IMPACT OF 20 YEARS LIQUID WASTE MANAGEMENT PRACTICES ON ENVIRONMENTAL SAFETY AT BRADWELL NUCLEAR POWER STATION

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Introduction

Bradwell Nuclear Power Station is one of the first of the UK commercial Gas Cooled Magnox Stations and began operation in 1962. Even then it was policy in the UK to control radioactive waste discharges so that not only were doses within a specified upper limit but also conformed to the principle of being as low as reasonably achievable. This has resulted in a very close liaison between the operator, the Central Electricity Generating Board (CEGB), and the authorising mininstries, particularly the Ministry of Agriculture Fisheries and Food (MAFF) in relation to discharges of liquid radioactive effluents into the marine environment, in the case of Bradwell the tidal Blackwater Estuary.

Exposure Pathways

Assessment of exposure pathways provides the basis for both discharge control and environmental monitoring. The composition of the critical group and the nature of the discharge may change with time and require a modification of the monitoring programme. This is illustrated by the following analysis of the changes which have occurred at Bradwell over 20 years. This paper updates an earlier paper covering the first 10 years. (Wasson & Mitchell, 1973).

Environmental Monitoring

Environmental monitoring is regularly carried out by both CEGB and MAFF working independently. The major locally caught foodstuffs are analysed for total beta radioactivity, and by gamma spectrometry. In addition seaweed and silt are also analysed as indicators, and gamma dose rate measurements are made on the foreshore to assess the external dose to members of the public. Habits surveys are conducted by MAFF at intervals to identify the critical group, which initially consisted of oyster consumers, to be replaced by fish eaters from 1975.

Fig.1 shows the concentrations of the relevant radionuclides measured by MAFF in oysters from 1964 and fish from 1975, all from within the Blackwater Estuary. Successive peak concentrations of ^{65}Zn, ^{134} + ^{137}Cs and ^{110m}Ag occurred in oyster flesh during 1967, 1968 and 1971 respectively and are attributed primarily to the Station discharges. By 1976 the concentration of ^{110m}Ag had fallen to zero and that of ^{65}Zn had also become low. These trends together with an increase in radioactive caesium in fish flesh after 1975 resulted in the fish eaters becoming the critical group from then onwards. This increase coincided not only with an increase in the amount of radiocaesium discharged from the station but came at a time when the concentrations in the southern North Sea were beginning to increase as a result of discharges from the fuel reprocessing plant at Sellafield being

carried round the north of Scotland by the prevailing current system. The picture is additionally complicated by the presence of ^{137}Cs from bomb testing fallout.

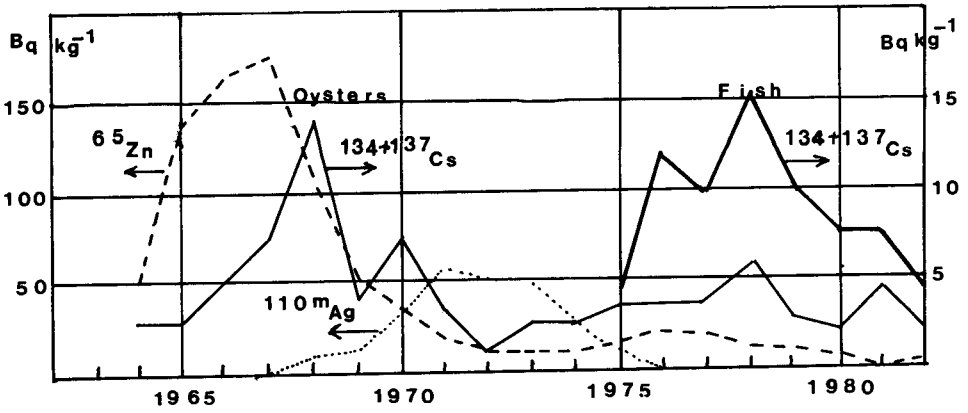

Fig.1:The concentration of ^{65}Zn, ^{110m}Ag and $^{137}+ ^{134}Cs$ in oyster flesh and $^{137} + ^{134}$ Cs in fish flesh from the Blackwater Estuary. Bq kg $^{-1}$.

Apportionment of the nuclides in oyster flesh is relatively easy since the species is non mobile. No Sellafield derived ^{65}Zn or ^{110m}Ag would be measurable in the Blackwater but a MAFF study of caesium in the estuary and the adjacent waters has indicated that during 1973-79 approximately 80%, 17% and 3% would have come from the Power Station, Sellafield and fallout respectively. In the case of fish, migration of individuals between the estuary and the southern North Sea makes apportionment almost impossible but a considerable fraction of the caesium measured has probably come from Sellafield.

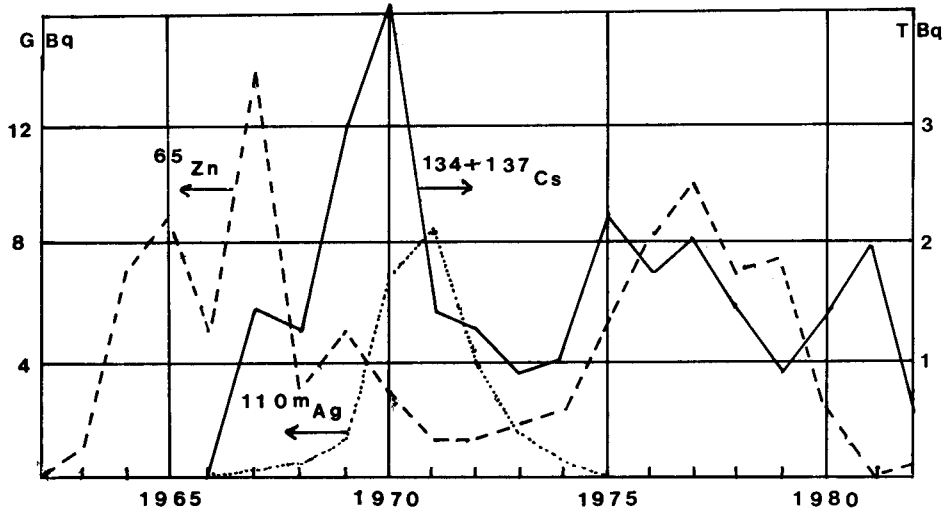

Fig.2:The annual discharges of ^{65}Zn, ^{110m}Ag and ^{137}Cs in liquid radioactive waste from Bradwell Power Station. G Bq/TBq.

Control of Discharges

There are three main sources of liquid effluent which are, in order of importance, the irradiated fuel storage pond, decontamination and reactor gas driers. Figure 2 shows the annual discharges for the radionuclides of radiological importance. Although the exposures involved are all significantly below the maximum permitted levels the operator has been able to respond in a way which has kept these as low as reasonably achievable.

The pre-operational assessment identified oyster consumers as the potential critical pathway and ^{65}Zn as the critical radionuclide. A special ion-exchange unit was included in the Pond Water Treatment Plant specifically to reduce the amounts of this nuclide before it reached the effluent system. In practice the levels of ^{65}Zn in the pond were substantially lower than predicted however the plant was operated in its design mode until 1967. In that year there was a significant increase in the levels of $^{134} + ^{137}Cs$ in the pond water and hence in the effluent. Although at that time these were not considered critical nuclides steps were taken to control their release by altering the operational regime for handling irradiated fuel to prevent mechanical damage which was allowing pond water access through the magnox cladding, at the same time replacing the original zinc removal resin in the pre-treatment unit with one which absorbs caesium. It is interesting to note that there was a simultaneous decrease in the amount of ^{65}Zn discharged. At the same time as the caesium was increasing another isotope, ^{110m}Ag, appeared and increased to such a degree that it surplanted ^{65}Zn as the critical nuclide in oysters. Investigations by CEGB identified the source of this nuclide, not as a fission product but as an activation product resulting from the presence of silver in a commercial chromating bath used to treat a batch of fuel element can components. As a result of this investigation the treatment was stopped. Although levels of ^{110m}Ag in the effluent continued to rise for a time they eventually declined as the affected batch of fuel passed through the system.

It should also be noted that while the discharges of ^{65}Zn from the station rose to a second maximum in 1977 this was barely reflected in the levels in oyster flesh. A knowledge of the concentration of stable zinc in the estuary over the whole period would be required before attempting to explain this apparent anomaly.

Public Radiation Exposure

The internal doses to the critical groups from the consumption of oysters and locally caught fish (figure 3) have been derived from ICRP 30 data. Note that Wasson and Mitchell (1973) employed an oyster consumption rate of $75gd^{-1}$ throughout, based on the highest individual consumer. The present critical group parameters have been derived using current MAFF techniques (Hunt et al 1982). The figure shows the decline in the dose to the oyster consumers after 1967 and the increase in the importance of the fish eating group after 1975. The largest dose to the critical group from the nuclides under consideration occurred in 1978, but this was still only 0.45% of the ICRP dose limit of 5 $mSv\ y^{-1}$ to members of the public. Other potential pathways such as external dose or consumption of other shellfish species are constantly reviewed but to date have been considered to be of negligible importance.

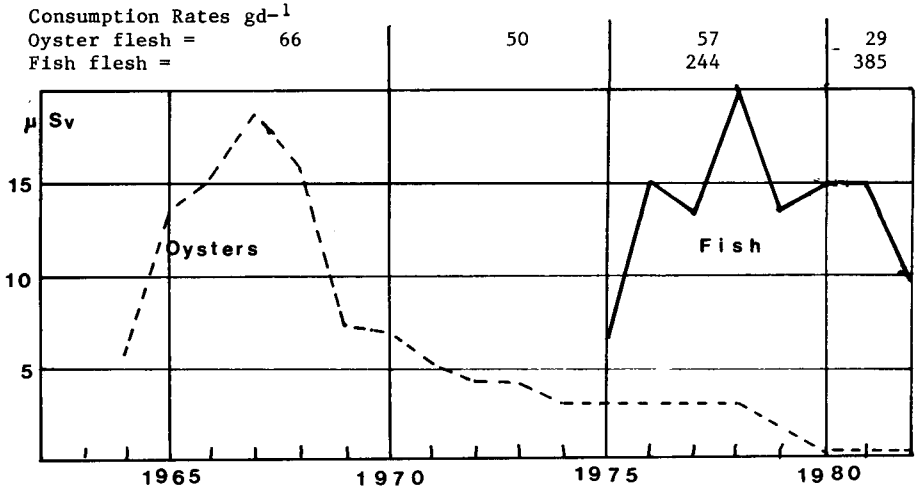

Fig.3 The internal dose to members of the critical group from the consumption of oyster and fish flesh. micro Sv.

Conclusion

The proper application of ALARA requires close liaison to be maintained between the operator and the authorising government departments so that site activities and the resulting waste discharges may be related to their impact on the environment. Inter alia this requires that the environmental monitoring programme and evaluation of pathways be kept under review, coupled with the ability to identify factors on site responsible for changes in dose and to take corrective action where necessary.

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