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IMPLICATIONS
of
CLIMATE CHANGE
on the behaviour and fate of
SEA DISCHARGED
RADIOACTIVE WASTES
and the integrity of
UK NUCLEAR SITES

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Radioactive waste discharges

•ALL the UK nuclear power stations, reprocessors and fuel manufacturing sites operate a policy of pollution management by export (PME)

•PME makes use of chimneys for disposal of waste radioactive gases and airborne particulates to the atmosphere

•PME makes use of pipelines for disposal of liquid wastes and liquid borne particulate wastes to aquatic environments (rivers, lakes and sea)

Behaviour of sea discharged rad-wastes
ORIGINAL HYPOTHESIS

In the beginning (1950's) there was no empirical data

- **So UK Nuclear Industry, UK Government & IAEA colluded to generate false hypothesis which stated that:**

- **Soluble radioactivity (caesium, tritium etc) would dilute and disperse to "infinity" or "background levels which would not harm humans (*incomplete list of solubles!)***

- **In-soluble radioactivity (plutonium etc) would bond to seabed sediments and remain "locked" there, sequestered from humans (*Incomplete list of in-solubles!*)**

- **1958: head of UKAEA confirms that sea discharges to the Irish Sea had been an experiment intended to discover how the radioactivity would behave**

Behaviour and fate of sea discharged rad' wastes (post 1960s) **Empirical Evidence**

- **Soluble radioactivity does NOT dilute and disperse to "infinity"or "background"**
- **Soluble radioactivity is shown to travel extensively in marine water columns**
- **Soluble radioactivity is shown to re-concentrate in marine biota, marine and estuarine sediments, seaspray and marine aerosols**

- **In-soluble radioactivity does NOT remain bonded to seabed sediments near discharge point**
- **In-soluble radioactivity is shown to travel extensively in marine water columns**
- **In-soluble radioactivity is shown to re-concentrate in marine biota, marine and estuarine sediments, seaspray and marine aerosols**

Pathways of sea to land transfer

- **Inundation of low lying coastal land**

storm surge, unusually high tides, tsunami, estuarine flooding (made worse by terrestrial/fluvial effect)

Transport of radioactive water AND sediments into terrestrial coastal zone

* **Sea spray**

effect greater in more extreme conditions

Re-concentration with EFs of up to 100 over ambient

But Poorly studied, admitted inadequate technology, only four or five (of 78+) radio-nuclides studied

- **Aerosol**

Effect greater in more extreme conditions

Re-concentration with EFs of several hundred over ambient

But Poorly studied, admitted inadequate technology, only four or five (of 78+) radio-nuclides studied

Pathways of exposure

- Inhalation of airborne seaspray, aerosols, **particulates**
- Bodily contact with aerosol/seaspray droplets, contaminated materials (soil/plant matter/house dust etc)
- Consumption of contaminated terrestrial foodstuffs

Case studies: inundation

- **Ravenglass** (Cumbria): salt marshes

Intertidal pastures (soil and vegetation)

Sheep meat, house dust (Caesium & Plutonium)

- **Towyn:** Feb1990 Storm surge

*Extensive flooding of coastal strip (houses, caravans, business premises, public spaces)

*Estimated several hundred tons of marine sediment deposited on dry land

*Over 50% (8 of 14) of sediment samples tested positive for (Sellafield derived) alpha/actinide **Americium 241** ***10X Generalised Derived Limit for urban areas***

*Consultant stated that given the context of **Am 241** conc's, then **Plutonium** levels "**quite probably**" also exceeded

***Consultant stated that **"when sediments dry out, there is a possible risk of radiation hazard due to the inhalation of radioactive dust**"

***RHYL 2013/2014 (Dee estuary, Wirral peninsula)?**

Case Studies 1: Sea spray/aerosol

***Dyfed CC RADMID (1987/88):** radioactivity monitoring in west Wales coastal strip found

Sellafield derived (sea discharged) Cs 137 and Cs 134

10 miles inland on pasture grass (proposed carried inland in sea spray during heavy onshore winds/storms)……[*lichens]*

Inevitable contamination of meat stock and dairy food chain

Inevitable contamination of arable/horticultural crops/produce

Inevitable dietary dose to humans via ingestion

Some doses to humans via inhalation of airborne Cs

Given presence of Cs : presence of sea to land transferred Am and Pu likely

Case study 2: sea spray/aerosol

***Kingsbridge: 1987 MAFF dietary comparison study**

Found that residents of South Devon estuary (believed to be“remote” from nuclear sites) consumed higher levels of dietary radioactivity (7 nuclides discharged from nuclear sites) in their local terrestrial food produce than a similar group living **next** to the Hinkley Point NPS on the Somerset coast

My (unchallenged) review of this study found that the Kingsbridge dietary excess was due to radioactive Cobalt 60, transported (adsorbed to mobile sediments) from the Devonport nuclear submarine base 30 kms distant by sea and then transferred from the sea to the land where it contaminated the terrestrial foodstuffs.

Case study 3 : Seaspray/aerosol

- **Hebridean islands: pre Chernobyl study (BMJ 1991) found**:

- N. Uist terrestrial environment saturated with Sellafield sea discharged Cs 137 & 134 (*200+km distant*)
- contamination of almost every type of island produced food (dairy, meat, vegetables)
- islanders who ate the highest percentage of locally grown foodstuffs had the highest body burdens of Caesium
- average islander dietary dose of Caesium 137 alone exceeded the average dose (**from multiple nuclides**) to individuals living close to some nuclear sites (*KINGSBRIDGE and some NPS*)

- If Cs transferring to land in such quantities then other radionculides also likely to be present
- If Sellafield derived rads present on Uist, then rad's from other "upstream" discharges also present

Implications on behaviour of sea discharged rad-wastes: (physical)

ice melt/thermal expansion =rising sea levels

- increase of “extreme” weather conditions/events (storm surges, peak tides, prolonged severe storms)
- change in coastal geomorphology
- change in currents/ and winds (distribution of rad mats)
- More frequent and more intense sea to land transfer

(all mechanisms)

Implications, behaviour/fate of sea discharged wastes: marine/estuarine chemical

*more fluvial flooding/increased coastal erosion = increased sediment loading of coastal waters **= greater potential for Adsorbtion of insoluble rads (Plutonium, Americium etc)**

- greater estuarine, coastal **deposition** "effect"
- (flocs/aggregates, Adsorbtion, deposition) as a result of mixing and marine/estuarine electro chemical processes (freshwater/saline water mixing)
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- water column temperature, ocean acidity (poss' impacts on environmental/chemical behaviour of rad mats)

Implications of ongoing climate change

*Physical impact on nuclear sites:

sea level rise: site flooding (sea level rise, storm surge, rivers), coastal erosion:

- NPS and reprocessors: at least 10 existing/new build sites at risk of flooding or erosion (DEFRA): **Under "worse case scenario's analysed PRIOR to winter 2013/2014 and without benefit of very latest data e.g.**
- **(rapidly accelerating increase of north east Greenland ice melt only reported 2014: expected to generate greater sea level rise than previously calculated)**

- **Waste Dumps/nuclear fuel factories /naval bases fate unknown as not included in assessment**