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Extensive direct tests for alpha emitters at Hinkley Point are necessary for the health of civil engineers at HPC and the public near Bridgewater and Cardiff Bays. 17-3-20

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As first author of a *Nature* paper [1] on plutonium production in the Hinkley Point A (HPA) Magnox reactors, I feel qualified to comment on tests that should be made before any further excavations from Hinkley Point are dumped in Cardiff Bay. I understand that CEFAS TR502 HPC 2019 proposes taking 2 core samples, one at outfall and one at intake, to test by alpha spectroscopy for plutonium (Pu239 and Pu240) and Americium 241. Though testing 2 cores, with sub-samples at all depths, is clearly better than no direct alpha testing (as was the situation before the 2018 dumping) only 2 core holes is far too restrictive for the reasons outline below. More core samples are required over the Hinkley site, on the shoreline, in the estuary, and in all the locations In the RIFE reports for 2016, 2017 and 2018 where Americium 241 levels have increased as a result of HPC dredging.

The necessity for expanded alpha testing off-shore and onshore around HPA results from:

a) evidence for a 300 gm plutonium leak in liquid discharges from HPA. See sections 1) - 4).
b) evidence for direct on-site plutonium contamination from cladding damage. Sections 5) – 6).

We conclude that if a plutonium signal is found, it is imperative that plutonium lung-burden tests of the type routine at Sellafield are made immediately on all the civil engineering workers at Hinkley Point C. Further details are provided in Ref. 2.

1) For the first years of operation of the Hinkley Point A (HPA) Magnox station the refuelling schedule of both reactors was chosen to maximise the output of low burn-up plutonium for the MoD. In one fiscal year (1968-69) more than half of the HPA core was replaced using a novel on-load refuelling system designed for 20% refuelling [1]. Refuelling accidents occurred [3]. The Magnox cladding of an unknown number of spent fuel rods was compromised during extraction and transfer to the cooling ponds, in the cooling ponds and in transfer to the flasks which conveyed the rods to Sellafield. Pieces of spent fuel may havebroken off in the cooling ponds [3]. Plutonium particles of up to 5μ diameter can exit through the filters with the liquid discharges [4]. Observations have been made of plutonium particles (1-2)μ diameter being blown back onto the Sellafield site in sea-spray [5]. These are of the size which are readily inhaled and can lead to cancer. Additionally, transfer of damaged fuel elements to and from the cooling ponds provided another route for plutonium to reach the site as discussed in 5) and 6).

2) In October 2018 we received a Freedom of Information reply from Magnox Ltd that contained data on gamma emitters and plutonium 239 in the liquid discharges from HPA from start-up to 1984, taken from NRPB-M173 [4,6]. These confirm a peak in the gamma signal (Fig.1) in 1969 that was not evident in official MAF data. The plutonium 239 signal in the waste discharges also peaks in 1969 (Fig.2). Fig.1 shows the effect of shifting the rise in plutonium extracted from the HPA core by 1.3 years. On average Magnox fuel spent 1.2 years in onsite cooling ponds [1]. Note that the shifted peak of refuelling and the peaks in the Pu239 and gamma signals all coincide with the start of a maximum in a leukaemia cluster in the region around Hinkley Point [7]. The reduction in leukaemia cases in 1974-79 suggests that on-site plutonium contamination, discussed in 2), 5) and 6), contributed to the cluster.

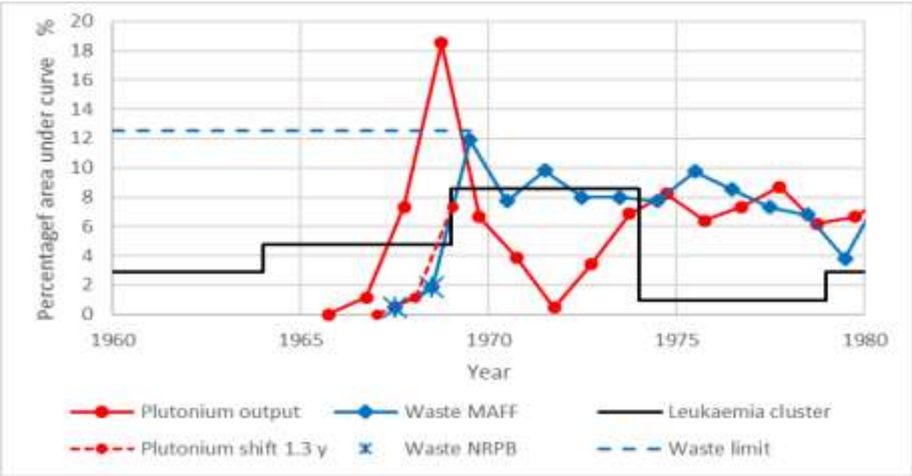

Fig. 1. HPA plutonium output (red) [1], official gamma signal in waste discharges data from MAFF (blue) [7], starred points from NRPB M173 [6] and the leukaemia cluster around Hinkley Point (black) [8]. Data sets have been normalised to the area under each curve. The broken red line shifts the plutonium output curve by 1.3 years. The average time Magnox fuel stays in cooling ponds is 1.2 years [1]. This graph provides strong evidence of many accidents in the cooling ponds around 1968. While the reactors were operating, more than half the spent fuel was discharged in a year with with a novel system designed for changing spent fuel at a rate of 20% a year [1].

3) The gamma emitter data in Fig. 2 show emissions declined in a slowly exponential as expected for the radioactive nuclei produced in association with plutonium. In contrast, the plutonium leak continues at approximately the same rate, implying that no remedial action was taken. At the average yearly rate of plutonium leakage, by early 2015 when the ponds were drained [9], around 300 grams of plutonium could have leaked in liquid waste. Spread over the 25 km^2 area used by the Environment Agency to estimate uranium levels [10], the plutonium contamination is 12 gm/km^2. That is nearly 4 times the 3.3 gm/km^2 plutonium contamination at which the NRPB requires evacuation [11].

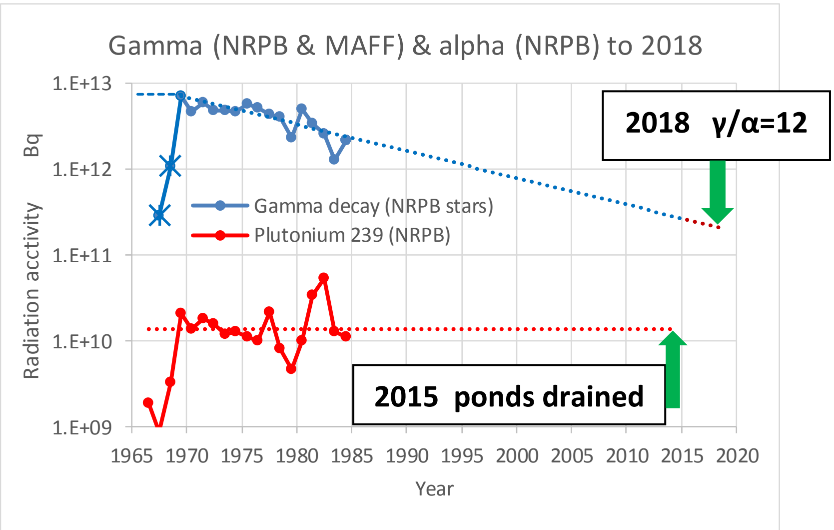

Fig. 2. Blue data is the sum of the gamma emissions from NRPB-M173 [6] in the liquid waste discharged at HPA. The two years starred were absent from the MAFF data in Fig. 1 but can be found from NRPB-M173. They clearly show gamma emission peaked in 1969, a year after maximum plutonium output at HPA [1]. The gamma emitters from damaged fuel elements decay. The plutonium 239 (red) lifetime is very long, hence the leak remains approximately constant, if there is a large plutonium residue in the ponds.

4) EDF argue that the low gamma signals measured in the mud dumped in Cardiff Bay in 2018 imply that the alpha plutonium signal (which was not measured) is very much lower, possibly by a factor around 340. This was the ratio in 1969 as can be seen from Fig. 2. However, the number of *gamma* emitters liberated by the 1969 cladding accidents gradually falls due to radioactive decay. By 2018 when the mud was dumped in Cardiff Bay the gamma to alpha ratio would have been down to 12 as the plutonium 239 lifetime is very long. This ratio is probably far lower as dense plutonium particles are fixed in the sediment, whereas many gamma emitters form soluble molecules which are swept away by currents.

5) A Green Audit study [12] of two soil samples from Hinkley Point provides evidence of on-site contamination by damaged HPA fuel elements. Mass spectroscopy shows "significantly high" levels of magnesium in both samples. Magnesium is the main component of the fuel cladding in HPA [13]. Beryllium is an extremely small component of Magnox alloy but is present in both samples. Beryllium increases the plutonium yield. The two HPA soil samples show beryllium to magnesium ratios 0.031% and 0.034%. Both are 3 times higher than the ratio (0.01%) in Magnox A12, the alloy used in Calder Hall military plutonium [13]. This is very strong evidence that the accidents exposed spent fuel in the air as well as under water and hence significant amounts of plutonium may be distributed over the Hinkley Point site.

6) Testing for alpha emissions in many cores at all depths on site and in the estuaries is vital because the peak in the plutonium leak occurred 51 years ago and the plutonium could now be buried deeply. Many of the cladding failures outside the cooling ponds discussed in 5) will have released plutonium on site a year or so earlier. Fig. 2 shows no sign of the plutonium leak declining up to 1984, hence plutonium was not depleting in the cooling pond debris. Hence there is probably significant amounts of plutonium still in the sludge being decommissioned [3]. This is consistent with plutonium escaping on site from damaged fuel elements during the transport to and from the cooling ponds, as suggested in sections 2) and 5). Massive, deep excavations have been underway in the last few years for the concrete base and waste tunnels of the new reactors. If a plutonium signal is found, it is imperative that plutonium lung-burden tests of the type routine at Sellafield are made immediately on all the civil engineering workers at HPA.

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