HORIZONTAL TRANSPORT OF ^{228}RA/^{226}RA IN THE SURFACE WATER OF SOUTHERN SOUTH CHINA SEA AND MALACCA STRAITS

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Abstract

Activity concentrations of ^{228}Ra and ^{226}Ra in the suspended particles from year 2002 to 2003 at the east coast and west coast Peninsular of Malaysia were determined using the Alpha and Beta Spectrometry, for estimating the horizontal transport of radium during the southwest and northeast monsoons. The suspended particles were acting as a vector for transport radium nuclides from the mainland to the ocean during monsoon seasons. At the same time, the radium nuclides in dissolved form were desorbed from the suspended particles. High distribution coefficient value (K_d) of radium isotopes were found in the southern South China Sea, indicate that radium nuclides were strongly absorbed onto the particulate phase. The K_d values of ^{226}Ra and ^{228}Ra were ranged from 0.78 × 10^5 L g^1 to 5.56 x 10^5 L g^1 and from 0.21 x 10^5 L g^1 to 1.86 x 10^5 L g^1, respectively.

Abstrak

Kepekatan aktiviti ^{228}Ra dan ^{226}Ra dalam bahan terampai dari tahun 2002 hingga 2003 di pantai timur dan pantai barat Semenanjung Malaysia telah diukur dengan menggunakan Spektrometri Alfa dan Beta. Ini adalah untuk menganggarkan pengangkutan mendatar radium yang ujud semasa monson barat daya dan timur laut. Pada masa yang sama didapati nuklid radium yang berada dalam fasa terlarut adalah terhasil dari rembesan bahan terampai. Nilai pekali taburan (K_d) bagi isotop radium adalah tinggi diperolehi di selatan Laut China Selatan mengambarkan nuklid radium kuat menyerap ke dalam fasa particulate. Nilai K_d bagi ^{226}Ra dan ^{228}Ra adalah berjulat dari 0.78 × 10^5 L g^1 - 5.56 x 10^5 L g^1 dan dari 0.21 x 10^5 L g^1 - 1.86 x 10^5 L g^1, masing-masing.

Introduction

In marine environments, ^{226}Ra and ^{228}Ra are readily detectable, soluble and used as a tracer for water circulation study [1]. They occur in the seawater primarily by diffusion from sediment via the interstitial water [2]. Pulau Redang is located at the southern South China Sea was gazetted as a marine park by Malaysian government. This area is reached with various types of coral and attracting local and foreign tourists. During monsoon season, this area has received large land input from the northeast and southwest monsoons. Then three estuaries in the west coast Peninsular Malaysia also were selected for this purpose. The purpose of this study is to determine the transport of ^{226}Ra and ^{228}Ra isotopes in the southern South China Sea and Malacca Straits.

Materials and Methods

About 15 L of surface seawater samples were collected from Malacca Straits and southern South China Sea on year 2002 and year 2003, respectively (Fig. 1). The in-situ parameters such as salinity, specific conductivity, pH and dissolved oxygen (DO) were measured using the calibrated portable meter (Model: YSI-SCT 6810). Briefly in the laboratory, water samples were filtered through the 0.45 µm pore size of pre-weighed membrane filter paper with a flow rate less than 10 mL min^{-1}. The filtrate was acidified with concentrated HNO_3 to pH 2, then continued spike with 25 mg of iron carrier and 20 mg of barium carrier. Sample stirred vigorously before stand an hour, and continue increasing pH to pH 10 with ammonia solution and Na_2CO_3. Then siphon out the supernatant from the filtrate and dissolve the carbonate precipitate with HNO_3 and $HCLO_4$. After removed carbon dioxide from the aqueous by heating on the hotplate and follow the published procedure [3]. Purification and counting radium nuclides were performed using the cation exchange resin and Gross Alpha/ Beta Spectrometer (Model: LB 5100–W; Tennelec), respectively [3]. The same analytical procedure also carried out for the suspended particular matter samples and standard reference material as quality control.

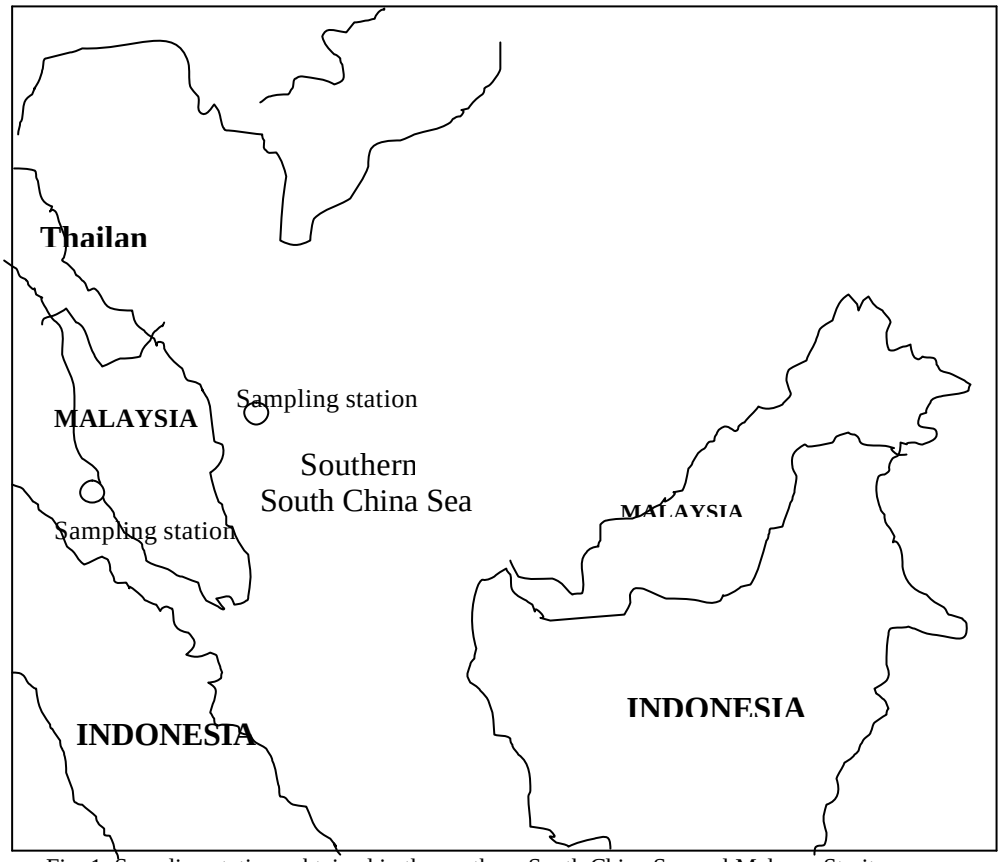

Fig. 1. Sampling stations obtained in the southern South China Sea and Malacca Straits.

Result and Discussion

Radium in dissolved and particulate phases

Radium isotopes activities in dissolved phase obtained from the southern South China Sea (Pulau Redang) were varied from 2.08 - 12.44 mBq L^{-1} for ^{226}Ra and 6.95 - 33.53 mBq L^{-1} for ^{228}Ra. Whereas in the Malacca Straits stations were ranged from 0.61 - 5.08 mBq L^{-1} and 16.39 - 93.95 mBq L^{-1}, respectively for ^{226}Ra and ^{228}Ra. Then the ^{226}Ra and ^{228}Ra in particulate phase were range from 0.16 – 9.13 Bqg^{-1} and 0.32 – 19.95 Bqg^{-1}, respectively for stations located at Malacca Straits and from 4.32 Bqg^{-1} to 10.29 Bqg^{-1} for ^{226}Ra and 5.12 Bqg^{-1} to 9.82 Bqg^{-1} for ^{228}Ra at the southern South China Sea. The obtained activity concentrations of radium in the Malacca Straits stations were higher as compared to the southern South China Sea because the Malacca Straits was classified as a closed system with restricted water circulation especially during monsoon seasons and most radium transported from the coastal line of Sumatra and Peninsular Malaysia will bury directly onto the seafloor [4]. Otherwise the southern South China Sea is semi-closed system with well water circulation during the monsoon periods.

The activity ratios of $^{228}Ra/^{226}Ra$ in the dissolved and particulate phases obtained from Pulau Redang were varied in the range of 1.88 to 7 and from 0.88 to 1.86, respectively, where the ^{228}Ra are more abundance in the dissolved phase and opposite shown by ^{226}Ra (Fig. 2). Low activity ratio at few stations found from southern South China Sea and Malacca Straits are resulting from the depletion of ^{228}Ra in the dissolved phase which is related to the solubility of uranium (^{238}U) over than thorium (^{232}Th) [5]. The relationship between ^{228}Ra with ^{226}Ra also not correlated suggesting a different source of both parents as well as showed by abnormal high ratio (Fig. 3). This might suggested a large portion of input isotope ^{228}Ra was occurred into the water column at Peninsular Malaysia especially Malacca Straits.

The distribution coefficient (K_d) is a measure the tendency of an element to be associated and transported with the particulate phase [6]. It is also widely used to understand and determine the eventual fate of metals and radionuclides released into the aquatic environment. In this study, the distribution coefficient (K_d) is defined as;

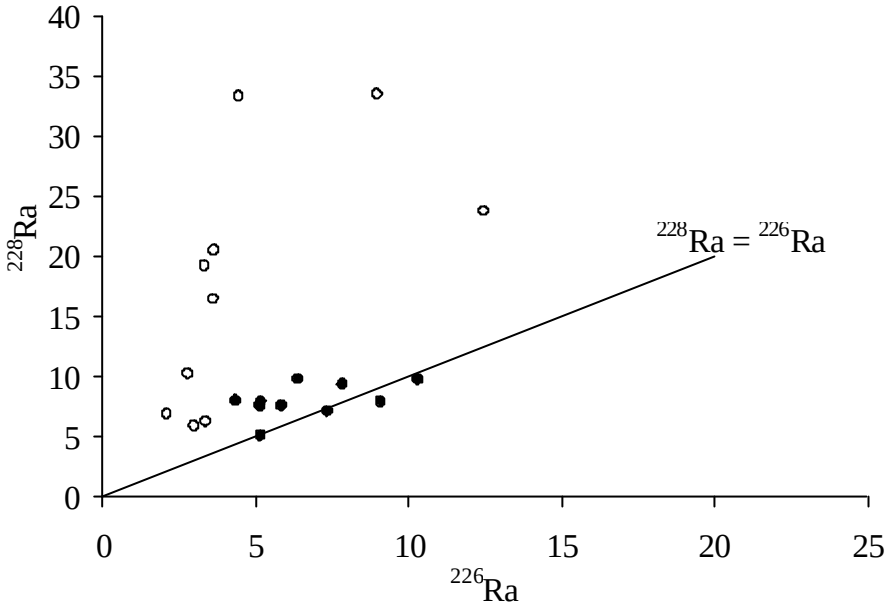

Fig. 2. Distribution of radium nuclides in the dissolved and particulate phases measured at Pulau Redang. The open circle and closed circle is refer to the dissolved phase (mBq L^{-1}) and particulate phase (Bq g^{-1}), respectively.

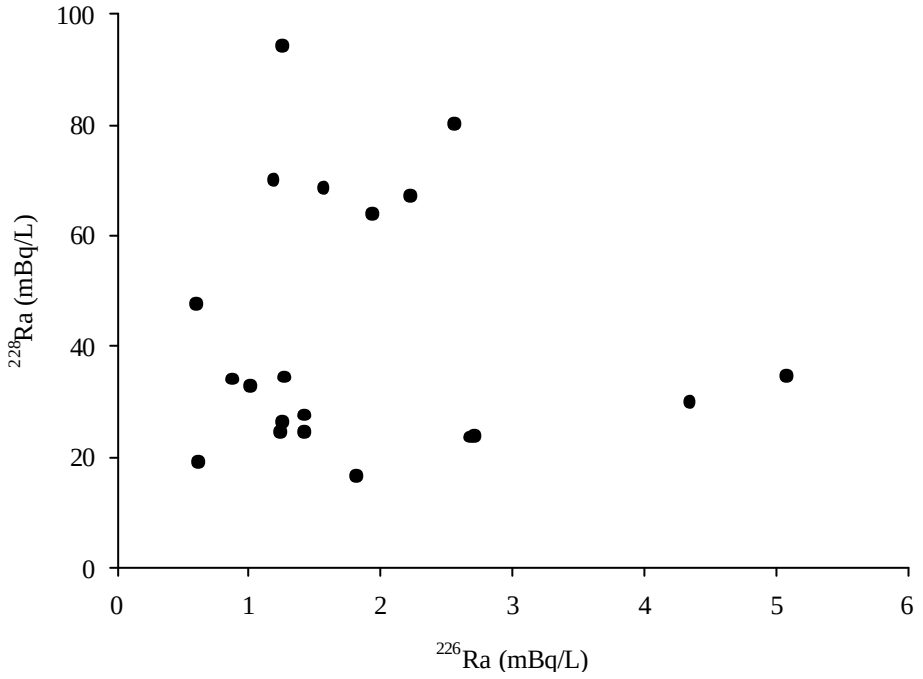

Figure 3. Correlation between ^{226}Ra and ^{228}Ra in dissolved phase

$$K_d = \frac{[A]_p}{[A]_d \times SPM}$$

Where the $[A]_p$ is the activity of particulate ^{226}Ra or ^{228}Ra (Bqg^{-1}), $[A]_d$ is the activity of dissolved ^{226}Ra or ^{228}Ra (Bqg^{-1}) and SPM is the concentration of total suspended particulate matter ($g\,L^{-1}$). The K_d values of ^{226}Ra and ^{228}Ra are ranged from 0.78×10^5 to 5.56×10^5 Lg^{-1}, and 0.21×10^5 to 1.86×10^5 Lg^{-1}, respectively. High K_d values of both radium isotopes are indicated that radium nuclides are highly reactive and adsorbed strongly onto the suspended particulate in marine environment (Fig. 4). The plotted values of K_d against the contents of suspended particle was insignificant ($r^2 < 0.5$) as well as reported by Baskaran and Santschi [7] at location containing less suspended particles (< 10 mgL^{-1}).

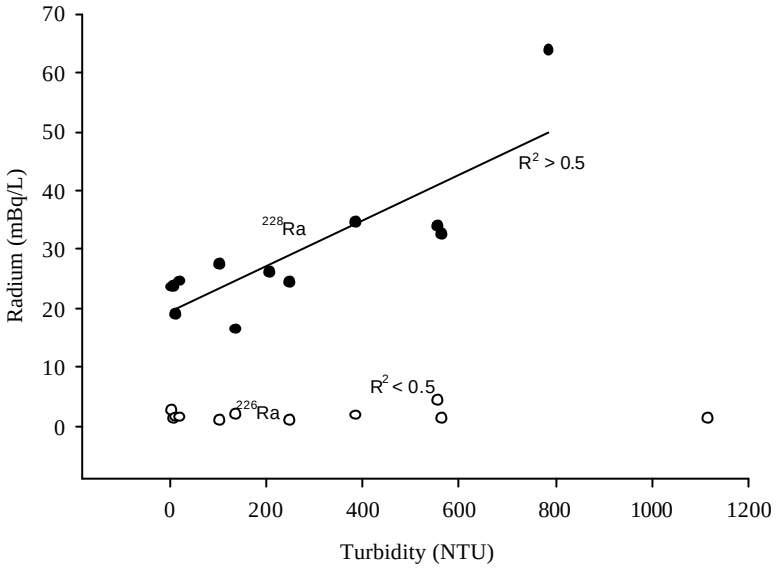

Figure 4. Relationship between turbidity of water column with the content of dissolved radium at three sampling sites.

Conclusions

The activities of ^{228}Ra measured during this cruise are two times higher than others study and most radium isotopes were strongly adsorbed into suspended particles. The effect of particle concentration is not found for samples containing a little amount of suspended particles (< 10 mg L^{1}). Distributions of radium isotopes in coastal waters around of Peninsular Malaysia were spatially variable with contents of suspended solid. Desorption processes from particles significantly enhance the activities of ^{226}Ra and ^{228}Ra in the marine environment.

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