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Short Note

Nuclear Energy Production in the South China Sea basin as an International Issue

(Penghasilan Tenaga Nuklear di Laut China Selatan Sebagai Isu Antarabangsa)

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ABSTRACT

The South China Sea is divided into two parts; the northern South China Sea (nSCS) and the southern South China Sea (sSCS), where the nSCS includes Taiwan, Hong Kong and the Republic of China. The sSCS region consists of Malaysia, Thailand, Singapore, Brunei, Indonesia, Cambodia, Vietnam and the Philippines. The South China Sea is a semi-closed system and is largely influenced by the western Pacific region especially during monsoon seasons. By late 2020 countries such as Thailand, Malaysia and Indonesia intend to operate nuclear reactors as an alternative energy source. Some radionuclide produced during their operation will enter the marine ecosystem through the water cooling process. This will affect most neighboring coastal waters as trans-boundary pollution. A recent investigation on seafood conducted before the Fukushima, Japan tsunami event by The Hong Kong Observatory clearly shows that artificial radionuclides such as plutonium-239, tritium, strontium-90, carbon-14, iodine-131, cesium-137 and potassium-40 were found at positive concentration levels. There were no significant differences in Cs-137 activities both in surface and bottom water samples at the 95% confidence level. The activity of Cs-137 was found to be in the range of 1.47 to 3.36 Bq/m^3 and 1.69 to 3.32 Bq/m^3 for both Sabah and Sarawak, respectively.

Keywords: northern South China Sea, southern South China Sea, trans-boundary, artificial radionuclides

ABSTRAK

Laut China Selatan telah dibahagikan kepada dua bahagian seperti utara Laut China Selatan (nSCS) dan selatan Laut China Selatan (sSCS), di mana dalam nSCS mengandungi Taiwan, Hong Kong dan Republik China. Tetapi di rantau sSCS terdiri Malaysia, Thailand, Singapura, Brunei, Indonesia, Kemboja, Vietnam dan Filipina. Laut China Selatan merupakan sistem semi-tertutup dan menerima pengaruh yang besar dari rantau Pasifik Barat terutamanya semasa musim tengkujuh. Menjelang tahun 2020 kebanyakan negara-negara seperti Thailand, Malaysia dan Indonesia akan mengendalikan reaktor nuklear sebagai alternatif untuk menghasilkan tenaga untuk bekalan negara. Beberapa radionuklid akan dihasilkan dan memasuki ekosistem marin melalui proses penyejukan air. Masalah ini menjejaskan perairan kebanyakan negara jiran melalui pencemaran trans-sempadan. Baru-baru ini siasatan telah dijalankan sebelum peristiwa Fukushima, Jepun pada makanan laut oleh Hong Kong Observatory dengan jelas menunjukkan radionuklid buatan seperti plutonium-239 Tritium, strontium-90, karbon-14, iodin-131, sesium-137 dan kalium 40 ditemui pada tahap kepekatan yang positif. Tidak ada perbezaan signifikan Cs-137 aktiviti di kedua-dua sampel permukaan dan air bawah pada tahap keyakinan 95%. Aktiviti C-137 didapati berada dalam julat 1.47-3,36 Bq/m3 dan 1.69-3,32 Bq/m3 untuk Sabah dan Sarawak.

Keywords: utara Laut China Selatan, selatan Laut China Selatan (sSCS), trans-sempadan, radionuklid buatan

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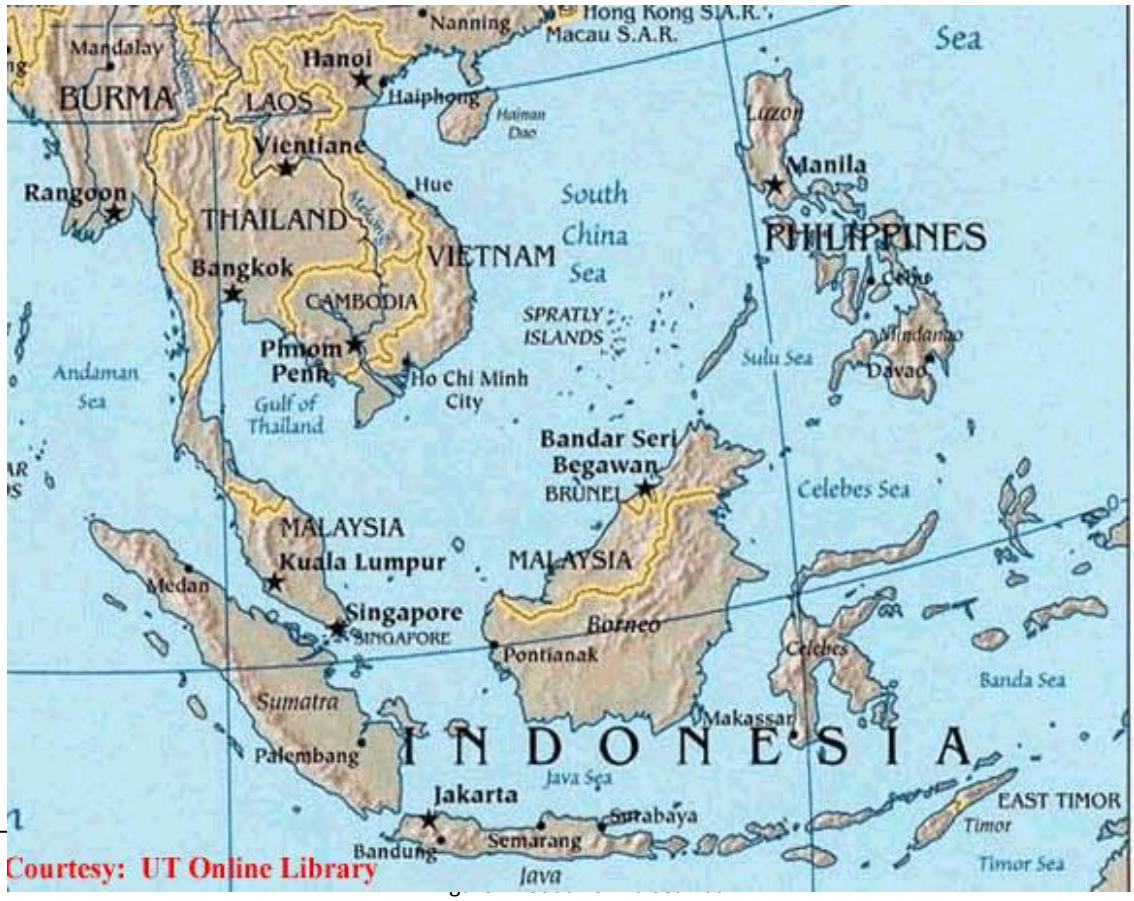
INTRODUCTION

The level of contamination of anthropogenic radionuclides in the world's seas and oceans is the result of human activities. More than 520 atmospheric nuclear weapon tests were conducted globally between 1945 and 1980 by the United States and the former USSR; while the United Kingdom, France and the People's Republic of China are the primary contamination source of anthropogenic radionuclide. Additional radionuclide is a further burden on the marine ecosystem after this existing nuclear waste has already been buried into ocean systems.

Contamination of the marine ecosystem from numerous underground nuclear testing especially in the Pacific islands has not been well documented. The French government supported research by the International Atomic Energy Agency (IAEA) in the South Pacific to assess the potential impact of 147 underground nuclear tests undertaken by France in the Mururoa and Fangataufa Atolls of French Polynesia. Few studies have been undertaken in the North Pacific, although that void may be addressed by current investigations of radionuclides in marine biota near three Amchitka, Alaska and United States test sites, where underground detonations were performed in the late 1960s and early 1970s.

Countries in the South China Sea basin (SCS) consisting of Malaysia, Singapore, Thailand, Indonesia, Brunei, Vietnam, Cambodia and Philippine have recently discussed intentions to develop the use nuclear power to supplement national electricity supplies (Figure 1). During a nuclear reactor's operation, most effluents containing artificial and natural radioisotopes are discharged into marine environments, and the monsoon will distribute this effluent to other countries in the South China Sea Basin. In this mini review national and international marine radionuclide databases have been used to gather baseline levels of radionuclides in current marine biota, water and sediment.



SAMPLING & DATA

Data published by national and international scientists has been collected to analyse the current status of radionuclides in the SCS basin, including work by Yamada et al., 2006, Mohamed et al., 2006; Mohamed 2008; ZalUyun et al., 2008; Povinec et al., 2005 and Yii & Zaharuddin 2007.

RESULTS & DISCUSSION

Natural radionuclides in the southern South China Sea

Actual concentration activities of radionuclides in the southern SCS vary slightly between each sampling station. The activities of ^{210}Pb in the surface sediment were relatively less than 60 Bqkg^{-1} (Zal Uyun et al., 2008) with a positive correlation between ^{210}Pb and ^{226}Ra (r^2 = 0.95) suggesting that ^{210}Pb was clearly produced by its parent, ^{226}Ra.

Concentration activity of ^{228}Ra and ^{226}Ra (Bqkg^{-1} dry) in the surface sediment of the southern South China Sea (SCS) ranged from 35 to 145 Bqkg^{-1} dry (ZalUyun et al., 2008). It was found that activity concentrations of those radionuclides in the surface sediment vary depending on sampling location and it was proven by an ANOVA analysis that showed a significant difference at the 95% confidence level for activities of ^{228}Po and ^{226}Pb in the southern SCS. Some areas containing high activity concentrations of radium could be to the result of the natural enrichment of radium especially areas rich in petroleum sources.

The activities of dissolved ^{226}Ra and ^{228}Ra obtained in Pulau Redang varied between stations ranging from 2.08 mBq L^{-1} to 12.44 mBq L^{-1} for ^{226}Ra. But the concentration activity of ^{226}Ra was about 2.52 mBq L^{-1} and 1.30 mBq L^{-1} in the Straits of Malacca and the South China Sea respectively as published by Nozaki et al (2001). Meanwhile, ^{226}Ra activities in the Bay of Bengal varied from 2.0 – 193.0 mBq L^{-1} (Moore 1997), while that in the Chao Phraya ranged between 2.1 – 4.3 mBq L^{-1} (Nozaki et al., 2001). Dissolved ^{228}Ra obtained in this study fluctuated within a range of 6.95 – 33.53 mBq L^{-1} and were slightly higher than other studies because most ^{226}Ra were derived from the continental shelves. On the other hand ^{228}Ra activities in the Bay of Bengal, the Chao Phraya, the Straits of Malacca and the South China Sea are 3.0 – 7.6 mBq L^{-1}, 2.4 – 18.4 mBq L^{-1}, 8.97 mBq L^{-1} and 2.98 mBq L^{-1}, respectively.

Distribution of uranium-thorium decay series in surface sediments, organisms and seafood

The concentration level of radionuclide in benthic organisms was not documented as well as in seawater and sediment. Compared to seawater or sediment, characterizing radionuclide concentrations in benthic organisms is more difficult as distributions can vary from one species to another and within different tissues in the same species. Organisms can concentrate different radionuclides to varying degrees. The concentration factor, which was obtained by comparing the concentration of a specific radionuclide in the organism to that in the medium (water), gives a measure of how well organisms can concentrate a given radionuclide.

Mean activity concentration of ^{210}Po measured at eight stations around Pulau Redang, Malaysia was 364.67 $\pm$ 21.00 Bq/kg and ranged from 62.33 ± 3.17 Bq/kg to 560.33 ± 30.83 Bq/kg. Nevertheless, the mean concentration of ^{210}Pb was 93.67 ± 6.83 Bq/kg and fell within the ranges of 13.33 ± 0.83 Bq/kg to 162.17 ± 11.67 Bq/kg.

The concentration activities of ^{210}Po were slightly more than 100 Bq/kg at all the stations and contradicted that of cockles (less than 100 Bg/kg) as reported by Tee et al (2004). This was due to the feeding habits of zooplankton, where grazing zooplanktons have the ability to concentrate ^{210}Po than ^{210}Pb from the particulate during ingestion and absorb it into digestive organs. Furthermore, zooplanktons are able to repackage nuclides into feacal pellets. Concentrations of

both nuclides found in zooplanktons were slightly higher compared to those in cockles, and this suggests that most nuclides especially ^{210}Po and ^{210}Pb deposited into the sea as rain or aerosol was used by a first producer such as zooplankton then deposited onto the seabed as settling particles and used by a second producer such as benthos (i.e., cockles).

Concentrations of ^{210}Pb were three to four times lower than concentrations of ^{210}Po. This is due to the fact that ^{210}Pb reveals a stronger tendency to be sorbed on mineral suspended matter but during this study a slight statistical correlation between ^{210}Po and ^{210}Pb was plotted (r^2 = 0.9347) in zooplankton tissues but did not appear for cockles. This occured for coastal zooplankton in particular because coastal water has direct or indirect input from land and accumulates in the zooplankton's body during daily biological processes. Previous measurements of ^{210}Po and ^{210}Pb in pelagic seawater showed that biological uptake maybe also be more important than inorganic absorption for ^{210}Po scavenging, while the opposite appears to be the case for ^{210}Pb.

^{210}Po and ^{210}Pb activities in 16 samples were detected from sampling conducted on 25th April and 7th September 2002 in the west coast Peninsular Malaysia. The analysis clearly shows that ^{210}Po and ^{210}Pb activities vary from 0.47 Bq kg^{-1} to 68.10 Bq kg^{-1} with an average value of 18.00 Bq kg^{-1} and from 0.65 Bq kg^{-1} to 23.10 Bq kg^{-1} with an average value of 6.12 Bq kg^{-1}, respectively. The highest value of ^{210}Po was about 68.10 Bq kg^{-1} observed in *Cynoglossus marcolepidotus* collected on 7th September 2002; a small fish with a total length of less than 29.0 cm. This could also be seen from the species of *Pampus argenteus*, where smaller fish had higher concentrations of ^{210}Po. Such differences in the levels of radioactivity in different species of fish might be explained by differences in metabolism rates and feeding patterns (Bustamante et al., 2002). Fish with high ^{210}Po activity are those that feed on fecal pellets or organic particulates that are rich in ^{210}Po, and/or predators feeding on ^{210}Po-rich prey, for example C*ynoglossus marcolepidotus*. But varied concentrations of ^{210}Po were observed for pelagic fishes such as *Alute mate*, *Pampus argenteus* and *Sillago sihama*. This could be due to their habit of obtaining food from the water column which contained relatively less ^{210}Po activity.

Data on biota in the Asia-Pacific Marine Radioactivity Database (ASPAMARD) indicates that the concentration of 137Cs in fish muscle and whole fish were observed to range from 0.02 to 2 Bq/kg wet weight with a median of 0.2 Bq/kg wet weight. Nagaya and Nakamura (1987b) observed that 137Cs concentration was recorded at the highest concentration in muscle, followed in decreasing order by viscera, gills, digestive tract and the skin of fish. According to Yamada and Nagaya (1998), 137Cs levels in marine biota have decreased almost exponentially with time. Again, this may be a result, at least in part, of decreasing concentrations of 137Cs in regional seas due to radioactive decay. Changes in 137Cs activity concentration in marine biota were also monitored over a 10-year period in the Yellow Sea and the Bohai Sea of China and a decreasing trend with time was also observed (Cai et al., 1992). Nagaya and Nakamura (1987b) further observed that 137Cs concentration in fish did not differ significantly if the fish were from shallow waters or deep bottom waters. The average values obtained suggest a concentration factor of 100 for 137Cs in fish. However, since 137Cs activity concentrations are lower in deep bottom waters, it is conceivable that the concentration factor for bottom-water fish may be higher than for shallow-water fish.

How is the transboundary of radioisotopes an international issue?

Nuclear industries are vigorous, comprehensive and modern. However, potential problems with safety, environment, or proliferation have raised a number of concerns. These may be related to the nuclear facilities, material control and regional environmental protection.

This means that the concept of regional collaboration to monitor airborne radiation levels is important. This concept should include the development of regional capabilities to monitor environmental safety and to support regional emergency preparedness. This approach to building nuclear cooperation may be feasible because the countries of ASEAN have the necessary technologies in place for their own internal environmental monitoring programs.

Airborne radiation is another hot topic for environmental cooperation because of the obvious transboundary impact of a nuclear accident anywhere in densely populated Asia. Data obtained would be useful to ensure the safety of the public, countering unfounded rumors about nuclear accidents, and increasing the modest level of nuclear cooperation already present in the region. Moreover, airborne data can be acquired over regional distances, which allows measurements that are useful, but not intrusive and not specific to a particular facility. Technology to measure radionuclides in the air is available worldwide at varying levels of sophistication to support a wide range of potential regional goals. If the immediate goal is emergency warning and monitoring of routine emissions, then a simple measurement of the total number of gamma rays might be appropriate. These systems are inexpensive; solar power can be used for remote areas, and the systems can be equipped with basic meteorological observation instruments because total gamma rate is adequate for public safety and will not reveal any chemical process in detail.

REMARKS

There are limited publications on natural and anthropogenic radionuclides in the South China Sea Basin especially in marine organisms. Intensive studies need to be conducted before the a nuclear reactor begins operation in the ASEAN region.

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