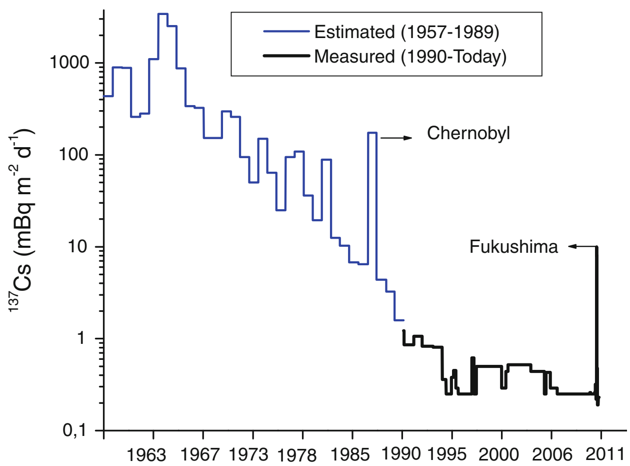

Fig. 3 Temporal trend of ^{137}Cs fallout in Cienfuegos (Cuba) between 1957 and 2011

week from the 23rd of March to the 1st of April, and reached values of 135 mBq m^{-2} day^{-1}.

As for ^{137}Cs, it was only detected in the week from the 23rd of March to the 1st of April, and reached values of 10.7 mBq m^{-2} day^{-1}. Figure 3 shows the temporal distribution of ^{137}Cs in the Total Atmospheric Depositions in Cienfuegos since 1957. This database was produced by using estimates of the ^{137}Cs fallout for the period 1957–1990 (Alonso-Hernández et al. 2004) and direct measurements, carried out at CEAC, between 1990 and 2011 (Alonso-Hernandez et al. 2006). The ^{137}Cs flux derived from the Fukushima accident, represents only ~10% of the value recorded in Cienfuegos following the Chernobyl accident. Both accidents result to be minor when compared to the ^{137}Cs fluxes produced by the nuclear weapon explosions in the 60 s.

The activity and flux levels that we measured for ^{131}I and ^{137}Cs are very low and pose no health risk to the public. In fact, the doses received as consequence to the Fukushima fallout by the Cienfuegos population's (0.002 mSv per year) don't overcome the limit of dose (1 mSv per year) fixed for the public in Cuba (CITMA 2002).

The results obtained in this study demonstrate the capacity and effectiveness of the Environmental Radiological Surveillance Network (RNVRA) implemented in Cuba, and should be of stimulus for implementing such structures in developing countries also in consideration of their low running cost.

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