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Distribution of ^{90}Sr in the High Seas and Coastal Regions of Korea-Japan-Russia-China

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Abstrak

Distribusi ^{90}Sr di daerah laut lepas dan pantai Korea-Jepang-Rusia-China telah diteliti sejak 30 Juni sampai 2 Agustus 2000. Pengambilan sampel permukaan air laut dilakukan di Laut China Timur, Laut Jepang (Laut Timur), Laut Okhotsk dan Barat laut Samudera Pacific. Salinitas, temperatur dan konsentrasi ^{90}Sr bervariasi dan tidak menunjukkan saling berhubungan. Temperatur lebih didominasi oleh pengaruh posisi lintang. Konsentrasi ^{90}Sr banyak dipengaruhi oleh beberapa faktor seperti sumber limbah buangan radioaktif dan faktor fisika. Di laut Jepang distribusi konsentrasi ^{90}Sr lebih didominasi oleh pengaruh jarak dari tempat sumber pembuangan limbah radioaktif, tetapi di lokasi-lokasi lain dipengaruhi oleh faktor kondisi fisik.

Kata kunci : *^{90}Sr, laut lepas, daerah pantai, faktor fisika.*

Abstract

Distribution of ^{90}Sr in the high seas and coastal regions of Korea-Japan-Russia-China have been measured from 30 June 2000 to 2 August 2000. The surface seawaters were collected from East China Sea, Japan Sea (East Sea), Okhotsk Sea and Northwest Pacific Ocean. Salinity, temperature and ^{90}Sr concentration were variable, and did not show correlation each others. The temperature levels dominantly influenced by latitude effect position. The ^{90}Sr activities ranged from not detectable to 2.22 mBq/l (mean: 1.18, n:23). The distribution of ^{90}Sr concentrations were more uniform in the coastal regions than in the high seas regions. The concentration of ^{90}Sr in this study area were caused by some factors such as from source radioactive waste discharge and physical factors condition. The distribution ^{90}Sr in Japan Sea generally was influenced by distance factor from radioactive waste discharge, but the other locations were influenced by physical factors condition.

Key words: *^{90}Sr, high seas, coastal regions, physical factors.*

Introduction

Radioactive wastes have long recognized as a frightening environmental concern, especially for the population who live in a country that have no nuclear power plants yet. The health hazards are well known. There are evidences that marine life in the food chain already contains high levels of radioactive elements (eg. in Far Eastern region, Togawa *et al*, 1999). The isotope ^{90}Sr has been discharged by power plants in some countries, but their dispersion in the seawater is very fast, so high level concentrations are not long resident in dumping areas. Concentrations in surface and bottom waters at dumping areas do not significantly differ from the values observed in background areas and from historical value (Hong *et al*, 1999a, Ikeuchi *et al*, 1999). According to Arapis *et al* (1997) that migration rate of radionuclides are influenced by many factors such as the physicochemical forms, the type of soils, the hydrological regime and ecological conditions. In addition Kang *et al*, (1997) stated that the radioactive contents of the surface seawater can be controlled by the atmospheric input such as that occur in the East Sea (Japan Sea) as a part of the North Pacific Ocean.

Korea, Japan and Russia are the countries that produce radioactive wastes both in solid and liquid, and they also dumped in the sea. As a result the western North Pacific Ocean and its marginal seas have become increasingly radioactive (Togowa *et al*, 1999).

The purpose of this study is to identify the level of concentration in separate locations (East China Sea, Japan Sea, Okhotsk and NW Pacific ocean) with attention to the effects of physical and biogeochemical factors. This investigations should also contribute to the historical record of ^{90}Sr isotope in that location, because measurement of ^{90}Sr can be a powerful tool to evaluate the effects of radioactive waste.

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Materials and methods

Description of the site area

The Korean, Japan and Russia seas located along the North Pacific (Fig. 1), were chosen for this study because they present many potential sources of radioanuclides from dumping areas. East Sea (Sea of Japan) is one of the most highly radioactive waste dumping areas in the world (Hong *et al*, 1999a), although the total activity dumped in the NW Pacific Ocean is still lower by factor of about 6 in comparison to dumping sites in the Arctic Ocean. The high level of consumption of marine foods in the Pacific Ocean (Far Eastern) region has brought about interest in possible radiological consequences (Livingston and Povinec, 2000). There are a few nuclear plants along the eastern coast of the Korean Peninsula and the western coast of Japanese islands also at Great Bay (Russia).

Analytical method

Surface water samples were collected during the undergraduate training programme on the Marine Vessel Gaya, the training ship of Pukyong National University from June to August 2000 with 23 stations (Fig.1). To determine ^{90}Sr levels, the method involved deteching ^{90}Sr from ^{90}Y, radiochemically purifying ^{90}Sr and measuring activity of daughter nuclei ^{90}Y. Activity of ^{90}Y was measured using the radiometer BETA. The activity of ^{90}Y was used for calculating the activity of ^{90}Sr.

Result and Discussion

The data of salinity, temperature and ^{90}Sr content during the study in each station are compiled in Table 1. Salinity and temperature varied with range 29.44 - 34.01 psu and 13.0 - 28.8 °C respectively. Generally salinity and temperature did not show correlation with concentration of ^{90}Sr in surface seawater during the study.

The variation of temperature at study areas were generally influenced by latitude position of each station. Temperature of surface seawater at upper 38 °N were less than 20 °C. These are lower temperatures than at station below 38 °N.

The variation in ^{90}Sr in surface seawater at each stations (Table 1) were variable, however, every groups stations that place are not too far from other stations will relative uniform, ie. in station 1, 2, 23 with place at not far from Korean coastal region have relatively uniform concentration of ^{90}Sr, that were 1.18, 1.13, 0.91 mBq/l respectively; also at station 8, 9, 10 with not far from Japanes coastal have concentration 0.75, 0.66, 0.89 mBq/l respectively; station 6 and 7 with location at inter Japanes islands have concentration 1.76 and 1.56 mBq/l of ^{90}Sr respectively. Its probably that concentration in each stations were dominated came from surrounding stations, where factors of physical, chemical and biological processes are not too significant to distributed of ^{90}Sr in the long distance. This distribution likely occurs because ^{90}Sr in seawater is easy to dilute and disperses rapidly. It becomes relatively uniform in the relatively close location such as in the Japan sea. However in open ocean this characteristic does not occur even though such locations are relatively close at each station.

In Japan Sea (Table 1) the ^{90}Sr contents in surrounding Korean region (station 1, 2, 17 and 23) were lower than at surrounding Japan region (station 3 and 4) and Russian region (station 15 and 16). These results were similar with Livingston and Povinec, (2000), where they have made an inventory of wastes dumped in the Sea of Japan by the Republic of Korea was negligible in comparison to the total activity of wastes dumped in this sea. On the other hand that distribution concentration of ^{90}Sr in the Japan Sea significantly influenced by discharges from reprocessing plants. The high concentration in station 15 and 16 it may due to source radionuclide from Vladivostok or Peter the Great bay, the largest port and city in the Russian Far East. The main sources of radionuclides in Peter the Great bay are as follows: (1) global atmospheric fallout; (2) river input; (3) discharge from naval facilities situated around Peter the Great bay (Tkalin and Chaykovskaya, 2000). One of these facilities, the "Zvezda" shipyard, is located in Bolshoy Kamen as repair and decommissioning of nuclear submarines are carried out at this shipyard (Handler, 1995). However, average concentration of ^{90}Sr in the Japan Sea were still higher compared with concentration at station 8, 9 and 10 at the east of Japanes island, it may be due to ^{90}Sr at station 8, 9 and 10 precipitated because those stations located in the coastal zone that had shallow depth. These results agree with Hong *et al*, (1999a) that Japan Sea is one of the most highly radioactive waste dumping areas in the world,

The concentration of ^{90}Sr in the surface seawater of NW Pacific Ocean (station 11 and 19) were the highest compared with other stations, it may be correlation with condition of these station that more open than others also deeper, thus the ^{90}Sr was slow to precipitate to the bottom. Beside that the western North Pacific Ocean receives a large influx of mineral particles and pollutants from eastern Asia, especially

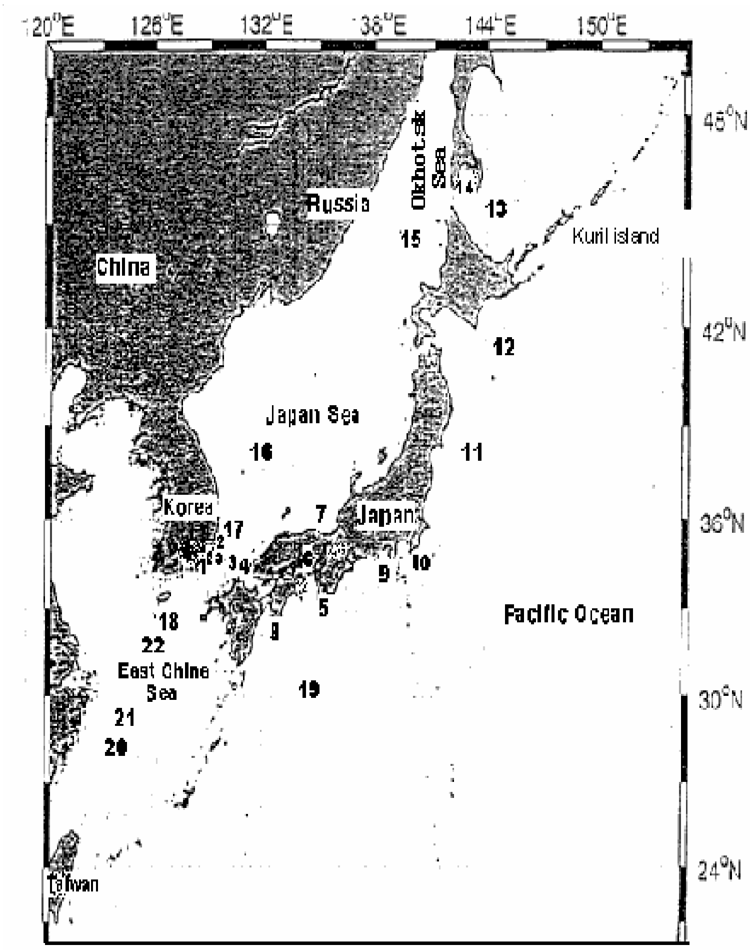

Fig. 1. Surface seawater sampling station.

Table 1. Salinity, Temperature and ^{90}Sr concentration in the surface seawater.

Station	Latitude.(°N)	Longitude(°E)	Samplingdate	Salinity(psu)	Temp(°C)	^{90}Sr(mBq/l)
1	34°45'036	129°08'258	200.6.30 (18.00)	32.54	22.6	1.18±0.20
2	34°50'94	129°36'49	2000.6.30 (22.00)	32.36	22.0	1.13±0.19
3	34°20'2	130°20'3	2000.7.1 (02.50)	33.81	22.7	1.32±0.23
4	34°03'475	130°45'488	2000.7.1 (05.10)	32.60	22.1	2.03±0.28
5	32°45'2	132°24'300	2000.7.1 (14.05)	32.89	20.7	2.22±0.23
6	34°25'21	134°02'27	2000.7.2 (10.15)	32.47	20.5	1.76±0.22
7	34°03'116	134°59'888	2000.7.2 (16.30)	32.41	23.8	1.56±0.52
8	33°23'98	135°46'19	2000.7.3 (10.25)	32.87	25.3	0.75±0.21
9	34°21'10	138°24'22	2000.7.3 (20.50)	32.62	24.3	0.66±0.19
10	34°57'00	140°07'00	2000.7.9 (15.40)	32.78	27.3	0.89±0.17
11	38°16'57	143°00'17	2000.7.10 (11.35)	33.65	19.1	2.01±0.34
12	41°24'5	144°58'3	2000.7.11 (03.45)	33.04	13.7	0.97±0.20
13	45°19'4	144°39'4	2000.7.12 (02.10)	32.43	13.0	0.71±0.15
14	46°17'29	142°55'04	2000.7.12 (09.25)	31.28	14.3	N D
15	44o23'7	140°21'7	2000.7.16 (00.25)	33.80	17.6	1.05±0.16
16	38°02'5	131°53'7	2000.7.16 (16.10)	34.01	24.4	1.93±0.22
17	35°58'	130°18'	2000.7.18 (04.00)	33.30	21.6	1.06±0.21
18	32°46'	126°45'	2000.7.21 (22.10)	31.62	-	1.32±0.19
19	30°01'0	134°50'5	2000.7.22 (10.00)	29.44	28.8	1.38±0.20
20	28°07'	123°39'	2000.7.23 (10.05)	33.19	-	1.20±0.17
21	29°06'97	124°15'76	2000.7.31 (04.30)	33.48	28.8	0.44±0.23
22	32°00'	126°17'	2000.7.31 (20.20)	29.96	28.0	0.58±0.15
23	34°42'107	128°53'719	2000.8.2 (05.00)	31.57	25.5	0.91±0.27

ND: not detected

from mainland China through long-range atmospheric transport (Duce *et al* 1983; Gao *et al*, 1992). According to Livingston and Povinec (2000) that anthropogenic radionuclides in the Japan Sea is stored in deep waters as the vertical mixing and it is much quicker than in the NW Pacific ocean.

The concentration ^{90}Sr in the station 14 and 13 located on the part of the sea of Okhotsk were not detected and 0.78 mBq/l respectively. At the Sea of Okhotsk no evidence was found of any contribution from radioactive wasted dumped and also in that place higher sediment inventories than in the sea of Japan or other location such as NW Pacific Ocean and East of China Sea (Livingstone and Povinec, 2000). Lee and Lee (2000) said that many radionuclides can be caught by clay mineral soil particles adsorption, ion exchange and precipitation as hydroxide or sulfide. The Sea of Okhotsk is a marginal basin located on the eastern side of Eurasian continent. It is connected to the Pacific Ocean via deep strait along the islands of the Kuril Archipelago and to the Japan Sea through much shallower straits (Fig.1). The sea of Okhotsk has many atypical characteristics such as severe winters with cold air and strong winds, mild but short summer (Ternois *et al*, 2001). Station 14 located at a part of Soya strait as much shallower strait, however station 13 located not too far from Kril archipelago that are connected through a deep strait.

The concentration of ^{90}Sr in the surface seawater of East China Sea (station 19, 20, 21 and 22) were variable with ranged 0.49-1.32 mBq/l were lower than concentration in surface seawater of Japan Sea (averaged 1.386 mBq/l), it may cause by the production of nuclear power plant in that surrounding areas. But, the differences between station 20 and 21, where at station 20 was higher than at station 21, it due to the station 20 located more southern and closer to mainland than station 21. The southern of East China Sea is a dynamic energy marginal sea based upon its geological, physical, chemical and biological features (Chen Lee, 1995; Hsueh *et al* 1992; Liu *et al*, 1992; Wong *et al*, 1991) and the Kuroshio current flows along the eastern coast of Taiwan and collides with the shoaling East China Sea Shelf when it approaches the northeastern tip of Taiwan. As result, it causes a variety of phenomena, one of which is development of a cyclonic eddy that exchanging seawater constituents between distinct water masses, particularly coastal water and offshore waters (Hyward and Mantyla, 1990) and it will effect on ^{90}Sr concentration in the seawater at that location.

In addition, the high concentration of ^{90}Sr at station 20, it may be that station much more support from Taiwan with through processes of the Taiwan-Tsushima Warm Current System (Isobe, 1999). He found that there are two different schools of thought with regard to the origin the Tsushima Warm Current. One school of thought believes that it comes from the Taiwan Strait, while the other believes that it enters the East China Sea from Sea from the Kuroshio region southwest of Kyushu Japan, crossing the steep shelf slope.

The fate of ^{90}Sr at station 18 and 22 were similar with ^{90}Sr at station 20 and 21, but the kind of physical processes at those places were different, where Taiwan-Tsushima Warm Current System strongly occur at station 20 and the Tsushima tide strongly occur at station 18. Teague *et al* (2001) has found that tide amplitudes range over 3 m along the southern line (include station 18), but only range about 0.7m along the northern line. Maximum total current velocities exceed 100 cm/s in the surface layers. Beside that (Kawatate *et al*, 1988) said that the fishing and trawling activities in the interior of the Korea-Tsushima strait is very intense. From these condition, the ^{90}Sr at station 18 will increase may be as result of chemical leached from soil and sediments throughed physical processes, because according to Oughton (1997) that radionuclides can be transported from the sediment to the water phase by physical, chemical and biological processes.

Conclusion

Temperature and salinity in the study area from East China Sea, Japan Sea, Sea of Okhotsk and NW Pacific Ocean were variable and no correlation with the distribution of ^{90}Sr in surface seawater. The level of temperatures depend on latitude position of station. The concentration level of ^{90}Sr in the surface seawater were dominantly influenced by distance from source of radionuclide waste discharge and also physical processes, where distribution of ^{90}Sr in semi-close location will relative uniform in the station were not too far distance each other, but in the open station such as in the NW Pacific ocean the distribution were variable even though each stations were not too far. The concentration of surface ^{90}Sr will decrease when the station was not depth and the current also tide was not high because they will precipitate together with particulate matter, however at the deep location and strong current and high tide the ^{90}Sr concentration at surface water will increase, because chemical leaching occur.

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