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Abstract

The present study has been carried out in the framework of our environmental monitoring programme and immediately after being informed by the IAEA of possible accidental releases of ^{137}Cs into the air, which might have been released between May 25th and the first of June 1998 from the Acerinox factory in Algeciras (Spain). Algericas is the region where a steel-processing factory has been set up. During the work procedure, a radioactive source of ^{137}Cs passed through the furnace resulting in accidental releases into the atmosphere. This radioactive contamination was detected in France, Switzerland, Italy and Germany, and some radioactivity measurements were carried out by the Commissariat A l'Energie Atomique to evaluate the gamma radiation status in areas selected in Algeria. The approach adopted in our case was to start in situ gamma-radiation measurements and to collect air and soil samples as well from a selected area in Algiers. Afterwards, and in order to have more reliable results, a sampling program was carried out in July 1998, in the frame of which some sampling stations were established in the west of Algeria, based upon Algerian meteorological data during the period of incident. A total number of 16 environmental samples from 9 stations, namely, soil, sediment, vegetation and seawater were collected, followed by in situ gamma radiation measurements in each sampling location. Soil, sediment and vegetation samples were analysed by direct gamma spectrometry, whereas, sea water samples were analysed radiochemically using microcrystalline AMP for coprecipitation and gamma counted. Taking into consideration the background levels of radioactivity in the studied areas, obtained by our previous monitoring programs, the results obtained do not show any increase of ^{137}Cs resulting from the incinerated Caesium source in the Acerinox steel factory in Algeciras, Spain. The conclusion drawn by this work is that the investigated area was not affected by the release of ^{137}Cs.

Keyword: ^{137}Cs, Monitoring, Contamination, Environmental Radioactivity, Radioactivity Measurements.

Introduction

At the end of May and the beginning of June 1998, France, Switzerland, Italy and Germany reported to the IAEA that ^{137}Cs had been detected in the air, resulting from the incinerated radiocaesium source in the Acerinox steel factory in Algeciras, Spain (CALMET, 1998). In accordance with the distance separating Spain from Algeria on the west Mediterranean side and the ordinary meteorological conditions, our country could have been contaminated by airborne ^{137}Cs, as climatic conditions could allow atmospheric fallout precipitation. The work described in the paper is the approach followed, as a case study, which enabled us to state whether the investigated area was contaminated or not, on the basis of radioactivity environmental monitoring.

Methods

As soon as we had been informed about the radiological incident, which had occurred at Algeciras, in Spain, various actions were taken. First, the in situ gamma-radiation levels were daily recorded in Algiers (F.Fanon site) during the period from 15 June to 10 of July 1998. In addition to that and in order to detect any eventual trace of ^{137}Cs, air samples, atmospheric precipitation (fallout) and soil samples were also collected.

As the ^{137}Cs levels in Algiers were found to be below the detection limits (0.1 Bq/kg for vegetation and 0.5 Bq/kg dry weight for soil and sediment), we proceeded by carrying out a sampling campaign throughout the west of the country. The sampling locations were selected according to the local meteorological data, namely direction, wind speed and precipitation level (see Table 1). Finally, the

Table 1
Meteorological data, direction and speed wind and precipitation level, from the National Meteorological office (Oran).

Date	Wind direction	Speed wind	Precipitation
23/05/98	East	Light	/
24/05/98	West to North-East	Light ~ 30 km/h	/
25/05/98	West to North-East	Light ~ 20 km/h	/
26/05/98	- Wind in Spain: From South- West to North- East could affect France, Italy,... - Wind in Algeria: Wind from North.	v ~ 40Km/h v ~ 15- 20Km/h	/ Oran 0.1mm Mostaga. 1mm Ghazaouet 4mm Benisaf 1mm
27/05/98	Wind from West to North-West	v ~ 30Km/h	/
28/05/98	Reinforcing of Wind from West to North-West	v ~ 50Km/h	/
29/05/98	Wind from West to North-West	v ~ 15Km/h	Mostaga. 0.6mm Maghnia 5mm Ghazaouet 2mm Benisaf 0.5mm
30/05/98	Same than 26/05/98		Oran 0.2mm

levels of in situ gamma-radiometry and the results of the environmental sample analyses were compared to those usually obtained by our routine national environmental monitoring program.

Sampling

During the period June to July 1998, air samples, atmospheric precipitation (rain as wet fallout) and soil, sediment and seawater samples were collected in Algeria, as shown in Figure 1. Atmospheric precipitation samples were collected from a one square meter container, whereas air samples were collected on active coal filters through a peristaltic pump. Regarding the environmental samples, soil (undisturbed layer) and sediment samples were manually collected from the (0-3) cm using an appropriate shovel, and vegetation from the same location of soil sampling, by taking five representative samples in 1 m^2 area covered. For seawater, samples of a 50 l volume each were simply collected from the coast using a bucket (seam) and acidified to pH 1 – 2 with 1M HCL.

Radioactivity Measurement

1) Gamma-ray analysis

A total number of 16 soil and vegetation samples were analysed to determine ^{137}Cs by direct counting gamma spectrometry, using a HpGe detector of relative efficiency of 23% and resolution (FWHM) 1.8 Kev at 1332 Kev gamma energy of ^{60}Co and multichannel analyser (4096 channels). The 1000 cm^3 Marinelli Beakers were filled with the samples and put in contact with the top of the detector. Detection efficiency of the system, was determined using a 1000 cm^3 standard sample prepared at our laboratory. This standard was prepared with sand, contaminated with a liquid radioactive multigamma source of total gamma activity of 2500 Bq. The soil and vegetation samples to be analysed were oven dried at 100 °C, crushed and homogenised prior to direct counting gamma spectrometry.

2) Analytical method

The collected 50 l samples of seawater were transferred to a polypropylene appropriate container and then acidified to a pH 1-2 with

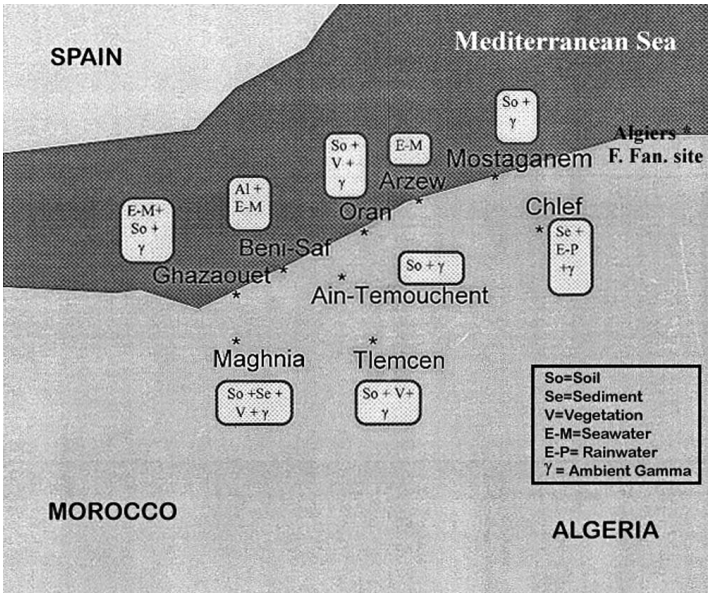

Fig. 1: Sampling locations.

concentrated hydrochloric acid. A known amount of ^{134}Cs (7Bq) was added as carrier and yield tracer. An amount of 15 g of micro-crystalline Ammonium Phosphomolybdate (AMP) was added to each sample in order to collect all caesium isotopes. After coo-precipitation and filtration, the precipitate was measured by gamma spectrometry, as described above (GHEDDOU, 1998.)

3) Gamma radiation levels

Natural ambient gamma radioactivity was recorded by means of an ionisation chamber detector, RSS 111 Reuter Stocks monitor type at 1 m above ground, calibrated using a standard ^{60}Co source of around 15 mCi activity. Measurements were carried out at different points in the west of Algeria (Fig. 1).

Results and Discussion

In such a radiological incident, nature of sample, locality and representativity are important parameters to be taken into account, according to their capability of retaining pollutants, particularly ^{137}Cs. Soil samples are known to accumulate radioactivity, vegetation and seawater to a lesser degree can be good indicators of a recent contamination of ^{137}Cs even at trace level.

In this work, the collected samples of soil, vegetation, sediment, seawater and rainwater were analysed to determine quantitative and qualitative contamination by ^{137}Cs resulting from the Algeciras incident. In addition to ^{137}Cs, ^{7}Be, ^{40}K as well as uranium and thorium series radionuclides were detected by gamma-spectrometry. The obtained results are presented in Table 2. The concentration of soil samples range from 1.3 to 20.7 Bq/kg for ^{137}Cs and from 7.8 to 24.8 Bq/kg for ^{7}Be. The presence of ^{7}Be can be explained by the wet atmospheric precipitation (rain) during this period. The ^{137}Cs concentrations of the analysed samples seem to be very close to those found in the establishment of the reference level of radioactivity along the whole territory of Algeria. A comparison between the obtained values and the range of maximum and minimum values, reported for Algeria (BAGGOURA, 1998) is presented in Table 2. Regarding seawater, the concentrations of ^{137}Cs range from 2.9 Bq/m3 to 3.3 Bq/m^3. These

Table 2
Concentration in Bq/kg of soil, sediment and seawater analysed samples collected from 9 stations.

Sampling Location	Nature	Concentration in Bq/kg	Concentration in Bq/kg	Range of Max and Min values in Bq/kg *
		^{137}Cs	^{7}Be	
	Air	Not detected	___	___
Algiers	Fal. Precip.	Not detected	___	___
	Soil	4.4 ± 0.52	___	(1.0 ± 0.1 - 12 ± 1.0)
Les Andalouses (Oran)	Soil	___	16.83 ± 1.51	(9.0 ± 0.9 - 5.0 ± 0.6)
Ghazaouet	Soil	9.34 ± 1.09	16.72 ± 1.69	___
Mostaganem	Soil	10.22 ± 1.24	13.66 ± 1.2	(9.6 ± 1.0 - 4.0 ± 0.5)
Ain-Temouchent	Soil	6.46 ± 0.75	24.77 ± 2.3	(15.5 ± 1.5 - 3.6 ± 0.4)
Tlemcen	Soil	20.68 ± 2.08	18.81 ± 2.0	(24.3 ± 2.3- 11.0 ± 1.08)
Maghnia	Soil	7.52 ± 0.93	16.39 ± 1.71	___
Ghazaouet	Seawater	3.33 ± 0.3 (Bq/l)	___	___
Arzew	Seawater	3 ± 0.28 (Bq/l)	___	___
Chlef	Sediment	7.16 ± 0.99	___	___
Tlemcen	vegetation	not detected	___	___

* (Baggoura, 1998)

Table 3
Ambient Gamma measurement (in situ gamma radiometry) in Algiers and in the western part of Algeria.

Locat.	Tlemcen[1]	Tlemcen[2]	Maghnia	Ghaza.	Ain Temouc.	Oran	Mostaganem	Chlef	Algiers
Min. val. μR/h	9.0 ± 0.49	5.3 ± 0.30	9.0± 0.49	8.5 ± 0.47	8.6 ± 0.47	5.3± 0.29	5.3 ± 0.29	9.3 ± 0.51	6.35± 0.35
Max. val. μR/h	11.6± 0.64	7.0 ± 0.39	10.1± 0.55	10.0± 0.55	9.6 ± 0.53	6.3± 0.35	6.8 ± 0.37	10.1± 0.55	6.65± 0.37

Tlemcen [1]: Station at the top of a mountain.
Tlemcen [2]: Station around the town.

values are very close to the mean concentration value of Mediterranean seawater (PNUE/AIEA, 1992). As for vegetation, which can in this case be an indicator of recent contamination, the concentrations of ^{137}Cs were below the lower limit of detection of the gamma-spectrometry system (the detection limits is 0.4 Bq/kg). Concerning the in situ gamma radioactivity, the obtained values (Table 3) are in agreement with those usually recorded (NOUREDDINE, 1997, BAGGOURA, 1998).

Conclusion

It is concluded that there is no evidence of ^{137}Cs contamination in Algiers and in the western part of Algeria resulting from the Algeciras (Spain) incident, which occurred at the end of May 1998, although some European countries measured ^{137}Cs originating from this incident.

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