

## <sup>90</sup>Sr CONDITION IN THE EAST CHINA SEA AND NORTH PACIFIC

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Received : April, 24, 2006 ; Accepted : June, 15, 2006

### ABSTRACT

The condition of <sup>90</sup>Sr concentration in the East China Sea and North Pacific closed to the Japanese island has been measured from 3 – 31 July 2000. There were differences condition of <sup>90</sup>Sr concentration in the those locations. The concentration of <sup>90</sup>Sr detected in the surface East China Sea and North Pacific ranged 0.44–1.32 mBq/l and 0.66-1.38 mBq/l respectively. Generally, the condition <sup>90</sup>Sr concentration in the East China Sea was lower than in the North Pacific. The highest <sup>90</sup>Sr concentration occurred in the off shore of North Pacific, because the <sup>90</sup>Sr in the open sea is dominantly from nuclear weapon testing and nuclear power plant accident (Chernobyl) rather than other resources, and it take long time to precipitate into the bottom. Kuroshio and Taiwan-Tsushima warm current systems influenced importantly in distribution of <sup>90</sup>Sr concentration in the East China Sea beside other physical factors such as fishing activity. These currents were not strong enough to stimulate increasing <sup>90</sup>Sr concentration in the coastal region of North Pacific close to the Japanese islands.

**Key word** : <sup>90</sup>Sr, East China Sea, North Pacific, currents, nuclear weapon testing

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### INTRODUCTION

The long-life artificial strontium-90 (half life 28.8 years) has been known as the most biologically hazardous radionuclides produces in nuclear fission processes. When it is introduced to environment will incorporate with calcium and eventually that calcium is consumed by humans together with this radionuclide. Generally, antropogenic radionuclides are controlled by horizontal advection, bottom topography of the ocean instead of deposition due to global fallout because major deposition of antropogenic radionuclides originating from the atmospheric nuclear testing.

Biogeochemical processes also contribute in the distribution of radionuclides

in the sea (Ikeuchi *et al*, 1999). The East China sea as one of the largest marginal seas in the world is situated in a transit between mainland China and the western North Pacific. This sea location between 25<sup>0</sup>N and 32<sup>0</sup>N. It is bounded by the Kuroshio Current on the eastern slope side and the coast of China on the west (Fig. 1) Massive quantities of terrestrial materials are emitted to the atmosphere in mainland China and deposited on the East China Sea shelf (Gao *et al*, 1996, 1997). Mainland China has been suffering from serious air pollution and acid rain owing predominantly to coal combustion by nearly two thousand power plants especially in eastern China (Zhao and

Sun, 1986). In addition Chen *et al* (1999) found that there were two favorable areas for explosive deepening, one over the east Sea of Japan, and the other over the northwestern Pacific, east and southeast of Japan. The latter was located close to the warm Kuroshio Current. This current and Tsushima current as a branch of the Kuroshio current are the most important currents in the waters around East China Sea and North Pacific. These currents flowing from the western North Pacific to

Japan Sea via East China Sea transports surface waters with higher  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  (Kasamatsu and Inatomi, 1998). Corresponded with these conditions, it is not surprising that much of scientists interested to study radionuclides in this area especially  $^{90}\text{Sr}$  condition. The purpose of the present study is to know the condition of  $^{90}\text{Sr}$  in East China Sea and in the west of Japanese island as part of North Pacific associated with the condition of area.

## MATERIALS AND METHODS

Collecting surface seawater was carried out at East China Sea and North Pacific closed to Japanese region (Fig. 1) from 3 – 31 July 2000 during the undergraduate training programme on the Marine Vessel Gaya, the training ship of Pukyong National University. About 40 l of seawater was collected with a

submerged water pump. The samples were stored in two pre-cleaned 20 l polyethylene bottles after acidification.  $^{90}\text{Sr}$  analysis was done in the geochemistry oceanography laboratory of Pukyong National University, Busan, Korea. The flow chart of  $^{90}\text{Sr}$  analysis method is shown in the **figure 2**.

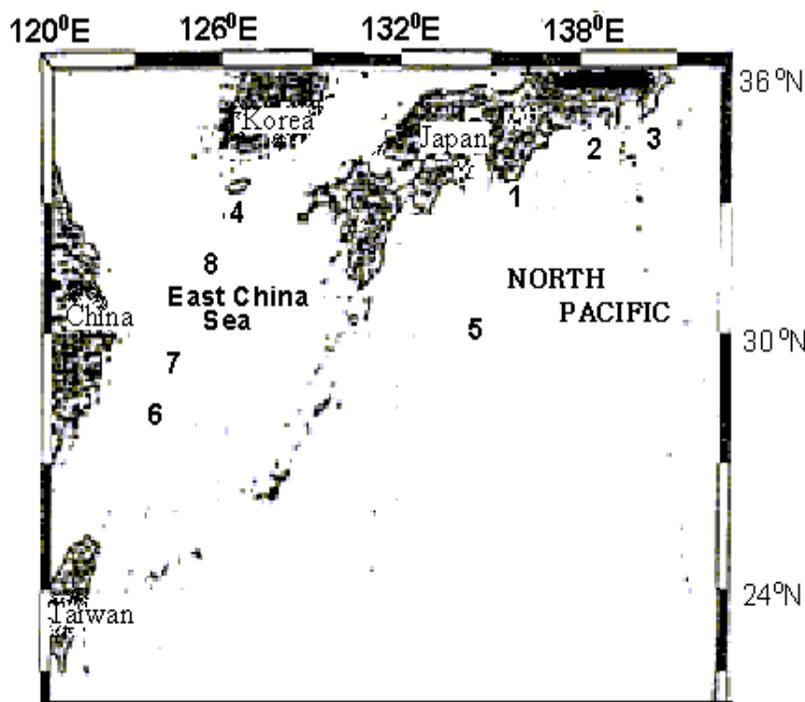


Fig. 1. Surface seawater sampling station.

## RESULTS AND DISCUSSION

The result of analysis of salinity, temperature and  $^{90}\text{Sr}$  concentration in the various latitude bands around East China Sea and North Pacific, is shown in the Table 1.

**Table 1.** Salinity, temperature and  $^{90}\text{Sr}$  concentration in the East China Sea and North Pacific

Station	Latitude. (°N)	Longitude (°E)	Sampling date	Salinity (psu)	Temp (°C)	$^{90}\text{Sr}$ (mBq/l)
1	33°23'98	135°46'19	2000.7.3 (10.25)	32.87	25.3	0.75±0.21
2	34°21'10	138°24'22	2000.7.3 (20.50)	32.62	24.3	0.66±0.19
3	34°57'00	140°07'00	2000.7.9 (15.40)	32.78	27.3	0.89±0.17
4	32°46'	126°45'	2000.7.21 (22.10)	31.62	-	1.32±0.19
5	30°01'0	134°50'5	2000.7.22 (10.00)	29.44	28.8	1.38±0.20
6	28°07'	123°39'	2000.7.23 (10.05)	33.19	-	1.20±0.17
7	29°06'97	124°15'76	2000.7.31 (04.30)	33.48	28.8	0.44±0.23
8	32°00'	126°17'	2000.7.31 (20.20)	29.96	28.0	0.58±0.15

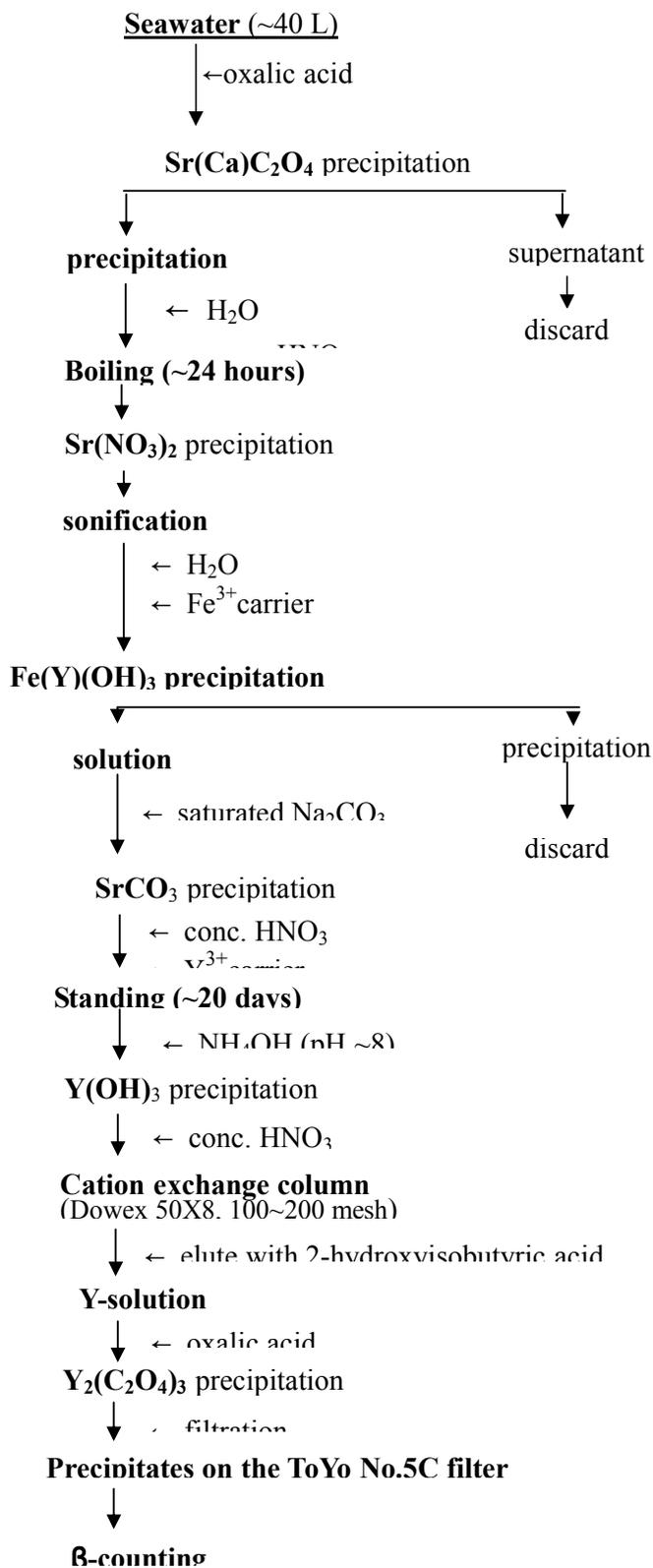


Fig. 2. Flow chart for seawater <sup>90</sup>Sr analysis

The concentration of  $^{90}\text{Sr}$  in the surface seawater of East China Sea (station 4, 6, 7 and 8) were variable with ranged 0.44 - 1.32 mBq/l. There were lower than concentration in surface seawater of Japan Sea (averaged 1.386mBq/l, Muslim in press). Concentration of  $^{90}\text{Sr}$  at station 6 was higher than at station 7, it due to that the station 6 located more southern and closer to mainland than station 7. 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 (Fig. 3 ). 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 (Hayward and Mantyla, 1990) and it will effect on  $^{90}\text{Sr}$  concentration in the seawater at that location.

In addition, the high concentration of  $^{90}\text{Sr}$  at station 6, it may be that station was much more supported from Taiwan with through processes of the Taiwan-Tsushima Warm Current System (Fig. 4, 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 the Kuroshio region southwest of Kyushu Japan, crossing the steep shelf slope.

The fate of  $^{90}\text{Sr}$  at station 4 and 8 were similar with  $^{90}\text{Sr}$  at station 6 and 7, but the kind of physical processes at those places were different, where Taiwan-Tsushima Warm Current System strongly occur at station 6 and the Tsushima tide strongly occur at station 4. Teague *et al* (2001) has found that tide amplitudes range over 3m along the southern line (include station 4), 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 conditions, the  $^{90}\text{Sr}$  at station 4 will increase may be as result of chemical leached from soil and sediments through physical processes.

According to Oughton (1997) that radionuclides can be transported from the sediment to the water phase by physical, chemical and biological processes. According to Chen *et al* (1999) that there were two favorable areas for explosive deepening, one over the east Sea of Japan, and the other over the northwestern Pacific, east and southeast of Japan. The latter was located close to the warm Kuroshio Current. The concentration of  $^{90}\text{Sr}$  in the surface seawater of NW Pacific Ocean (station 1, 2, 3 and 5) were in the range 0.66 - 1.38 mBq/l. The  $^{90}\text{Sr}$  concentration in the station 1, 2 and 3 which located at coastal region were quite homogeneous. Station 5, however, that located in the off shore significantly higher than station 1, 2 and 3. It may be caused the station 5 more open and deeper than others, thus the  $^{90}\text{Sr}$  was slow to precipitate to the bottom, because the vertical profile of  $^{90}\text{Sr}$  in the water columns decreased exponentially with depth (Nagaya and Nakamura ,1970, 1987 and Miyao *et al*, 1998). Thus, the source of  $^{90}\text{Sr}$  from mainland are distributed horizontally to the off shore. Beside that the western North Pacific Ocean receives a large influx of mineral particles and pollutants from eastern Asia, especially from mainland China through long-range atmospheric transport (Duce *et al* 1983; Gao *et al*, 1992). The atmospheric radionuclides in this area dominantly came from global fall out. After Japan was bombed, Russia, China and North Korea are the countries in surrounding Pacific Ocean that have ever tested nuclear weapons and contributed radionuclide into North Pacific Ocean very much. Chernobyl accident also had produced anthropogenic radionuclides are equal with nuclear weapon testing (Kanivets *et al*, 1999). Thus, the sources of  $^{90}\text{Sr}$  in the open sea are predominantly by nuclear weapon testing and nuclear power plant accident rather than other sources (Bowen and Roether, 1973)

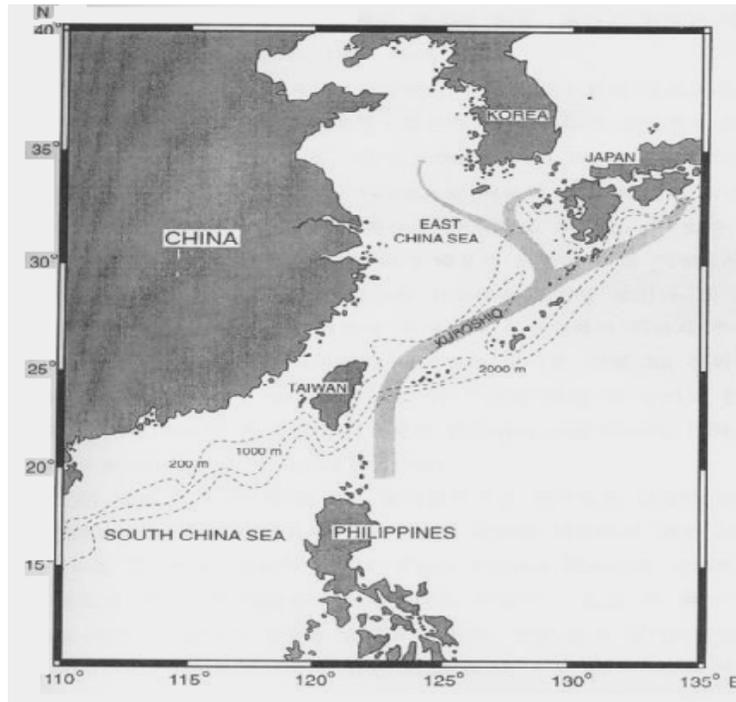


Fig. 3. Schematic diagram of the current system in the East China Sea (Nitani, 1972)

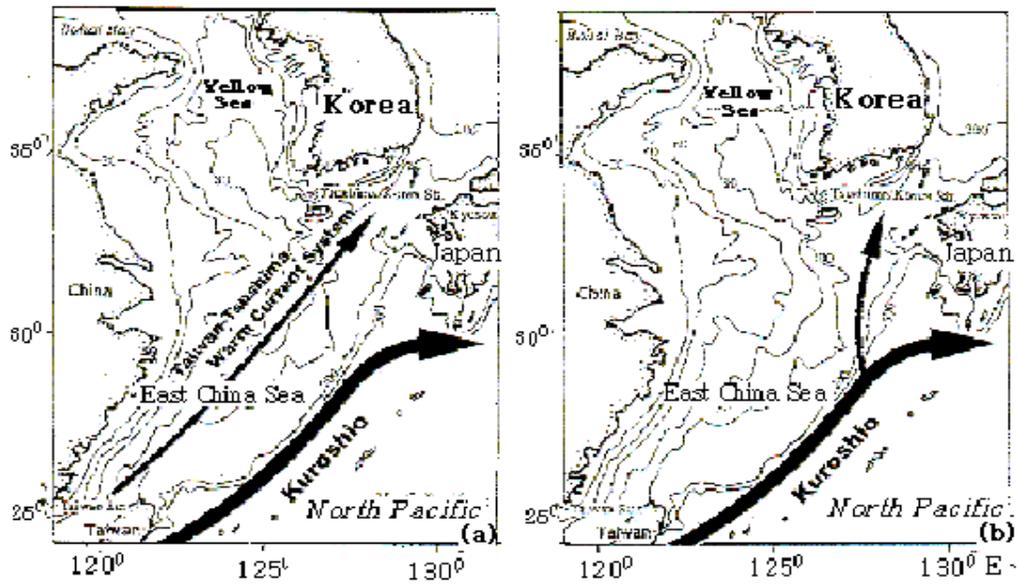


Fig 4. The Taiwan-Tsushima warm current system (Isobe, 1999).

## CONCLUSION

Condition of  $^{90}\text{Sr}$  concentration in the East China Sea is lower than Japan Sea and western Japanese island a part of North Pacific. The highest  $^{90}\text{Sr}$  concentration occurred in the open sea of North Pacific, it due to the source of  $^{90}\text{Sr}$  in the deep sea from global fallout of nuclear weapon testing and

nuclear power plant accident of Chernobyl rather than from other resources. Even though the Kuroshio and Taiwan Tsushima warm currents passing East China sea, but the  $^{90}\text{Sr}$  concentration in this area is still relative low, it may caused by the situation of the area which as a marginal sea.

## ACKNOWLEDGMENTS

I would like to specially thank to the captain and crew of Gaya training ship for their help in seawater collecting during undergraduate student training of Pukyong National

University (PKNU), Busan, Korea. I also wish to thank members of Geochemistry Oceanography laboratory of PKNU for facilitating the data analysis.

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