



NFLA Radioactive Waste Policy Briefing Number 78: Sea to Land Transfer of Man-made Radioactivity – an update

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Sea to Land Transfer of Man Made Radioactivity – an update

i. Overview of Policy Briefing

This edition of the NFLA Radioactive Waste Policy provides an update of research by the independent marine radioactivity consultant, Tim Deere-Jones. This considers concerns around the transfer of radioactive particles discharged into the marine environment that come back to land through the likes of storm surges, sea spray and suchlike.

A copy of this article has been presented recently in 'The Ecologist' magazine and this report has been produced with the kind agreement of Tim Deere-Jones. It will also be shared by the NFLA to our colleagues in KIMO International, whose work considers threats to the marine environment. This issue has been raised at previous NFLA All Ireland and NFLA Welsh Forum meetings and remains an issue of concern to the NFLA.

1. Introduction

Man-made radioactivity has been endemic in UK waters since the inception of industrial scale discharges from UK nuclear plants in the 1950's. In addition to the radioactivity discharged from regional sites, Sellafield derived alpha, beta and gamma emitters are now an accepted factor of marine radioactivity in all UK coastal waters. As the UK is full into the 2019 season of winter and spring gales, residents of the coastal zone need to be aware that they are annually exposed to dietary and inhalation doses of man-made marine radioactivity, discharged to sea from nuclear power stations, fuel fabrication sites and re-processors, and transferring from the sea to the land in sea spray and marine aerosols (micro-droplets). Both spray and aerosols are driven at least 10 miles inland by onshore winds, onto the UK's west coast for around 60% of the year, slightly less on the east coast.

2. "Official" Sea to Land transfer studies

Sea to land transfer studies were initiated by the UK nuclear industry and a number of UK Governments, acting through the UKAEA which, in the late 1970's and early 1980's, researched the sea to land transfer of the alpha-emitting Plutoniums (Pu) 238, 239, and 240, Americium (Am) 241 and the beta-emitting Caesium (Cs) 137, across the Cumbrian coast near Sellafield. **(Ref 1)**

This work confirmed that all five radio nuclides, transferred readily from the sea to the land in sea spray and marine aerosols generated by breaking waves. The Beaufort Scale notes that waves start to break in Force 3 winds (8-12 mph) and the UKAEA reported that their study was conducted in up to Force 5 (19-24mph) winds.

Compared to ambient seawater, Cs was enriched in spray and marine aerosols with enrichment factors [EFs] of around 2. The alpha emitting Pu and Am were shown to have EFs, relative to filtered ambient seawater, of up to 800. It was noted that the sea spray and aerosols were generated by breaking waves in both the offshore zone and at the surf line. Alpha emitters were found to be associated (*by ad-sorption*) with micro particles of sedimentary and organic material suspended in the marine water column and ejected into the atmosphere as aerosols, by bursting bubbles.

However, once the sea to land transfer of alpha emitters with massive enrichments was confirmed, further empirical field studies were abandoned and virtually no field work on the extent of the inland penetration of spray and aerosols and human doses and exposure pathways has been completed. As a result all such assessments have been, and continue to be, “modelled”, based on hypothetical assumptions derived from the incomplete historical data. It is also noteworthy that, of the 60 + radio nuclides known to be discharged to sea from UK nuclear sites, only the five named radio nuclides have been researched for their sea to land transfer potential. This remains particularly noteworthy given the decision in 2018 – leading to major discussions within the Welsh Assembly – of large amounts of mud from the proposed Hinkley Point C reactor site development being dumped on an offshore marine site in the Cardiff ‘Deep Grounds’ not that far from Cardiff Bay. This procedure may be undertaken again in 2019 / 2020.

3. Onshore winds and Sea to Land Transfer

30 year wind data from the UK’s west coast indicates that onshore winds (SSW to NNW), occur for around 5,150 hours per year. **(Ref 2)**. Specific individual sites along the UK’s west coast will be subject to regionally and locally variable conditions and may receive more or less hours per year of onshore wind. On this basis it may be proposed that sea discharged gamma emitting Cs 137, and the alpha emitters Pu 238, Pu 239, Pu 240 and Am 241 are transferring from the sea, to west coast terrestrial coastal zones in sea spray and marine aerosols, generated in both the offshore zone and the inshore zone, for approximately 60% of the time during an average year.

4. “Independent” Sea to Land Transfer Case Studies

The proposition is supported by the data. In 1988, independent empirical research by a west Wales local authority reported that Sellafield derived, sea discharged Cs had been found in pasture grass up to 10 miles inland of the Ceredigion coast (Am and Pu were not analysed for). **(Ref 3)** Clearly, this must contribute to human dietary doses via the dairy and beef food chain. The research also indicates the probability of further dietary doses from arable and horticultural crops. Given that airborne radioactivity is driven at least 10 miles inland, it should be assumed that coastal populations are also exposed, on a repeated annual basis, to inhalation doses.

Independent, empirical field research by a team of GPs in the Hebrides, has shown broadly similar, but more detailed results and demonstrated that island and coastal environments are saturated with sea borne Cs from distant sources. The GP’s research demonstrated that islanders who ate more “local” terrestrial produce had higher doses of Sellafield sea-discharged Caesium 137 than those who ate “non-local” produce. Some island residents received higher doses of Sellafield derived, *sea discharged* Cs, from their locally grown, terrestrial produce, than from sea foods. The same residents received higher doses from their terrestrial produce than sea food eaters living next to nuclear pipelines discharging liquid waste to sea. Given the available evidence of the West Wales study, it is logical to propose that the same might apply in that case. **(Ref 4)**

Since the UKAEA study has unequivocally proved that Cs transfers across the surf line of the Cumbrian coast in association with highly enriched concentrations of Pu and Am, it is legitimate to propose that similar outcomes will occur in West Wales and the Hebrides, where both sea areas are known to hold Sellafield derived Pu and Am. However, despite the worrying empirical data on the fate and behaviour of sea discharged radioactivity generated by independent studies at sites distant from marine discharge point sources, UK Governments, their regulating and environmental protection agencies and the nuclear industry have not only refused to undertake follow up research but have drastically reduced their radiological monitoring of marine and coastal sites distant from discharge points.

5. Failings of Official Research

Since the UKAEA studies of the late 1970’s and early 80’s, virtually nothing has been done by the nuclear industry or commissioned by governments to follow up the implications of those early observations of sea to land transfer of Pu, Am and Cs.

Although “official” research has demonstrated the significance of sea to land transfer, it was unable to provide any useful quantitative empirical data. The UKAEA authors admitted that their field work had used highly inefficient spray and aerosol “muslin screen” collectors in wind speeds up to only Beaufort Scale Force 5. The authors “estimated” that, under those conditions, the muslin screens were only 20% efficient in absolute terms and warned that their data should be used only for “qualitative” studies **and not for quantitative calculations**. Wind speeds greater than Force 5, would be expected to further reduce the efficiency as the porosity of the screens increased, while at the same time generating greater volumes of sea spray and aerosol as a result of a magnified wave climate.

6. “Mis-reporting” of the facts about Sea to Land transfer

The 1982 UKAEA study concluded that the inhalation (lung) dose to the public from the sea to land transfer of Pu 239 and Pu 240 (2 nuclides only) was about 1% of the ICRP 5mSv annual effective dose equivalent then in operation. It is important to note that the study had measured the presence of 5 sea to land transferring nuclides on the measuring devices (Cs 137, Pu 238, Pu 239, Pu 240 and Am 241). Thus the reported dose to the public was based on only a partial record (2 out of the 5 nuclides measured by the study)

It should also be noted that there has never been any evidence to suggest that only the 3 man-made Pu nuclides, Am 241 and Cs are actively transferring from the sea to the land via atmospheric pathways, because none of the other nuclides discharged to sea have been assessed for their sea to land transfer potential. There are, in fact, strong grounds for proposing that many of the 60 + nuclides discharged to sea in UK nuclear site liquid effluent streams are just as susceptible to sea to land transfer in onshore winds. Thus it is inevitable that marine aerosols and sea sprays are also delivering doses from many more radio nuclides than those 2 factored into the already flawed dose estimates.

In 1990, page 29 of the MAFF Aquatic Environment Monitoring Report (No 23) stated that “The levels of radio nuclides in marine sediments give rise to only very minor radiation exposures to the public following inhalation of re-suspended particulates, including those from the surf line”. In justification of this statement, the MAFF AEMR referenced a 1981 study in which the dose was reported to be 0.2% of the derived air concentration (DAC), modified for members of the public. (Ref 5)

It is relevant to note that both of the studies used to achieve dose assessments were carried out at an early stage in the investigations of sea to land transfer and made use of the data gathered by the inefficient and inaccurate tools which had been specifically described as not suitable for quantification work. Note also that one vector of sea to land transfer (breaking waves in the OFFSHORE zone) identified by the UKAEA study, is omitted by the MAFF report.

It is also of relevance to note that the dose calculations undertaken for the 1981 and 1982 studies were based on 1979 ICRP values at a time when the annual effective dose equivalent limit was 5mSv. In 1986 the ICRP limit was reduced to 1mSv and in 1987 the UK NRPB had given “interim guidance” that the limit should be reduced to 0.5 mSv per year.

It is evident that the 1990 MAFF AEMR No 23 uncritically and mistakenly carried forward these errors and lapses in information to the public, and that the calculated doses were based on information derived from the use of inefficient and inappropriate equipment specifically described as not suitable for quantification studies. That very basic error was exacerbated because the dose calculations themselves were based on historical dose rate limits which were both outdated and a factor of 10 times higher than the contemporary “guidance” dose rate limit (NRPB 1987) and 5 times higher than the eventual agreed level of 1mSv.

This catalogue of inaccuracies about dose rates by inhalation via the marine sea spray/aerosol pathway was repeated in subsequent MAFF AEMR reports through to 1993, and has subsequently been promulgated as fact, thus enabling industry and pro industry governments to jettison and disregard any further concern about that specific pathway.

7. “Changing the goalposts”

By 2000, the issue of re-suspended particulates in **sea spray from the surf zone** had also been dropped from official reports and replaced by a discussion of “re-suspended beach sediments” which are a radically different issue. From a marine science perspective, re-suspended particulates in sea spray and marine aerosols must, by definition, be relatively small and “fine” enough to be suspended in the water column for prolonged periods. “Beach sediments” are those found deposited out on beaches (sands/gravels/pebbles), generally of larger particle size range than those “suspended” in coastal water columns. Beach sediments are not involved in sea spray/marine aerosol transport from sea to air to land. By virtue of their generally larger grain size, beach sediments are also far less likely to be respirable and generate an inhalation dose.

The 2000 Radioactivity in Food and the Environment report (RIFE 5) page 40, under the heading “External exposure”, makes no mention of inhalation of sea spray and aerosol borne re-suspended particulates from either the surf line or the offshore zone, but does report that “inhalation of re-suspended beach sediments and inadvertent ingestion of the same material give rise to only minor radiation exposures to the public” and references an NRPB study published in 1994 as the source for the statement. (Ref 6)

Review of that 1994 NRPB study reveals that the research began in 1987 and consisted of a desk review of early field and later modelling work. No new field work was carried out and no new empirical data was gathered. The study did not investigate the impacts of marine aerosol/sea spray as this had already been concluded insignificant. All dose calculations were based on the dosimetry set out in the even earlier (1977) ICRP Publication 26. Clearly, the 1994 NRPB study was deeply flawed because it repeated and compounded the errors set out above with regard to investigating a very limited group of nuclides and making use of outmoded and redundant ICRP dosimetry.

It is evident that the “official” understanding of the mechanisms of sea to land transfer is largely based on theoretical modelling informed by a very small and inadequate data base, and that technologies suitable for the quantification of sea to land transfer of radio nuclides in marine aerosols and sea spray are either not available or have not been deployed.

It is also evident that attempts to calculate potential dose to the public via inhalation of marine aerosols and sea spray containing both suspended particles with their ad-sorbed Pu and Am, and dissolved soluble radio nuclides such as Cs and Tritium, remain incomplete, lacking in empirical data and cannot provide reliable useful data. This Briefing concludes that the data that has been promulgated is deeply flawed and generates a false and misleading representation of the doses to the public via these pathways.

8. Unavailable information on the issue of Sea to Land Transfer of radioactive wastes

In addition to the issues discussed above, a major problem has been the paucity of relevant work, coupled with the official single minded focus on researching sea to land transfer issues in the north eastern basin of the Irish Sea (i.e. that area to the east of the Isle of Man). Other than the work in that sea area, very little has been conducted elsewhere. Despite an intense data search I have only found reference to one other study in UK waters at Carlingford Lough (Ireland).

The fact that research is focused on the N.E. basin of the Irish Sea, presumably relates to the presence there of the Sellafield site, and that its sea discharges represent by far the largest volume of (single source) radioactive waste inputs to a UK sea area. However, it is the fact that the sea is not a single uniform entity and that even within one sea area there will be wide range of variations in the environmental parameters (sediment loading, current speeds, freshwater inputs, water temperatures, wind exposure and fetch etc). Across several discrete sea areas these variations are likely to be even greater. Thus Bristol Channel environmental parameters differ widely from those found in the North Sea and neither are similar to those found in the north east basin of the Irish Sea. In that context the Nuclear Industry/Government Agency focus on N.E Irish Sea research on sea to land transfer means that there are a range of unknown “data gaps”, about both the behaviour and fate of radioactive wastes discharged to sea, and sea to land transfer mechanisms and impacts in sea areas other than the N.E. basin of the Irish Sea.

In the case of the UK work, while some information is available from peer reviewed journals, some data produced by government agencies and nuclear industry bodies can rapidly disappear from public access. One example has been highlighted by attempts to access a copy of a 1999 UK Government/Regulating Agency review of Sea to Land Transfer issues entitled "Sea to land transfer of radio nuclides. How much do we know?" which had been referenced in contemporary annual RIFE reports and other documents, in support of the argument that sea to land transfer is of low radiological and public health significance. (Ref: 7)

Applications for a copy of this paper, made to the libraries of DETR, CEFAS, DEFRA, DECC and to the author himself were met with the reply that it was no longer available and that no copies remained in existence. Thus it is not possible to carry out an analytical review of this, or similar papers. Given the title of the Ould-Dada paper it is proposed that it would have some close relevance to issues under discussion here.

During the research work carried out for production of Consultation Responses (re Hinkley C & Wylfa B) none of the documents (originating from developers or regulatory agencies) studied by this author made any reference to the Ould-Dad paper and thus it is concluded that they too are either not aware of its contents or its implications or did not wish to discuss its conclusions. It is a matter of the greatest interest and relevance to campaigners concerned about nuclear developments that there has been a discussion of the issue of sea to land transfer among the UK Government's "official" monitoring and regulatory agencies, but public access to this material appears to have been suppressed.

The nuclear industry insists that doses to coastal populations from sea to land transfer are merely a small fraction of the official "permitted" dose endorsed by both the industry and government, and clearly have no interest in acquiring the necessary empirical data. However, from the available empirical evidence and in the absence of any empirical contra-indication, it can be proposed that repeated long term exposures of coastal zone populations to doses of sea to land transferred radioactivity, via multiple pathways, represent a significant potential public health impact risk.

9. Conclusions

Without the advantage of a set of detailed empirical research outcomes, based on a thorough understanding of the way radio activity behaves in coastal and coastal zone environments, successive UK government regulators and environmental protection agencies lack any relevant knowledge of the public health impacts of the radioactive wastes that have been discharged into UK territorial waters since the 1950s. As a result coastal zone populations are left both uninformed and unprotected in the face of chronic long term dietary and inhalation exposures.

The absence of that quantitative empirical evidence adds urgency to calls for further intensive and independent (not the nuclear industry or government/environmental agency) research into the pathways of exposure of coastal populations to doses of sea to land transferring radio activity, the chronic long and short term doses received by resident and visiting coastal zone populations, and much needed research into those 60+ radio nuclides, discharged to sea by UK nuclear sites, which have NOT yet been assessed for their sea to land transfer potential

Information on the report author:

Tim Deere-Jones was educated at Cardiff University's Department of Maritime Studies, where his research dissertation was on the Sea to Land Transfer of Marine Pollutants. He has been working as a "non-aligned" marine pollution researcher and consultant since 1983 and has worked with most of the major 'green' NGOs and campaign groups in the UK and Europe, and many from the US and Australasia. Tim has a particular field and research interest in the behaviour and fate of anthropogenic radioactivity released/spilled into marine environments.

10. References;

Ref 1: "**Magnitude & Mechanism of Enrichment of Sea Spray with Actinides in West Cumbria**". JD Eakins, UKAEA HARWELL March 1982

- Ref 2: https://www.meteoblue.com/en/weather/forecast/modelclimate/aberystwyth_united-kingdom_2657782
- Ref 3: **“Radiation Monitoring in Dyfed 1987-1988: First Report”** Dyfed County Council, Carmarthen. Wales
- Ref 4: **“Body concentration of Caesium 137 in patients from Western Isles of Scotland”** CG Isles et al’. BMJ: June 29th 1991
- Ref 5: **“Atmospheric measurements on radionuclides previously discharged to sea”** pps 201-221. in **“Proc’ Int. Symp. IAEA on the Impacts of Radionuclide releases into the Marine Environment”** Pattenden, N.J et al’: “IAEA. Vienna. IAEA-SM-248/138
- Ref 6: **“An Assessment of the Present and Future Implications of Radioactive Contamination of the Irish Sea Coastal Region of Cumbria”**. Wilkins BT et al’: National Radiological Protection Board. NRPB-R267.
- Ref 7: **“Sea to land transfer of radio nuclides. How much do we know?”** Z Ould-Dada, 2000. Proceedings 2nd Radrem-Tesc Workshop. London: January 21st 1999. DETR/RADREM/00.001 DETR London