IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

April 15, 2020

Information note

Fires in Ukraine in the exclusion zone around the Chernobyl power plant: Point position

Since the publication of our previous information note on April 7, 2020, fires in Ukraine have spread nearby the Chernobyl nuclear power plant. Following numerous questions received by our Institute about their radiological consequences, which, according to Ukrainian authorities, which have now been brought under control, this note provides an assessment of the possible radiological impacts for the firefighters as well as for the inhabitants of Kiev. It also reviews cesium 137 (^{137}Cs) airborne activity levels likely to be detected in France due to the transport of contaminated air masses.

1/ Current situation as of April 15, 2020

Forest fires broke out in Ukraine about ten days ago in a territory heavily contaminated by the 1986 Chernobyl nuclear accident. These fires reached the exclusion zone and the surrounding environment (about 1 km) of the nuclear power plant from April 8, 2020 (see Fig. 1).

Nearly 400 fire-fighters and 90 specialized aerial and terrestrial vehicles, including planes and water-bomber helicopters, have been mobilized for more than a week for the control of the fires. According to some estimates, the burned area reached about 20,000 ha.

Ukrainian authorities said earlier this week that "the efforts of the fire- fighters and the rain have reduced the forest fire in the Chernobyl exclusion zone". They assured Tuesday, April 14, 2020 in the morning that the risks of fire spreading were now limited to isolated or smoldering fires.

At the end of April 14, 2020, the Ukrainian authorities indicated that the fires were under control. The satellite images of April 15, 2020 show no more fire spot in this part of heavily contaminated territories (see Figure 1).

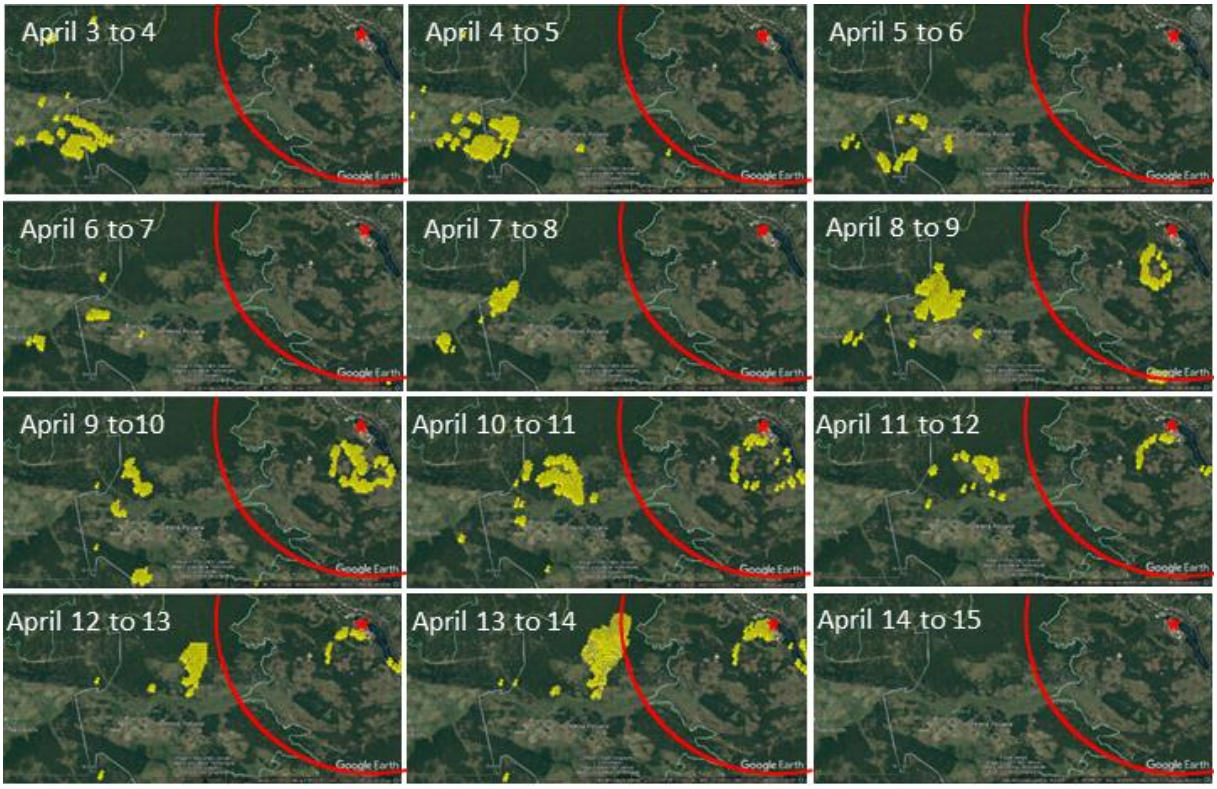

Figure 1: Daily maps of fire spots between April 3 and April 15, 2020 (source of data: NASA / FIRMS). Location of the Chernobyl nuclear power plant is marked with a red star and the arc of a red circle delimits the exclusion zone with a radius of 30 km around the plant.

2/ Available measurements

Ambient gamma dose rate measurements near fire-affected areas are available at http://www.srp.ecocentre.kiev.ua/MEDO-PS/index.php?lang=ENG. They do not reveal abnormal values. It should be remembered that these measurement devices are only capable of detecting major radiological accidents[1]. Such a probe is installed at the French Embassy in Kiev and is part of the IRSN's Téléray network deployed in France.

The radioactivity released into the atmosphere by the fires was therefore not high enough to be detected by these devices.

On the other hand, much more sensitive measurements have been carried out by various Ukrainian scientific bodies which have published airborne ^{137}Cs activities from aerosol samplings[2] (see Table 1).

[1] Gamma radiation resulting from radioactivity in air greater than 1 Bq/m^3

[2] Airborne particulate matter

Table 1: Measurements of Airborne cesium 137 activity in Kiev and in the Chernobyl exclusion zone reported by two Ukrainian scientific bodies.

Central Geophyscial Observatory, Kiev

Sampling period	05-06 April	06-07 April	07-08 April	08-09 April	09-10 April	10-11 April	11-12 April	12- 13 April
Airborne ^{137}Cs activity ($\mu Bq/m^3$)	83	< 110	<140	290	<140	700	170	<180

Ukrainian Hydrometeorological Institute, Kiev

Sampling period	27 March -5 April	27 March -6 April	06-07 April	06-08 April	08-09 April	09-10 April
Airborne ^{137}Cs activity ($\mu Bq/m^3$)	50	56	57	65	220	470

Measurements in the exclusion zone[3]

Location	*Date*	*Airborne ^{137}Cs activity ($\mu Bq/m^3$)*
ASKRS Chernobyl	10 April 2020	240
ASKRS Kids	08 April 2020	54
ASKRS Kopachi	11 April 2020	1000
ASKRS Kopachi	08 April 2020	72
ASKRS GRP-750	08 April 2020	630
Chernobyl, vul. Kirov, 42	11 April 2020	2600
Chernobyl, Vul. school, 6	12 April 2020	290
Korohods'kyi Peninsula 12 kv	12 April 2020	42000
Korogodske L-in 41 m2	12 April 2020	1600
Chernobyl NPP Ukrenergomontazh - GRP-750	13 April 2020	180000

In Kiev, the highest airborne ^{137}Cs activities in the air were recorded from April 9 to 11, 2020: 470 micro becquerel/cubic meter ($\mu Bq/m^3$) from April 9 to 10 ; 700 $\mu Bq/m^3$ from April 10 to 11. A value of 1,200 $\mu Bq/m^3$ during the night of April 4 to 5, 2020 has also been reported by the Scientific State and Technical Center for Nuclear and Radiological Safety in Ukraine but has not been confirmed.

[3] Ukrainian Government Agency for the management of exclusion zones: http://dazv.gov.ua/novini-ta-media/vsi-novyny/radiatsijna-situatsiya-v-zoni-vidchuzhennya-v-rajoni-pozhezhi- stanom-na-12-3.html

These values are significantly higher than the values usually measured for cesium 137 in the air in Kiev [4]and show evidence of the passage of contaminated air masses. However, they remain moderate and have no health consequences (see Chapter 4).

In the Chernobyl exclusion zone, much greater air contamination is observed due to the closeness to the measuring devices in the burned area. The possible consequences of this contamination are assessed in Chapter 4.

3/ Modelization

IRSN has performed a modeling estimation of the amount of radioactivity re-emitted by fires. This would be around 200 GBq [5] issued between April 3, 2020 at 12:00 p.m. and April 13, 2020 at 12:00 p.m.

The simulations carried out show a good agreement between measurements provided by the Ukrainians and modeling results.

On this basis, IRSN simulations indicate that air masses from the area of the fires that occurred on April 5 and 6 were able to reach France in the evening of April 7, 2020. As of April 14, these air masses still covered half of the territory (see Figure 2). Expected radioactivity levels in France are extremely low, below 1 µBq/m^3 in ^{137}Cs.

The releases occurring between April 9 and April 11, 2020 are more significant according to the modeling. The weather conditions that prevailed until April 14 favored the transport of air masses to Belarus, southern Ukraine, eastern Romania and Bulgaria. They have not reached France to date.

Aerosol sampling on filters by large-volume devices from the IRSN's OPERA-AIR network and associated low-level measurements are underway. This search for traces requires the implementation of very precise and long measurements, the results will not be available until the end of next week.

[4] About 6 µBq/m^3 of ^{137}Cs

[5] 1 GBq = 10^9 Bq = 1,000,000,000 Becquerels

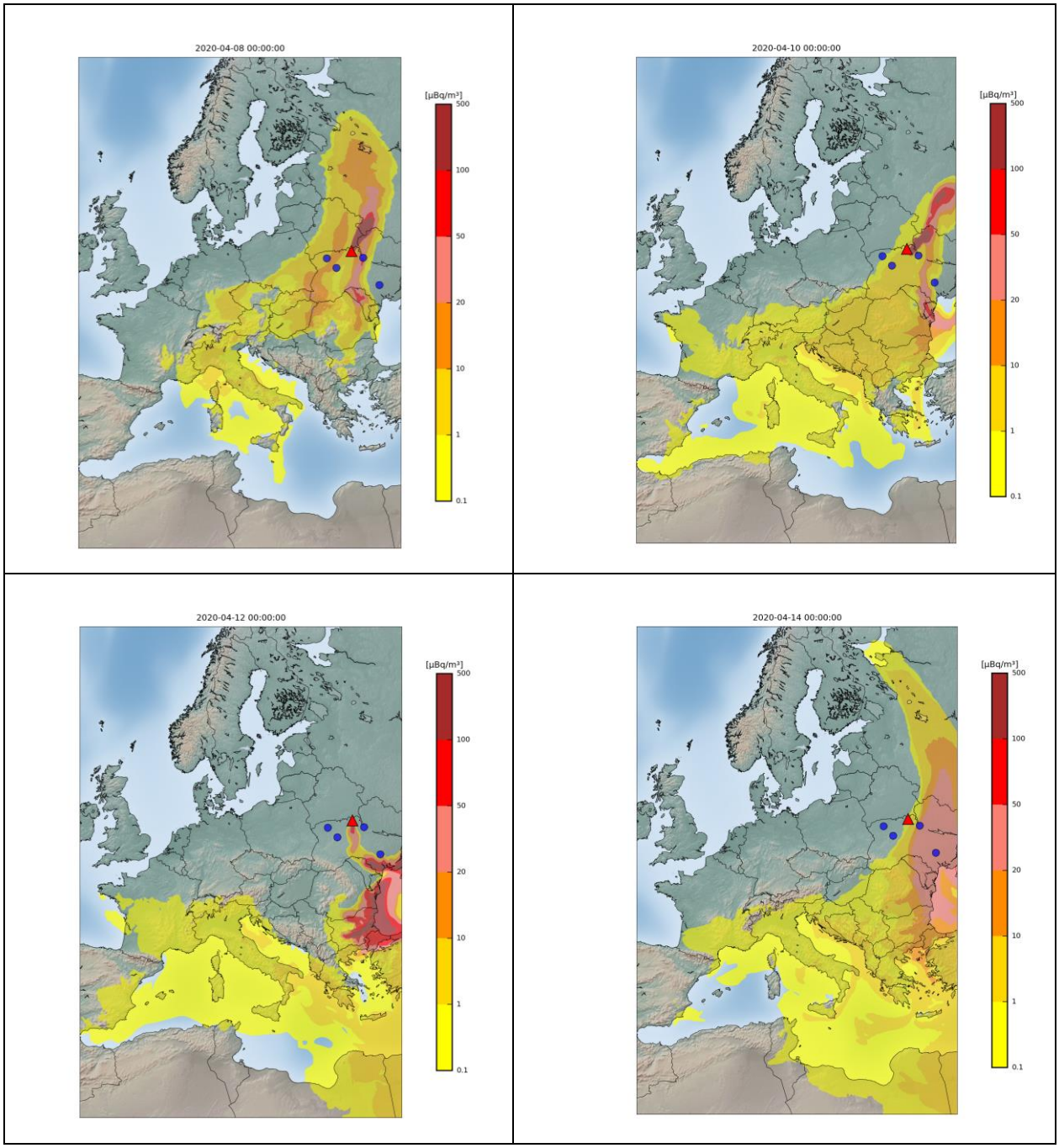

Figure 2: Modeling of the plume dispersion over Europe. Red triangles represent the fire locations of the fires and the blue dots the measurement stations in Ukraine). A video is also available on the IRSN web site[6].

[6] https://www.irsn.fr/EN/newsroom/News/Pages/20200415_Fires-in-Ukraine-in-the-Exclusion-Zone-around-chernobyl.aspx

4 / Dosimetric impact

IRSN has carried out an estimation of the dosimetric impact of the fires according to different scenarios:

- For a fire-fighter who worked for 100 hours in the exclusion zone in an environment with an airborne activity level of 1 Bq/m^3 (or 1,000,000 µBq/m^3) of cesium 137 and 1 Bq/m^3 of strontium 90 (a major assumption compared to the measurements carried out in the area), the calculated dose corresponding to the inhalation of radioactive fire smokes is approximately 13 micro sievert (µSv) [7].

It should be noted that this dose is much lower than that which results from the external exposure of fire-fighters by the radiation emitted by the contaminated soil and which, in the exclusion zone, is very often greater than 1 µSv/h. This is consistent with estimates made by Ukrainian scientists which indicate that the doses received by fire-fighters as a result of smoke inhalation are in the range of 1% of the dose induced from the exposure to ground radiation[8].

- for a resident of Kiev exposed for a few days to radioactivity levels comparable to those measured by Ukrainian organizations in Kiev, the inhalation dose received by an adult is less than 1 nano sievert (1 nSv = 0.001 µSv) which is extremely weak[9].

- IRSN completed its assessment by considering the exposure due to the ingestion of contaminated foodstuffs in Ukraine, near the disaster areas, by the deposit of radioactive ashes transported in the fire plume. The evaluation was made by assuming the consumption of 500 grammes of leafy vegetables (most penalizing case) per day for a two-month period[10]. The effective dose committed for an adult would reach, after two months of consumption, 30 µSv for strontium 90 (^{90}Sr) and 15 µSv for ^{137}Cs. This exposure remains low.

As mentioned in the IRSN note of April 7, 2020, the impact resulting from the inhalation of the radioactivity carried by the masses in the air arriving in France should be insignificant.

5 / Risk for storage facilities

The last reactor at the Chernobyl plant was shut down in 2000 (20 years ago), but there are still radioactive materials on site. These are first of all the structures and debris from unit 4 which exploded in 1986, the removal of which poses significant technical difficulties, and waste from the cleanup and dismantling of the reactors and the site, on which they are located. The spent fuel from the other three reactors (1 to 3) is stored on site, in a dedicated facility (ISF2). This is a dry storage.

[7] 11 µSv for ^{90}Sr and 1.4 µSv for ^{137}Cs. 1 µSv = 0.001 mSv

[8] V. A. Kashparov, S. M. Lundin, A. M. Kadygrib, V. P. Protsak, S. E. Levtchuk, V. I. Yoschenko, V. A. Kashpur, N. M. Talerko. Forest fires in the territory contaminated as a result of the Chernobyl accident: radioactive aerosol resuspension and exposure of fire-fighters. Journal of Environmental Radioactivity, 51, (2000), 281-298.

[9] The annual public exposure limit is 1,000 µSv as an added effective dose.

[10] Doses by ingestion of contaminated food induced by airborne activities of 1 Bq/m^3 of ^{137}Cs and 1 Bq/m^3 of ^{90}Sr for 24 hours. In this season, only vegetables, milk and meat can be produced. For this estimate, IRSN retained the case penalizing leafy vegetables with a consumption of 500 grams / day. Considering a dry deposit with a deposition velocity of 5 10^{-3} m/s, the deposited activity is then 430 Bq/m^2.

Very significant efforts have been made by the Ukrainians and the international community to ensure that these radioactive materials are stored securely in new installations designed and built in accordance with current safety standards. This is the case for the on-site waste storage facilities and the new sarcophagus which now protects the damaged unit. The risks of accidents were taken into account in the safety studies which were produced to support their design. Particularly endowed with a robust civil engineering, the risk that these installations could release the radioactivity which they contain due to fires is unlikely.

There are also storage facilities and waste deposits in the exclusion zone, which are located in areas which were *a priori* affected by the fires. Table 2 summarizes the main characteristics of these deposits and the map in Figure 3 specifies their location.

Table 2: Main waste storage and warehousing facilities in the Chernobyl exclusion zone

Facilities	Characteristics	Waste Types	Inventories
Buriakovka storage	Trench storage still in use	Low and intermediate waste levels	2.6 10^{15} Bq (Cs, Sr, Eu, Pu, Am)
Poldesny storage	Storage in concrete casemates	Sanitation waste following the accident (high-level and long-lived waste)	2.6 10^{15} Bq (^{137}Cs, ^{90}Sr, ^{134}Cs, ^{154}Eu, ^{155}Eu, ^{238}Pu, ^{239,240}Pu, ^{241}Pu, ^{241}Am)
Storage of so-called phase III waste from the Chernobyl nuclear site (« ChNPP stage III »)	Storage in concrete buildings	Sanitation waste produced during the emergency phase (low and medium activities and long life)	3.4 10^{14} Bq (^{137}Cs, ^{90}Sr, ^{155}Eu, ^{238}Pu, ^{239,240}Pu, ^{241}Pu, ^{241}Am
Waste repositories (« RICS »)	Open ground trenches and wells)	Low and intermediate waste levels	2 10^{15} Bq au total (spread over 9 sites)
Storage of Vektor's radioactive waste	Storage in concrete buildings	Low-level solid waste from the Chernobyl power station and other sites	1.7 10^{11} Bq (^{90}Sr, ^{137}Cs, ^{134}Cs, ^{135}Cs, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{241}Pu, ^{241}Am, ^{242}Am)
Storage of used sealed sources from Vektor	Long-term storage of radioactive sources		1.6 10^{13} Bq 1,634 sources of Cs, Co, Am, Ra

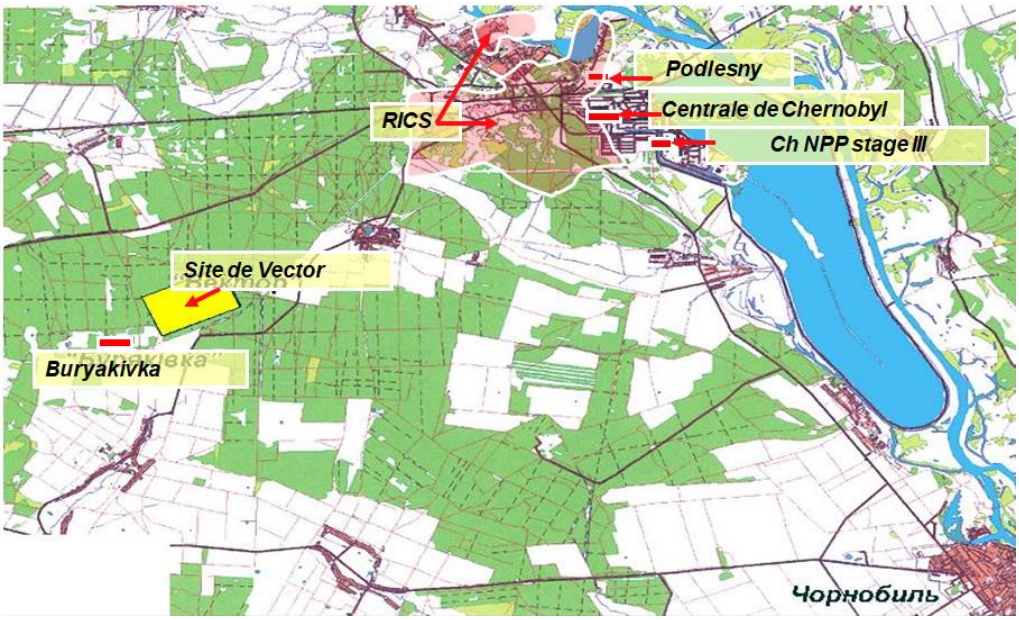

Figure 3: Map of waste storage and warehousing facilities in the exclusion zone.

These facilities are mostly old and some of them were created in an emergency to meet the needs to reduce the consequences of the accident in the exclusion zone. Generally sketchy in design, however, they have characteristics that offer good resistance to the remobilization of waste activity by fires. Thus, the Buriakovka site consists of trenches covered with a compact layer of clay material. It is also cleared (see Figure 4). The storage facilities at Podlesny (see Figure 5) and at phase III of the Chernobyl nuclear site are made of concrete and are also located in cleared areas. The more recently commissioned Vektor storage and warehousing facility is intended to store mostly essential waste.

Figure 4: View of the Buriakovka storage site

Figure 5: View of the Podlesny storage site

The most basic sites are the trench waste deposits distributed in the exclusion zone (RICS: Raw Interim Confinement Sites) and whose main radioactive inventory is mainly grouped in 9 zones located near the power plant. These are trenches containing waste produced in the exclusion zone, including metal parts, rubble and contaminated wood.

Even if, strictly speaking, they do not have barriers against the long-term dissemination of activity in the environment, these sites remain not very vulnerable with regard to the risk of fire because the waste is buried and covered with a layer of soil or sand.

In conclusion, even if there is a very significant activity in the exclusion zone linked to waste deposits, it appears to be not very mobilizable by fire. In fact, there is no measure in the exclusion zone published to date which suggests that a storage or warehousing site has been reached and may have released a significant part of the radioactivity it contains.

IRSN will continue to monitor the radiological situation in Ukraine in the coming days and will publish the results of air radioactivity measurements it will perform on the aerosol filters of its OPERA-AIR network in France.