Analysis of Hinkley Point Jetty application mud sample digital spectra supplied by CEFAS in January 2018

Christopher Busby PhD

Green Audit
Bideford, Devon
January 2018

1. Background

A licence permitting the dumping of 330,000 tons of dredged mud from Hinkley Point Nuclear Power Station in the Cardiff Grounds area of the Severn Estuary is being considered by the Welsh Assembly Government and was the subject of an earlier report (Busby 2017a). CEFAS have characterised the mud in radiological terms through the gamma spectroscopic analysis of samples obtained in 2013 and in 2017. A request for the raw data was made in December 2017 and files were provided by CEFAS. They consisted of interpretations of the data and a second application was made for the raw digital spectral files. These were provided on 22nd January 2018 as text files and also a set of what were clearly originally the spectrometer digital files. These had been altered so they could not be opened. They were, however, clearly of a type known to us and by altering the file type designator they could be opened as Canberra Genie data files and examined using proprietary software FitzPeaks. An example of one of the spectra as uploaded and analysed is given in Fig 1 below. Here are reported the results of those analyses, and an overview of the results.

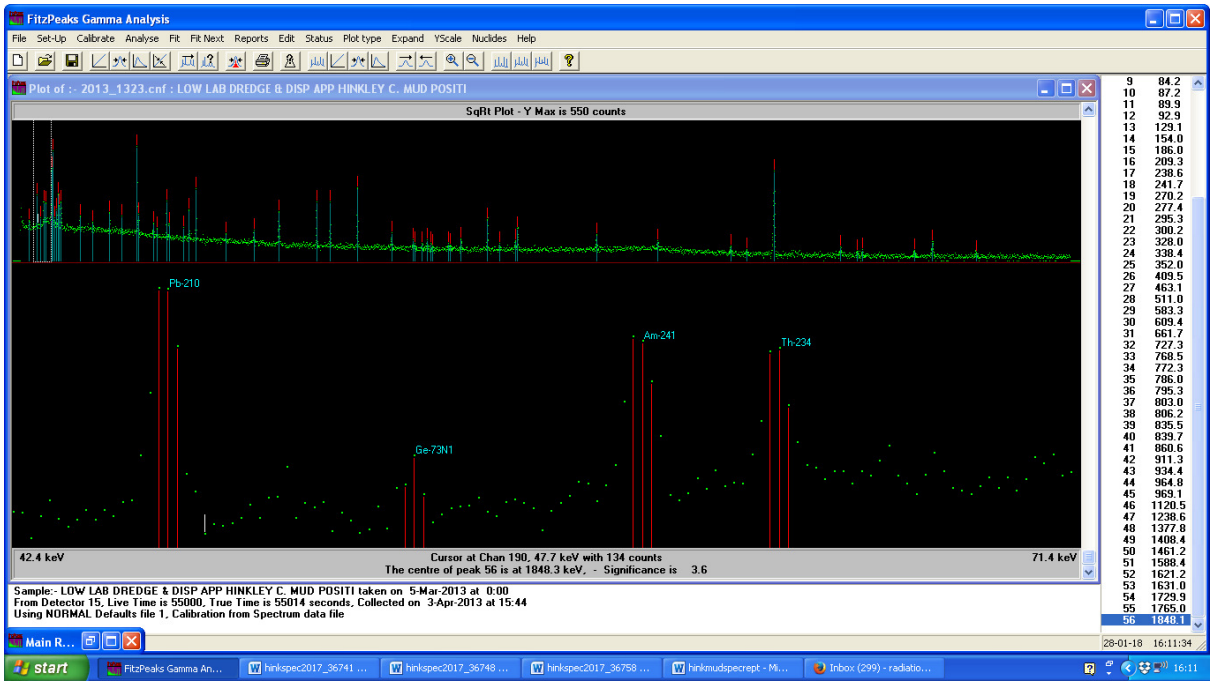
2. Summary of findings

There were two sets of samples, 15 from 2013 and 12 from 2017. Count periods for generally 250g of material were 50,000 secs but for some samples a recount was made at 80,000sec. Spectra were of good quality. Between this analysis and that provided by CEFAS the main issues were:

1. Isotopic ratios of U-238 (Th-234) and U-235 indicated that all Uranium was significantly enriched. This was an issue raised by Green Audit in 2011 and 2012 when analysing the Environmental Impact reports for the application (Busby and Collingridge 2011a and 2011b, Busby et al, 2012). There was no comment or analysis of this by CEFAS which did not report the levels of U235 for any sample.
2. Uranium enrichment was significantly greater in the 2017 samples than in the 2013 samples suggesting that there had been addition of material containing enriched Uranium to the sediment offshore during the intervening period.
3. Americium-241 was present in many of the samples but was not reported or was manually dismissed by CEFAS. Am-241 indicated the presence of Plutonium-241 and thus Pu-239 and Pu-238.
4. Europium-155 was reported present in most samples but not reported by CEFAS which manually dismissed the gamma line as an artefact.
5. Pb-210/Po-210 was present in most of the samples in significant quantities but not reported by CEFAS. Po-210 is a significant alpha emitter hazard which was used to poison the Russian Alexander Litvinenko.
6. Several samples were missing in the numerical sequence.

7. Levels of Cs-137 were significantly higher than those reported in RIFE 2016 for sediment in the same area. Levels were significantly higher in 2013 than in 2017 which cannot easily be attributed to radioactive decay.
8. Levels of Am-241 were significantly higher than those reported in the 2016 RIFE report for Hinkley and local sediment.
9. Digital files had been overwritten so they could not be opened. Canberra Genie files with the suffix: .cnf had been altered to .cnf;1

Fig 1 Gamma spectrum 2013_1323 and identification of Am-241 (3.83+- 0.61) and Pb-210/Po-210 (54+-18) Bq/kg.



3. Results in detail

The spectra all showed the presence in various levels of natural radionuclides in Th-232, U-238 and U-235 series. These included the partial gamma emitters Ra-226, Ac-228, Pb-214, Pb-212, Bi-212, Bi-214, Th-228, Be-7, Tl-208 and K-40. These will not be discussed further but results can be made available on request for each sample.

3.1 Enriched Uranium

There were indications that the Uranium present was significantly enriched, that is to say that the ratio of U-238 to U-235 was significantly less than 21.4, the natural Uranium activity ratio. This means that the Uranium is not natural and is derived from a nuclear energy or

nuclear weapons stream. The probable source is the nuclear power station at Hinkley Point. Similar but enriched Uranium isotope ratios were seen in the gamma spectra of soil samples as presented in the Hinkley C application document (AMEC 2008) . The trend with distance from the sea and with depth suggested that that material was from sea-to-land transfer (Busby and Collingridge 2011). Isotopic ratios in the soil from the application documents were about 17, but in the present mud samples the ratio is generally below 10 indicating much greater enrichment. This is likely to be from the Hinkley site since independent sampling and measurement by Green Audit in 2012 using long count time gamma spectroscopy and ICPMS in Germany, showed the presence of high levels of enriched Uranium in the soil near the station (Busby et al 2012). Uranium activity in the soil was 127Bq/kg and isotope ratios were found using the Thorium 234/Thorium 231 lines in the gamma spectrum which gave between 8 and 17, values which are similar to those found in the mud samples. Table 2 gives results for Uranium from the 2013 samples analysis. Table 3 shows results for the 2017 samples. The clear implication is that the power station has been discharging enriched Uranium to the land and sea. Furthermore, the increase in enrichment ratios seen between 2013 and 2017 suggests that the operators were disposing of the contaminated soil found in Busby et al 2012 to the sea in the period 2013-2017.

CEFAS did not report the presence of U235 and so the Uranium isotopic ratios cannot be calculated from CEFAS interpretation data.

Table 2 Activity of U-238 and U-235 from the 2013 data. Bq/kg (this analysis); Percent error (1 sigma);Natural Uranium activity ratio is 21.4

Sample No	**U238**	**σ U238 %**	**U235**	**σ U235 %**	**Activity Ratio U238/U235 (interpretation)**
1317	25.7	23	3.23	25	7.9 Enriched
1318	33	20	3.1	27	10.6 Enriched
1319	32	21	3.1	27	10.3 Enriched
1320	28	22	2.87	27	9.8 Enriched
1321	30	18	3.44	23	8.7 Enriched
1322	26.5	17	2.63	27	9.9 Enriched
1323	30	17	3.18	26	9.4 Enriched
1324	15.5	24	1.54	28	10.1 Enriched
1325	29	18	2.8	25	10.4 Enriched
1326	34	21	3.3	26	10.3 Enriched
1327	33	21	3.3	26	10 Enriched
1328	31	22	3.46	26	9.0 Enriched
1329	27	24	3.4	26	7.9 Enriched
1330	32	21	3.39	26	9.4 Enriched
1331	25	24	3.17	26	7.9 Enriched
1332	30	23	3.4	26	8.8 Enriched
1333	31	21	3.2	27	9.7 Enriched
All mean	29	21	3.08	26	9.41
Collected Sqrt. Error	29	5.1	3.08	5.1	9.41 (8.52, 10.37) Enriched

Table 3 Activity of U-238 and U-235 from the 2017 data. Bq/kg (this analysis); Percent error (1 sigma);Natural Uranium activity ratio is 21.4. Count time 55,000s except for those labelled * which have 80,000s. Six samples are missing from the sequence.

Sample No	**U238**	**σ U238 %**	**U235**	**σ U235 %**	**Activity Ratio U238/U235 (interpretation)**
36741	19.1	43	3.37	27	5.7 Enriched
36746	33.1	25	3.47	25	9.5 Enriched
36747	19	38	3.38	26	5.6 Enriched
36748	30.9	22	3.07	26	10.1 Enriched
36749*	36	15	3.76	22	9.6 Enriched
36750	21.9	30	2.94	25	7.5 Enriched
36752	25	24	3.16	26	7.9 Enriched
36753*	22	24	3.37	22	5.9 Enriched
36754	24	22	3.29	25	7.3 Enriched
36755	30	20	2.84	27	10.5 Enriched
36756	18.9	40	3.42	24	5.5 Enriched
36758	28.3	22	2.73	26	10.3 Enriched
All mean	25.6	27	3.23	25	7.3 Enriched
Collected sqrt error	25.6	5.2	3.23	5.0	7.3 (7.16, 8.56)

3.2 Americium-241 and other indicator nuclides.

Am-241, an alpha emitter, is a common nuclear industry release and is reported in samples from the Irish Sea near Sellafield and also near most nuclear energy sites. It is the daughter of Plutonium241 and its presence indicates the presence of Plutonium 239 and Plutonium 240 also. In Sample 2013_1323 shown above in Fig 1 the Am241 peak is clear and shows an activity of 3.83 Bq/kg. It is of interest here that CEFAS has not reported Am-241 for many of the sample reports they released. Additionally, the RIFE report in 2016 does not indicate Am-241 presence in any one of the 14 mud samples listed (Table 4/7(a)) which raises the issue of the credibility of the data in the RIFE reports. Table 4 gives levels of Caesium-137, Americium-241, Lead-210 and Europium-155 found in this analysis together with levels reported by CEFAS in their interpretation reports which were given prior to the raw data. The significance of Am-241 is that it is the daughter of Plutonium-241 and is generally a flag for Plutonium. Europium-155 indicates that the sample is from a nuclear waste stream.

3.3 Caesium-137

This is the well-known fission-product which is found in nuclear site waste streams and also in weapons test fallout. Levels in all 27 samples were significantly higher than expected from current fallout levels and ranged from 12 to 27Bq/kg, mean level 15.6 SD 2.3

The RIFE 2016 reported levels near Hinkley point in sediment are 2.5 to 17, mean level 8.6 SD 4.5. From RIFE results for sediment on the north Somerset coast some 20 miles from Hinkley, the Cs-137 levels from fallout are less than 1.5Bq/kg. Thus the Cs-137 levels in the mud due to Hinkley operation are more than 10 times background.

Table 4 Caesium-137, Americium-241, Europium-155 and Lead-210 in data from 2013 and 2017 together with interpretations supplied by CEFAS; **(σ)%.** If column has a Yes, this means it is detectable above the MDA which for Eu-155 is 2.5 and for Am-241 is 1.5. Disagreements or exclusions are highlighted.

Sample	**Cs137 This (σ)**	**Cs137 CEFAS**	**Am241 this**	**Am241 CEFAS**	**Eu155 this**	**Eu155[a] CEFAS**	**Pb210[b] This**
2013							
1317	20 (6.9)	20 (4.7)	**1.24 (47)**	No**	**Yes**	No**	56 (33)
1318	20 (7)	21.6 (4.6)	No	No	**Yes**	No	45 (46)
1319	21.2 (7)	21.2 (4.7)	No	No	No	No	Yes
1320	27.5 (7)	27.3 (4.5)	No	No	No	No**	Yes
1321	19.6 (7)	19.3 (4.7)	**Yes**	No	No	No**	59 (33)
1322	17 (7)	17.4 (4.7)	**Yes**	No	No	No	51 (32)
1323	21 (7)	21.2 (4.7)	**3.83 (16)**	3.16 (13)	No	No	54 (33)
1324	7.1 (7.8)	7.2 (5.1)	No	No	No	No**	Yes
1325	22 (7)	21.7 (4.6)	No	No**	**Yes**	No**	56 (32)
1326	32 (6.5)	31.1 (4.5)	No	No	**Yes**	No**	Yes
1327	23 (6.6)	23.2 (4.6)	No	No	No	No**	Yes
1328	20 (6.8)	20.5 (4.6)	No	No	No	No**	41 (50)
1329	19 (6.9)	18.9 (4.6)	No	No	**Yes**	No**	40 (52)
1330	20 (6.8)	20.8 (4.6)	**Yes**	No**	No	No**	Yes
1331	22 (6.9)	22.1 (4.6)	**Yes**	No	**Yes**	No**	55 (33)
1332	29 (6.6)	22.9 (4.6)	No	No	No	No	Yes
1333	18 (6.7)	18.5 (4.7)	No	No	No	No	35 (54)
Mean	21.1 (6.9)	21.0 (4.65)					
2017							
36741	19.3 (7)	19.5 (4.6)	No	No	Yes	No**	Yes
36746	19.4 (7)	19.5 (4.6)	No	No	Yes	No**	Yes
36747	18.0 (7)	17.9 (4.8)	No	No	Yes	No**	38 (48)
36748	17 (7)	17.5 (4.8)	No	No	Yes	No**	Yes
36749	14.4 (8)	14.8 (5)	Yes	No	Yes	No**	64 (32)
36750	14.5 (7)	14.6 (4.7)	No	No	Yes	No**	41 (47)
36752	14.8 (7)	15.1 (4.8)	No	No	Yes	No**	Yes
36753	15 (6.9)	15.0 (4.7)	Yes	No	Yes	No**	58 (32)
36754	14.3 (7)	14.8 (4.7)	No	No	Yes	No**	56 (32)
36755	14.6 (7)	14.8 (4.8)	No	No	No	No	40 (55)
36756	12.6 (7)	12.8 (4.9)	No	No	Yes	No**	Yes
36758	13.7 (7)	13.6 (5)	No	No	Yes	No**	41 (55)
Mean	15.6(7)	15.6 (5)					

[a] CEFAS column label ** means that instrument reported nuclide but operator manually removed it or dismissed it as an artefact.
[b] Lead 210 not reported by CEFAS from any sample

3.4 Europium-155

This fission-product is a common contaminant found near nuclear sites and is unambiguous evidence of discharges from nuclear power stations and an identification of the source of contamination in environmental samples. It is present in most of the sample spectra but was not reported. Indeed, it was manually discounted by the editor of the spectra on the spurious basis that the parent line was absent. It has not been reported in the RIFE Hinkley Point sampling results for 2016 but was for various other sites, e.g Chapelcross, Hunterston.

4. Discussion

4.1 Public confidence in government-funded agencies.

Human rights legislation, signed up to by most countries, including the UK, clearly states that the public has a right to information on environmental contamination, and also its possible effects upon health (Note 1). It is also now well accepted that exposure to environmental radioactive contaminants causes adverse health effects with the probability of biological damage occurring at the lowest exposure dose (the linear no-threshold model). Since the development of nuclear weapons and nuclear energy, the biosphere has been accumulating novel radioactive materials, not only the Uranium fission products like Caesium-137, but also human activity-enhanced and novel forms of Uranium and other natural radionuclides. The regulation of exposures to these contaminants is based upon a radiation risk model which assesses cancer incidence following the Hiroshima bombs. However, there is increasing evidence that this model is unsafe when applied to internal exposures (Busby 2016). Indeed, the Swedish Environmental Court in January this year refused permission for the development of a nuclear waste repository on the basis of concerns about the health effects of the project.

The current risk model is in any case part of a legal challenge in a number of countries of Europe on the basis of research showing significant increases in congenital effects at birth in several countries of Europe and the ex-Soviet Union (Schmitz-Feuerhake et al 2016).

Whichever risk model is employed, the data necessary to make decisions has to be obtained and presented to the public. It must be accurate and not omit information. In England and Wales, the job of collecting samples and analysis is given by government to a number of agencies. The coordinating work is carried out by the CEFAS laboratories in Lowestoft. Data is presented every year in the RIFE reports. These reports show contamination levels of various radionuclides in samples taken from near sites which discharge radioactivity.

The public has no alternative to accepting that these results are accurate and do not omit important possible exposures. There are few independent laboratories that can measure radionuclides in samples, and those that there are charge significant amounts for their analysis (e.g. one gamma spectrum costs about £200). Furthermore it is not at all clear that, for critically important samples, these laboratories are themselves above reproach.

The questions raised by the Welsh Assembly government about the proposed dumping of contaminated mud 3km from Cardiff have forced the release of the historical data for the gamma analysis of the samples. The response by CEFAS was first to release only the interpretation data. Then when this was pointed out, the raw data files were released, but in a form that could not be used owing to changes in the digital tags for the files. Digital files had been overwritten so they could not be opened. Canberra Genie files with the suffix: .cnf had been altered to .cnf;1. By manually re-naming the files they could be uploaded into the program Fitzpeaks which Green Audit purchased many years ago as part of a legal case in the USA.

But how many members of the public, or NGOs have a program that can interrogate these data files? And how many have the expertise to understand the results? And how much money has been spent by Green Audit attaining a position where independent analysis can be done?

In Sweden, following arguments relating to the human rights implications of radioactive discharges, the government funds independent anti-nuclear groups, a kind of red-teaming which is intended to balance the group-think position associated with developments of nuclear energy. As a result of what has emerged in the independent analysis of the mud results and what they argue for the credibility of the RIFE reports, it is concluded that such an approach is necessary in the UK.

4.2 What does this independent analysis show?

Every year, with the RIFE reports, is sent a form asking for suggestions about how the process can be improved. Many times we have responded saying that since the principal material employed by nuclear sites is Uranium, usually enriched Uranium, and since all nuclear power stations emit Uranium particles from the stacks, there should be analyses of Uranium 238 and 235 in samples. Uranium is not measured near nuclear power stations. It is only reported near the Uranium production facilities Capenhurst and Springfields and the atomic weapons site at Aldermaston (but only following a Government enquiry into a leukemia cluster chaired by Helena Kennedy QC). Yet there is considerable recent evidence in the literature that Uranium, especially in the form of particles like those released from nuclear power plants, represents an anomalous health hazard of surprizing and alarming magnitude (Busby 2015, 2017c). The release of the mud sample digital data enables us for the first time to see the levels of Uranium contamination of the local environment resulting from the operation of a nuclear power station. It is clear that those analysing these data at CEFAS did not wish for the enrichment ratios to be calculated, since they did not show in any

of the interpretation data, the concentration of the key nuclide, U-235. This can be obtained from its gamma peak at 186keV but also, in more concentrated samples by the ratio of the Thorium-234 (the daughter of U-238) and Thorium-231 (U-235 daughter) peaks, together with a second weaker U-235 peak at 143keV.

Here it is necessary to briefly draw attention to earlier work by Green Audit which addressed the presence of Enriched Uranium in the Hinkley C application documents. In 2011 and 2012 we carried out work examining contamination of the proposed site at Hinkley Point. In two reports we showed the presence of enriched Uranium, first using data provided by the applicants (AMEC 2008) and then from samples taken by us from the site and sent for gamma spectroscopy (Busby and Collingridge 2011, Busby et al 2012).

The response from the Environment Agency was to dismiss our results and interpretations, and to take samples of unknown location, which were sent for ICPMS at Southampton University. These showed no enrichment. However, we have no way of knowing where these samples were collected from. Our own sample, sent to a trusted laboratory in Germany for ICPMS, showed enriched Uranium. There the matter stood until now.

In passing we should say that work carried out by us in collaboration with ESG at Harwell shows clearly that the results of Uranium determination using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) on soil and mud samples are critically dependent on the dissolution method and solvents used. The Uranium particles, which can be ceramic, do not readily dissolve in anything but the most aggressive solvents. This is also clear from the inter-comparison analytical studies carried out in the Netherlands at Wageningen. These showed (unpublished, but available from Green Audit on request) that only methods which analysed the whole sample (gamma spectrometry, neutron activation analysis) gave the correct result. In many cases, the ICP-MS achieved only 60% of the total Uranium content.

Therefore we now see new evidence of a nuclear power station producing significant levels of enriched Uranium and contaminating its local environment. This is unsurprising since these machines use enriched Uranium as fuel and release particles from their exhaust stacks, and no doubt other discharge routes. We also see from the data that there was a significant change in the levels of Uranium and the enrichment between 2013 and 2017.

There are other discoveries which raise the issue of the credibility of both the CEFAS current analysis and the RIFE reports for Hinkley Point.

Americium-241 was present in many of the samples but was not reported or was manually dismissed by CEFAS. Am-241 indicated the presence of Plutonium-241 and thus Pu-239 and Pu238. Europium 155 was reported present in most samples but not reported by CEFAS which manually dismissed the gamma line as an artefact.
Pb210/Po210 was present in most of the samples in significant quantities but was not reported by CEFAS. (Po-210 is a significant alpha emitter hazard which poisoned the Russian Alexander Litvinenko.)

Several samples were missing in the numerical sequence.
Levels of Cs-137 were significantly higher than those reported in RIFE 2016 for sediment in the same area. Levels were significantly higher in 2013 than in 2017 which cannot easily be attributed to radioactive decay.
Levels of Am-241 were significantly higher than those reported in the 2016 RIFE report for Hinkley and local sediment.

5. Heavy metals and Marine Conservation Environments

Two files containing measurements of certain metals in the mud samples were provided. These have not been addressed here. In view of the European Conservation status of the Severn Estuary, it is recommended that more samples are analysed for heavy metals and results provided.

6. Conclusions and recommendations

The analysis of the mud data by CEFAS is unsafe owing to the omission of results for Uranium-235 and no analytical interpretation of the enriched uranium levels in the mud. Since the Uranium is clearly from the nuclear site, and is therefore partly in the form of particles, the arguments made in our previous reports about the dangers of sea-to-land transfer are supported. It is astonishing and worrying that the proposal to dump about 1 ton of Uranium into the sea about 1 mile from a highly populated city located downwind of the sea-spray and sea-to-land transfer has contained no mention of the Uranium and its source in the nuclear power station, nor have the data even reported the levels of U-235 so that some independent assessment of the potential effects might be made. Additionally, the omission of other radionuclides and the manual dismissal by CEFAS of the data for Americium-241 and Europium-155 (nuclides that indicate the origin of the contamination as the nuclear site) suggest an unacceptable bias in the interpretation of the data. Finally, the differences between the results and those tabulated in the RIFE reports for the same site indicate bias in the assembly/ interpretation/ sampling associated with the RIFE programme which is also unacceptable.

1. It is recommended that future samples be counted for 100,000s to enable the presence of Am-241 and Th-231 to be obtained so that better measures of U-235 can be employed.
2. The missing sequence sample results should be made available.
3. It is recommended that the Welsh Assembly fund an independent laboratory in Wales to enable independent measurements in environmental materials of radionuclides, particularly Uranium. It is unfortunate that the world class laboratory at the University of Bangor, directed by Dr David Assinder, was shut down in 2007. It is recommended that this laboratory be restored as part of a funded collaboration between scientists designated by the NGOs and stakeholders so that an independent oversight of the CEFAS and government agencies can be possible.

Note 1
Human Rights and the Environment

As early as 1972 the Stockholm Conference on the Human Environment addressed the interrelationship between Human Rights (as already enshrined in the Articles of the UN Declarations) and environmental protection. At the 1968 Teheran conference, Principle 1 of the final UN declaration stated (Final Declaration 1972) : *Man has the fundamental right to Freedom, Equality and Adequate conditions of Life in an environment of a quality that permits a life of dignity and well-being and he bears a solemn responsibility to protect and improve the environment for present and future generations*.

(International Covenant on Economic, Social and Cultural Rights Dec 16 1966 993 UNTS 2, 6 ILM 360 1967)

Twenty-two years later UN Resolution 45/94: *Recognises that all individuals are entitled to live in an environment adequate for the health and well-being and calls upon member states and intergovernmental and non-governmental organizations to enhance their efforts towards a better and healthier environment.*

To those whose well-being suffers due to environmental degradation Human Rights law currently provides the only set of international legal procedures that can be invoked to seek redress for harm that is the consequence of an act or an omission attributable to a State. The inclusion of INACTION is significant since most environmental harm is due to State non-activity. Thus, whilst no international human rights procedure allows direct legal action against private enterprises or individuals who cause environmental harm, a State allowing such harm may be held accountable.

Judge Weeremantry of the International Court of Justice put it: *The protection of the environment is a vital part of contemporary human rights doctrine. Damage to the environment undermines all of the human rights spoken of in the Universal Declaration.*

Degradation of the environment impacts the right to health and the right to family when genetic or genomic damage is involved since human fertility is affected.

Procedural consequences

- Rights to environmental information
- Public participation in decision making
- Remedies in the event of environmental harm

Stockholm Principle 1; Rio Declaration

Individuals shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities and the opportunity to participate in decision making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings including redress and remedy shall be provided.

1998 Aarhus Convention (UNECE)

Every person has the right to live in an environment adequate for his or her health and well-being and the duty, both individually and in association with others to protect and improve the environment for the benefit of present and future generations

Article 1:

Citizens must have access to justice in environmental matters

WHO European Charter

Every individual is entitled to information and consultation on the State of the Environment

Public Participation in environmental decision making

It follows from the above that there must be such participation based on the RIGHT of those who may be affected, including foreign citizens and residents to have a say in their environmental future.

1. The right to be heard
2. The right to affect decisions

Appreciation

I would like to record my appreciation of the regular nagging, encouragement and involvement of the late Cecily Collingridge, of Burnham on Sea, without whose tireless work and moral energy these investigations around Hinkley Point would not have occurred. Without such individuals, who are prepared to stand up for the rights and the safety from harm of the public who are exposed to the harmful discharges from industry, we and our children would be entirely at the mercy of those who contaminate the planet for their power and profit, and the dishonest and questionable science that underpins their projects. It has been a great development in this area of nuclear contamination safety when the Swedish Land and Environmental Court, which took evidence from us in Stockholm over two days, published its decision last week that the disposal of high level nuclear waste to the proposed the Baltic Sea coast facility at Forsmark Sweden could not be permitted. It is a shame Cecily is not around to celebrate this landmark decision.

References

AMEC (2008) Phase 2 Supplementary Investigation of Potential Radiological Contamination EDF Access Appendix C Soil Sampling Data and Comparison with Background Values-December 2008 AMEC 15011/TR/00091

Busby Chris (2017a) The potential health effects to coastal populations of the dumping of 330,000 tons of radioactively contaminated mud on the coast of Wales, 2.8km from Cardiff, material originating from dredging near the British nuclear site at Hinkley Point, Somerset Occasional Paper 2017/2. Bideford: Green Audit [http://www.llrc.org/2Dec2017Hinkleymud.pdf]

Busby, Chris, Cato, Rosa and Collingridge, Cecily (2012) Measurements of radiation dose rates, radionuclides and other contaminants on EdF Energy's site for the proposed Hinkley Point C Nuclear Power Station. Report 2012/1 Aberystwyth: Green Audit

Busby, Chris, Collingridge, Cecily (2011) Evidence of significant enriched uranium atomic fuel contamination of the Hinkley Point proposed nuclear site in Somerset and its potential implications. Green Audit Occasional Paper 2011/1 Aberystwyth: Green Audit January 2011

Busby Christopher (2017b) Child health and ionizing radiation: Science, Politics and European Law. *Pediatric Dimensions*. 2(3) 1-4 doi:10.15761/PD.1000150

Busby Christopher. Letter to the Editor on "The Hiroshima Nagasaki survivor studies. Discrepancies between results and general perception." By Bernard R Jordan. *Genetics*. 2016; 204(4) 1627-1629

Busby Christopher, de Messieres Mireille and Morgan Saoirse (2015) Infant and perinatal mortality and Stillbirths near Hinkley Point nuclear power station in Somerset, 1993-2005; an epidemiological investigation of causation. *JJ Epidemiol. Prevent*. 2015 1(2) 013

Busby Christopher (2015) Editorial: Uranium Epidemiology. *Jacobs Journal of Epidemiology and Preventive Medicine* 1(2)- 009;

Busby Christopher (2017c) Anomalous health effects of Uranium exposure. ISBN 978-620-2-30250-0. Saarbrucken (Germany): Scholars Press

Schmitz-Feuerhake, Busby C, Pflugbeil P Genetic Radiation Risks-A Neglected Topic in the Low Dose Debate. Environmental Health and Toxicology. 2016. 31Article ID e2016001. http://dx.doi.org/10.5620/eht.e2016001.