SIMULATION MODEL PREDICTING CONTAMINANT SPREAD DUE TO RADIONUCLIDES RELEASED FROM NUCLEAR POWER PLANTS

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INTRODUCTION

Presently there are 12 units of nuclear power plants in operation (1-BWR, 10-PWRs, 1-ATR), 3 units under construction (2-PWRs, 1-FBR) in Fukui Prefecture located near the center of the Japanese Archipelago. Environmental radioactivity and radiation surrounding these plants has been studied and it has been confirmed that the released radioactive waste is not detrimental to the environment.

However, we need to know the future contaminant spread in order to judge whether it is necessary to make any changes in regulations. While it is not possible to evaluate the future contaminant spread by means of environmental monitoring alone.

Therefore, a three-dimensional finite model (Fukui Prefectural Model) for evaluating the contaminant spread, has been developed.

PRINCIPLE OF MODEL

The purpose of this research is to investigate the behavior of radionuclides, especially CO-60, which has been mainly released from nuclear power plants and validate the applicability of numerical model.

This model includes:

(1) Transport mechanisms
- ◆ advection and dispersion of radionuclides due to water movement
- ◆ deposition of radionuclides accompaning with settlement of suspended matters
- ◆ vertical diffusion of radionuclides in the interstitial water in sediment

(2) Radionuclide decay term

(3) Adsorption/desorption with sediment

Contaminant movement in coastal area can be expressed by the diffusion equation derived from mass conservation equation.

Assuming the sorption phenomenon consists of the reversible adsorption on sediment grain and the irreversible adsorption sink to sediment, then the sorption model combined with a linear isotherm and a first order kinetics can be used:

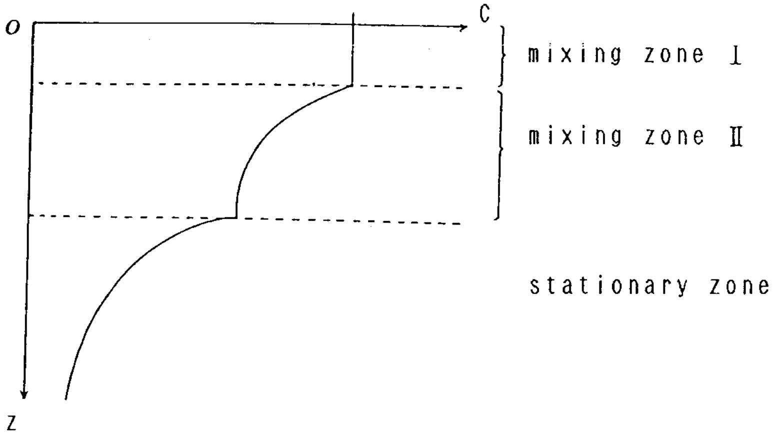
$$\frac{\partial Q}{\partial t} = K\frac{\partial C}{\partial t} + k \cdot C$$

where,
Q: the concentration of the radionuclide in the solid phase[Ci/g]
C: the concentration of the radionuclide in the liquid phase[Ci/g]
K: The distribution coefficent[cm^3/g]
k: The rate coefficent of the first order kinetiic [cm^3/g・s]

We measured the K value by the batch experiment, though it depends on many factors such as clay minerals in sediment and the temperature of sea water.

It is clear through environmental monitoring that coastal sediment and interstitial water in top layer are continuously stirred with wave movement or the activities of living things. So the sediment layer was divided into a mixing zone and a stationary zone. Moreover, the mixing zone was divided into zone I and II which has more moderate mixing effect. The concentration in the interstitial water in the mixing zone I is assumed to be equivalent to that in sea water.

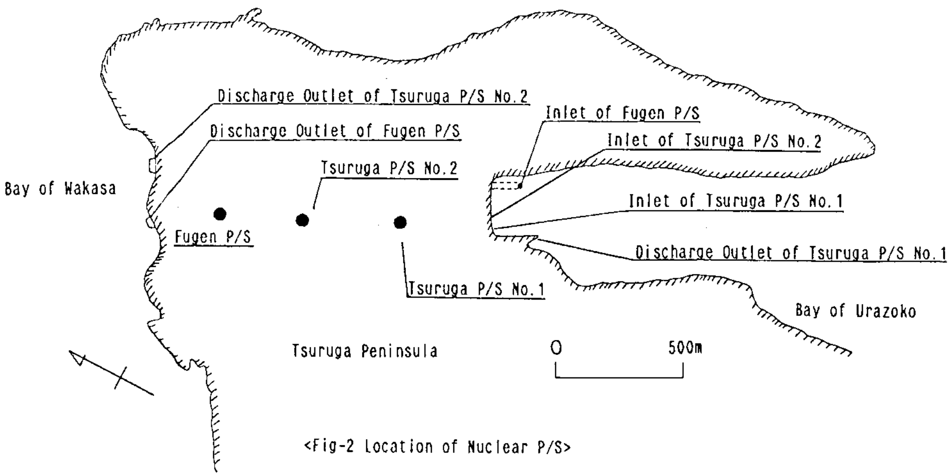
< Fig-1 concept of coastal sediment >



C: concentration in the interstitial water
Z: depth

VALIDITY AND APPLICATION

To evaluate the propriety of this model and predict the behavior of radionuclides till 2000, the contaminant spread of Co-60 resulting from the nucler power plant was calculated in the



<Fig-2 Location of Nuclear P/S>

area of the Bay of Urazoko(1.5km× 700m)in front of Tsuruga Power Station (BWR;357MW) . The Co-60 concentrations of about 0.02～ 1 pCi/g ・dry-sediment have been detected in the bay where the radioactivity was released so enormously at the beginning of the plant operation.

The model constitution and parameter used are as follows,

○ Sea water current

The water current is composed of a tidal current,an ocean current and a wind driven current,etc.These currnts are important for predicting the contaminant spread in sea water.

Material transport in sea water should be sorted out according to the duration considerd.

Fukui Prefectural Model treats long-term prediction of spread, so short-term phenomena such as a periodic current and a turbulent are neglected.Then the flow pattern in a steady state was simulated at first in this model as follows.

(1) The current directions are observed periodically in the surveying sea area and categorized into patterns with considering simultaneity.
(2) Then the frequency of the patterns is measured.
(3) For patterns occurring at a comparatively high frequency,the average flow vectors are calculated.
(4) The flow patterns achieved by the above are treated as the steady flow of the subject sea area and simulated by using a three-dimensional steady flow model.

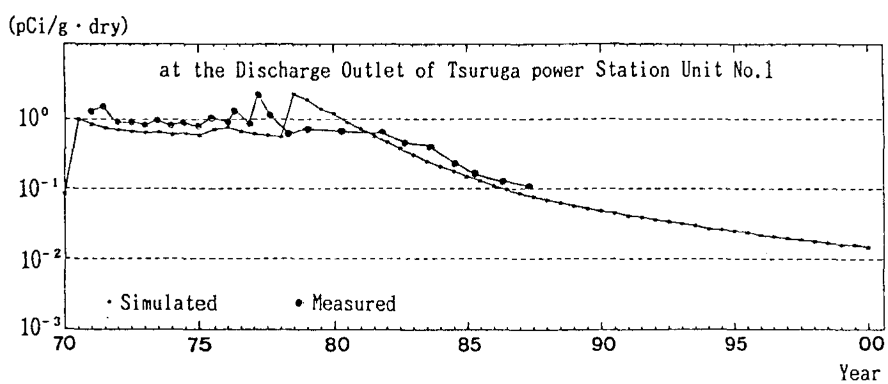
The grid interval is 50m × 50m or 200m× 200m and the differential time is 20 seconds for the finite difference method.

○ Distribution coefficent

The K is measured for several kinds of coastal sediments at 5 ℃, 15℃, 28℃.The degree of adsorption K is 120～ 19000 and desorption K of 2000 ～ 34000 (cm³/g).

The concentrations of Co-60 both in sea water and in sediment were calculated using the super computer CRAY 1.

<Fig-3 Concentration of Co-60 in the Sediment>



CONCLUSION

(1) The results estimated by the finite difference calculation well coincide those of sea bottom measured by a Ge(Li) semi-conductor.

So this model seems to be useful to evaluate and predict the behavior of released liquid radionuclides.

(2) The average concentration of Co-60 in mixing zone has decreased simply since 1979.The half decreasing rate is about five years that is almost the same as the half liffe of Co-60. So it shows apparently that the released Co-60 is not newly adsorbed to coastal sediment.The concentration will be reduced to one-tenth of the present concentration in 2000.

The reasons are mainly,

Ⅰ the released Co-60 from Tsuruga Power Station unit No.1 has decreased since 1978.

Ⅱ Tsuruga Power Station unit No.2 and Fugen Power Station have been intaking the circulating water of about 90m^3/s from the Bay of Urazoko and discharging it to the Bay of Wakasa. The former station has been doing so since 1986 and the latter since 1978.So the desorption from sediments has been promoted in the Bay of Urazoko by replacing sea water.

(3) The contaminated sediment near the discharge outlet of Tsuruga Power Station unit No.1 has been moving to the mouth of the Bay of Urazoko.But the migration of sediment itself is not considerd in this model,so the calculated concentrations are a little bit less than those measured near the discharged point.

(4) It became evident that about 25% of the total released Co-60 was accumulated in the Bay of Urazoko in 1978. But it will reduce to only 5% in 2000.

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