Nuclear Free Local Authorities

RADIOACTIVE WASTE POLICY

Briefing No. 41 – Fukushima marine radioactivity issues

Prepared for NFLA member authorities, August 2013

FUKISHIMA: RADIOACTIVITY in SEAWATER

An OPEN NON-TECHNICAL BRIEFING for general readership

NFLA Secretariat introduction

This NFLA Radioactive Waste Briefing provides member authorities with an overview of some of the marine radioactivity issues arising from the Fukushima disaster. Recent reports suggest around 75,000 gallons of radioactively contaminated water is leaking from the Fukushima site into the Pacific Ocean on a daily basis (See for example this article in the New York Times: 'Japanese Government is stepping in to help clean up Fukushima atomic plant', August 7th 2013, http://www.nytimes.com/2013/08/08/world/asia/fukushima-nuclear-plant-radiation-leaks.html?pagewanted=all&_r=1&).

The leaking of radioactivity into the marine environment has been a matter of concern for the NFLA for many years. In recent years it has co-operated with KIMO International to lobby governments within the OSPAR Commission over discharges into the Irish Sea from UK nuclear sites.

NFLA is always keen to provide its members with original research on marine radioactivity and this briefing is a personal opinion non-technical overview by Tim Deere-Jones of the issues around radioactivity in seawater arising from the Fukushima incident.

Tim Deere-Jones is a UK-based marine radioactivity consultant, researcher and campaigner and has been researching this subject area since the 1980's. Tim has undertaken a number of reports for the NFLA in reference to marine radioactivity, including parts of its final submission to the Weightman Review of the Fukushima disaster and its implications for UK nuclear operations. Tim has kindly given permission for NFLA to reproduce this briefing for member authorities in order to contribute to a greater understanding of some of the marine issues arising from Fukushima.

(Tim's reports for the NFLA on the Weightman report can be accessed from the following weblinks: http://www.nuclearpolicy.info/docs/consultations/NFLA_Weightman_submission_annex.pdf and http://www.nucloearpolicy.info/docs/consultations/Weightman_final_response_TDJ_appendix.pdf)

1. Introduction

In the context of the ongoing contamination of the marine environment following the multiple meltdowns and loss of coolant from the Fukushima site, I note the ongoing near-site monitoring of the marine environment (sea water) and of some marine environmental media (principally fish, with some marine algae).

However, I am deeply concerned to note that a number of highly relevant issues and phenomena relating to the behaviour and fate of sea discharged radioactivity from the Fukushima facility, and its potential for delivering doses to human populations, remains unrecorded, under-researched and/or completely ignored.

Thus it is evident that the true impacts of the radioactive contamination of the Japanese east coast are not being documented or acted upon.

This short, informal non-technical briefing, set out in the following pages, identifies and comments on some of these issues and introduces the outcome of a number of UK observations and studies (principally carried out in one of the most radioactive sea areas: the Irish Sea and it's adjacent waters) in order to provide some supporting background information in support of my concerns relating to the Fukushima case.

2. Two key issues of concern

Issue 1: The number of radio-nuclides entering the marine environment of the east coast of Japan

The current operating marine environmental monitoring regimes in the relevant sea area are focussing on a very small number of radionuclides, principally caesium, iodine and strontium. These represent less than 10% of the total inventory of nuclides likely to be found in the reactor and cooling ponds of a BWR nuclear power station (there are between 40 and 50 other radio-nuclides).

In my view this is happening because of the relatively high financial costs of radiological analysis of samples. Having been involved in a number of field work campaigns which have involved raising funds in order to pay for radiological analysis, I can confirm that the cost of analysis for caesium (for instance) is much lower than those of analysis for plutonium or tritium.

In the case of independent and self-funding 'green' groups and NGOs with limited resources this is both an understandable and acceptable practice. However, in the case of national governments, government funded environmental protection agencies and the nuclear industry, under whose watch a disaster of this magnitude has occurred, I can see no justification for refusing to investigate the concentrations of approximately 90% of the radioactive material (all of which are capable of contaminating environmental media and delivering doses of radioactivity to wildlife and human populations) that may have entered the marine environment.

Issue 2: The nature of the radio-nuclides derived from reactor and cooling pond outputs

Iodine is formed in fuel elements and would only be present in (coolant) discharges as a result of fuel cladding defects and/or fuel pin failure. Caesium is a fission product and is also present in coolant as a result of fuel pin cladding defect or failure. The presence of both Iodine 131 and the two isotopes of caesium demonstrate that fuel pin cladding defect and/or fuel pin failure has occurred.

If this is the case then there can be little doubt that a range of other isotopes including actinides/ alpha emitters (probably 4 or 5 isotopes of plutonium, 3 of Uranium, and also Americium and Curium) will also have been released and entered into the marine environment.

3. Fate and behaviour of marine radioactivity

Some nuclides tend to dissolve relatively easily in seawater - caesium, tritium and iodine are an example.

Other nuclides have a low solubility and are preferentially adsorbed onto the surface of particulate matter suspended in the water column. These sediments will in time settle and accumulate in sedimentary deposits such as sub-tidal and inter-tidal and estuarine mud flats: (fine sediments, with their larger surface area, will accumulate more than coarse sediments: therefore this mud will have far higher concentrations than sand).

However, finer sediment particles are more susceptible to suspension in the water column than larger/coarser sediment particles and subsequent longer term transport before becoming deposited in estuarine and coastal environments.

4. Caesium, Iodine and Tritium

Highly soluble nuclides become well distributed through the water body and concentrations generally appear to dilute with distance from source. However, a number of mechanisms of re-concentration do exist in marine, coastal and estuarine environments.

UK studies in the Irish Sea have demonstrated that caesium (Cs) concentrations in marine sediments may be concentrated, relative to those in ambient seawater, and enriched by factors of two or three times in marine aerosols and sea sprays generated in both open water and at the surf line.

Caesium concentrations can be shown to be enhanced through marine food chains relative to sea water concentrations and indeed through coastal zone foodstuffs (impacted by sea spray and marine aerosols) relative to adjacent ambient sea water concentrations.

5. Caesium and mainland coastal environments

Irish Sea Caesium, derived from Sellafield liquid discharges to sea, has been found up to 10 kms inland (south west Wales) in pasture grass and hence available for dietary dose delivery to human consumers via the dairy and meat food chain pathways.

Further implications of this study are:

1. that the Caesium must be similarly contaminating any arable of horticultural produce grown in the relevant area;
2. that since the Caesium must be blown inland from the coast then it is available for inhalation doses to the populations living at least up to 10kms inland.

The south west Wales sample sites referred to above was not only 10 km inland but also over 100kms distant by sea from the source of the Caesium.

6. Caesium and island communities

Irish Sea Caesium from Sellafield liquid discharges has been found in the entirety of a Hebridean island local food production having transferred from the sea to the land in sea spray and marine aerosols generated in both the open sea and the coastal surf line by winds from many directions.

The highest individual, dietary dose was received by a terrestrial produce eater who did not eat fish, but did eat island grown vegetables, dairy and meat and only a small volume of “off island” (imported) produce. This was a most important observation because it demonstrated that it was possible to receive a greater dietary dose of marine radioactivity through terrestrial foods than through sea foods.

The average dietary dose of the sea borne caesium alone, received by the island population was higher than the average dietary dose of sea borne radioactivity from multiple nuclides/isotopes (up to 10) received by some populations living adjacent to UK nuclear waste sea discharge points. The island in question was over 200 kms (by sea) from the source of the discharged Caesium.

These two examples provide evidence of both sea to land transfer and dietary doses at distance from the discharge point. They also point to the strong likelihood that other water soluble radioactive materials will behave in a similar fashion.

I have found no evidence of any studies of this phenomenon for any soluble material other than caesium, but the available evidence strongly implies the potential for doses of iodine and tritium (and others), because they too are soluble.

In the context of these terrestrial doses it is evident that there is a potential for inhalation doses of caesium, tritium and iodine, both from sea spray, marine aerosols, evaporation from coastal mud flats etc.

Non soluble (adsorbing) nuclides on the other hand are strongly susceptible to re-concentration mechanisms:

- Irish Sea Plutonium (Pu) and Americium (Am) are shown to become enriched in marine micro-layers relative to bulk seawater by factors of about 4.

- Pu and Am have been shown to become enriched in marine aerosols (generated by bursting bubbles) by factors ranging up to 600 relative to bulk seawater. These aerosols are airborne and readily cross the surf zone and penetrate inland.

- Such enrichment mechanisms are found in the context of relatively high sedimentary (fine) particle loadings of the ambient water column.

- "Adsorbing" actinides such as Pu and Am are also highly susceptible to re-concentration in fine sediment deposits. Thus, even at a distance from input source, they may be found (in mud flats etc) at concentrations several hundred times higher than those observed in ambient sea water samples and less fine coastal sediments found much closer to the source of the discharge.

- Inter-tidal fine sediment deposits may provide a source of readily air mobile fine sediments (in drying conditions with effective winds) with adsorbed and elevated concentrations of actinides. Such conditions offer the potential for additional sea to land transfer of actinides.

- Strontium is similarly insoluble and thus there is a strong possibility that it has the same behaviour/fate characteristics as the alpha actinides referred to above.

7. Coastal geomorphology and coastal inter-tidal and sub-tidal sediment deposits:

I note that satellite imagery of the Pacific coast of Japan (Fukushima Prefecture) shows an area of relatively shallow and turbid (high suspended sediment load) water extending off shore for about 1 to 2 kms along the relevant stretch of coast.

I also note the presence of a number of rivers running down off the high ground inland, across the relatively narrow coastal plain and into the sea. I postulate that (in the wet season) these rivers will make a fairly high fine sediment (clay and organic mineral) contribution to the coastal water sediment budget. Such sediments are particularly prone to the adsorbtion of actinides.

I have not yet accessed data about the local inshore currents along that stretch of coast. However, I can confirm that the general offshore water body movement along the Pacific coast (Kuro Shio current) trends north during the northern hemisphere winter.

Satellite imagery of the relevant coast also shows the presence of some significant embayments 50 kms+ to the north of the Fukushima Daichii plant outfalls. Both Matsushima Bay and Ishinomaki Bay are extensive and characterised by high sediment loadings and sediment deposits.

Such environments have the potential to be long-term deposition sites for any actinide/alpha emitter present in "upstream" (i.e. northward moving) environments.

It is my conclusion that the official monitoring regime being carried out by TEPCO and other Japanese agencies is inadequate to the task of identifying the potential radiobiological threats to the public.

The Japanese authorities are under-measuring both in terms of nuclides and the number and type of samples they are investigating because they have failed to pursue the issue of iodine and caesium production to it's logical conclusion, which is that fuel failure also leads to the production of alpha-emitting actinides which must also be present in the environment (note the Pu found in "pools" adjacent to the NP station).

I would argue that official authorities in Japan have over-represented the issue of dilution and dispersion. They have also under-represented the issues of re-concentration, transport, transfer from one environmental media to another and pathways of delivery to human populations.

8. Further weaknesses in Japanese marine environmental monitoring

In the context of the existing plutonium (Pu) discoveries and the inevitability that Pu and other alpha emitters will now be entering the marine environment, I offer the following comments:

- Given the intense use of ad hoc, large volume inputs of cooling water from a variety of sources, coupled with the inability to control/contain ad hoc cooling waters as a result of the tsunami damage inflicted on the site infrastructure (drainage, bunding, pumps), it is inevitable that much of that ad hoc coolant will have entered unprotected soils and drainage channels and that there will be an extended time lag before all of it has drained into the sea.
- Any future rainfall will wash any surface contamination (e.g. undiscovered Pu puddles, deposits on buildings and other surfaces etc) into unprotected soils and drainage channels with similar extended time scales for marine contamination.
- The evidence to date suggests that the currently identified marine contamination is both at the early stage and that more extensive contamination is likely.
- It is likely that there will be transport (and subsequent deposition) of long lived insoluble nuclides into intermediate and far field fine sediment deposits along the east coast of Japan, where significant degrees of re-concentration may be expected and reservoirs or “sinks” of in-soluble radioactivity will be created.
- It is likely that there will be sea to land transfer of both soluble and insoluble forms of radioactivity, across Pacific coast surf lines and in to the Japanese terrestrial coastal zone, with subsequent potential for deliveries of dose via dietary and inhalation pathways. Such mechanisms may well deliver doses to areas and populations which have not been in receipt of (Fukushima accident) doses delivered by atmospheric routes.

9. Some recommendations for action

- It is important to establish a base line for Pu and other alpha/actinide data against which to measure future concentrations.
- Therefore, those marine fine sediment depositionary environments (inter-tidal and sub-tidal) where actinide/alpha depositions will re-concentrate isotopes **should be monitored and analysed now** (local and regional estuarine mudflats and salt marshes and “far field” Matushima Bay, Ishinomaki Bay). Otherwise at a later date it could be claimed that any contamination was from another source (e.g. weapons tests).
- Similarly, coastal zone terrestrial zones (outside the known aerial fallout zones) should also be examined in order to generate data which could be used to provide baseline information against which to measure sea to land transfer and related phenomena (terrestrial produce contamination, house dust contamination etc).
- The same could be said for caesium, tritium and iodine.
- A useful exercise in reference to Plutonium and other alpha/actinides and Strontium might be to filter seawater and analyse clear water and sedimentary material separately in order to assess:
  a: potential sea surface micro-layer and aerosol enrichment factors
  b: potential for future sedimentary deposit concentrations.

There is a stated assumption that marine environmental concentrations will soon decline, and that concentrations will “soon be of no concern due to the short half lives of nuclides mentioned”. This is not true of the Caesium isotopes measured (half life approx 30 years).

It is even less true of the alpha/actinides which will be present in the marine environment for very long time spans which must be measured in the hundreds of years (and in some cases the thousands of years).

It is imperative (for the slightly longer term) to initiate action to facilitate the identification of:

- all possible post accident marine radioactivity exposure/dose pathways

- all potential, post-accident, marine radioactivity, near field, intermediate field and distant field Critical Groups.

Critical Groups can be defined as those populations most likely to be exposed to the highest doses from these sources and pathways as a result of:

- their habitation of particular areas and zones,
- their consumption of sea foods,
- their consumption of terrestrial foods contaminated by sea borne radioactivity as a result of sea to land transfer,
- their inhalation of sea borne radioactivity suspended in and being transported through the coastal zone aerial environment as a result of sea to land transfer.

For a full set of references for this briefing contact Tim Deere-Jones at timdj@talktalk.net.

This briefing is the personal opinion of the author. The NFLA reproduces it to contribute to the debate on marine radioactivity and ongoing concerns with the Fukushima facility. NFLA will send this report on to groups in Japan that it is linked with and international NGOs.

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