SPATIAL DISTRIBUTION OF ^{210}Pb ACTIVITY CONCENTRATIONS IN MARINE SURFACE SEDIMENTS WITHIN EAST COAST PENINSULAR MALAYSIA EXCLUSIVE ECONOMIC ZONE (EEZ)

(Penyebaran ^{210}Pb Kepekatan Aktiviti di Dalam Sedimen Permukaan di Kawasan Zon Ekonomi Ekslusif Pantai Timur Semenanjung Malaysia)

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Abstract

A sampling expedition into the East Coast Peninsula Malaysia Exclusive Economic Zone (EEZ) was carried in June 2008. Marine surface sediment samples were collected and the activity concentrations of ^{210}Pb have been determined. Its distribution was plotted and the findings show that the activity concentrations decline from north to south. On the other hand, the activity concentrations are increasing from west to east right to the edge of the EEZ. The ^{210}Pb activity concentrations were found to be in the range of 18.3 – 123.1 Bq/kg.

Keywords: Activity, lead, sediment, distribution, trend, EEZ

Abstrak

Ekspedisi persampelan ke kawasan Zon Ekonomi Ekslusif (EEZ) Pantai Timur Semenanjung Malaysia telah di buat pada bulan Jun 2008. Sedimen permukaan telah di ambil dan kepekatan aktiviti ^{210}Pb telah ditentukan. Taburannya telah di plotkan dan di dapati kepekatan aktiviti menurun dari utara ke selatan. Sebaliknya, kepekatan aktiviti telah meningkat dari barat ke timur sethingga kepenjuru EEZ. Kepekatan aktiviti ^{210}Pb di dapapti berada dalam julat 18.3 - 123.1 Bg/kg.

Kata kunci: Activiti, plumbum, sedimen, taburan, tren, EEZ

Introduction

The East Coast Peninsular Malaysia Exclusive Economic Zone (EEZ) is an area between 1° 14.04' to 7° 48.92' N latitude and 102° 5.03' to 105° 48.77' E longitude. The area is approximately 1,150 km long and 417 km maximum width. The area is relatively shallow with maximum depth around 60 m to 70 m. Human activities in the area include fishing, tourism and oil exploration. The area is also a major shipping lane. These factors make the EEZ a good area to study the effects of human activities on the marine environment.

^{210}Po ($T_{1/2}$ = 138 d, α) and ^{210}Pb ($T_{1/2}$ = 22.3 y, β) are both members of the ^{238}U decay series. ^{238}U is a naturally occurring radionuclide with a half-life of 4.5 billion years. ^{210}Pb decays to ^{210}Bi which then decays to ^{210}Po. These radionuclides are recognised as tracers for natural processes and suitable in determining ocean processes [1]. For example, ^{210}Pb has been extensively used to study environmental changes in different sedimentary environment and marine pollution [2]. ^{210}Pb is determined by counting its daughter ^{210}Po which is α emitter. This method assumes secular equilibrium between ^{210}Pb and ^{210}Po. Radiochemical separation is employed to separate ^{210}Po and the source is counted using alpha spectrometry counting system. The technique is widely used due to its lower detection limit, relatively inexpensive and requires small amounts of samples [3].

Materials and Methods

The sampling of the EEZ area was done between 11 June 2008 and 26 June 2008. Sampling locations were arrayed in a grid of about 30 - 40 km between locations. This array allows good coverage of the EEZ with little blank spots. Seawater, core sediments and surface sediments were taken for various analyses. The surface sediment samples for ^{210}Pb analysis were taken using a Ponar grab sampler. Samples were put into a HDPE container and sealed for further analysis in the laboratory. Supporting data such as water depth, salinity, turbidity and temperature were also taken as supporting data.

The samples were then completely dried at 60^{O}C in forced air oven. Grinding of the samples were done using Rocklabs and sieved using Fritsch Analysette 3 Pro siever. Two grams (2g) of sample were weighed and added

with ~6dpm ^{209}Po tracer. Acid leaching method using nitric acid (HNO_3) and hydrochloric acid (HCl) was employed to digest the sample. Sample was filtered and the solution was heated until dryness. The solution was then dissolved in 0.5M hydrochloric acid and 0.1g ascorbic acid was added to the solution prior to deposition of ^{210}Po onto a silver disc for 24 hours.

The silver disc was counted for 24 hours using Ortec Octette+ Alpha Spectrometry System to determine ^{210}Po activity. The activity of ^{210}Pb was then calculated assuming secular equilibrium with ^{210}Po [4].

Table 1. Date of sampling and sampling location coordinates

No.	Station	Date	Latitude	Longitude	Water Depth (m)
1	SF01	18.06.08	06° 13.99' N	102° 19.00' E	13
2	SF02	17.06.08	06° 50.04' N	102° 47.04' E	47
3	SF03	17.06.08	07° 05.03' N	103° 04.99' E	50
4	SF04	17.06.08	07° 25.98' N	103° 26.01' E	61
5	SF05	16.06.08	06° 56.09' N	103° 56.04' E	62
6	SF06	16.06.08	06° 42.14' N	103° 35.17' E	52
7	SF07	16.06.08	06° 10.00' N	103° 01.00' E	45
8	SF08	18.06.08	05° 52.10' N	102° 51.92' E	34
9	SF09	20.06.08	05° 22.06' N	102° 21.97' E	47
10	SF10	14.06.08	05° 48.20' N	103° 48.98' E	55
11	SF11	14.06.08	06° 06.16' N	104° 09.11' E	72
12	SF12	14.06.08	06° 32.01' N	104° 22.11' E	59
13	SF13	13.06.08	06° 16.98' N	105° 16.99' E	55
14	SF14	13.06.08	05° 57.15' N	104° 58.13' E	56
15	SF15	12.06.08	05° 29.08' N	104° 29.02' E	61
16	SF16	12.06.08	05° 18.50' N	104° 12.60' E	60
17	SF17	20.06.08	04° 54.12' N	103° 42.98' E	54
18	SF18	11.06.08	04° 28.14' N	103° 49.98' E	40
19	SF19	22.06.08	03° 37.07' N	103° 41.08' E	23
20	SF20	22.06.08	03° 55.10' N	104° 00.05' E	50
21	SF21	23.06.08	04° 22.16' N	104° 22.07' E	65
22	SF22	23.06.08	04° 44.19' N	104° 38.44' E	66
23	SF23	12.06.08	05° 08.10' N	105° 12.90' E	67
24	SF24	23.06.08	03° 32.08' N	104° 36.00' E	62
25	SF25	24.06.08	03° 09.14' N	104° 09.04' E	41
26	SF26	26.06.08	02° 56.13' N	103° 49.97' E	20
27	SF27	24.06.08	02° 16.94' N	104° 16.97' E	30
28	SF28	24.06.08	02° 39.18' N	104° 38.91' E	58
29	SF29	25.06.08	02° 00.55' N	104° 41.97' E	46
30	SF30	25.06.08	01° 48.04' N	104° 15.03' E	14

Quality assurance was complied by using reference material IAEA-368 Marine Sediment. The reference material was processed in the same batch as the samples and the activity concentration of ^{210}Pb was compared to the certified value.

Results and Discussion

The activity concentration of ^{210}Pb in surface sediments in the sampling area is shown in Table 2.

Table 2. Activity concentration of ^{210}Pb in surface sediments other physical data

Location	^{210}Pb (Bq/kg)	Temperature (^{O}C)	Salinity (psu)	Turbidity
SF01	123.1 ± 0.2	30.38	33.34	5.267
SF02	24.4 ± 0.1	27.33	34.49	4.450
SF03	28.7 ± 0.1	27.30	34.43	4.300
SF04	46.1 ± 0.1	27.16	34.48	4.050
SF05	64.4 ± 0.1	26.90	34.43	10.753
SF06	48.3 ± 0.1	26.80	34.52	4.150
SF07	31.4 ± 0.1	27.04	34.47	3.450
SF08	52.4 ± 0.3	26.92	34.42	3.300
SF09	57.0 ± 0.1	26.45	34.40	4.250
SF10	43.6 ± 0.1	27.38	34.27	3.300
SF11	49.3 ± 0.1	27.31	34.17	3.200
SF12	88.1 ± 0.1	27.65	34.19	3.767
SF13	122.5 ± 0.2	29.32	33.88	4.367
SF14	99.0 ± 0.1	28.87	34.03	3.833
SF15	63.4 ± 0.1	27.77	34.14	3.950
SF16	34.1 ± 0.1	27.10	34.13	3.600
SF17	45.3 ± 0.2	26.54	34.43	3.650
SF18	43.0 ± 0.2	26.52	34.16	3.250
SF19	18.3 ± 0.1	29.44	34.02	2.700
SF20	44.7 ± 0.2	26.56	34.37	3.100
SF21	39.0 ± 0.1	25.57	34.49	3.633
SF22	53.2 ± 0.1	25.54	34.47	3.250
SF23	69.1 ± 0.1	26.66	34.21	3.800
SF24	45.3 ± 0.2	25.41	34.56	3.380
SF25	42.7 ± 0.1	26.16	34.50	3.750
SF26	35.0 ± 0.1	28.16	34.18	3.050
SF27	49.7 ± 0.7	29.12	34.06	3.050
SF28	60.4 ± 0.1	25.55	34.63	3.500
SF29	49.6 ± 0.1	27.86	34.22	3.450
SF30	60.4 ± 0.1	29.49	33.78	15.267

Spatial Distribution

The spatial distribution was plotted using ArcGIS and the distribution is shown in Figure 1.

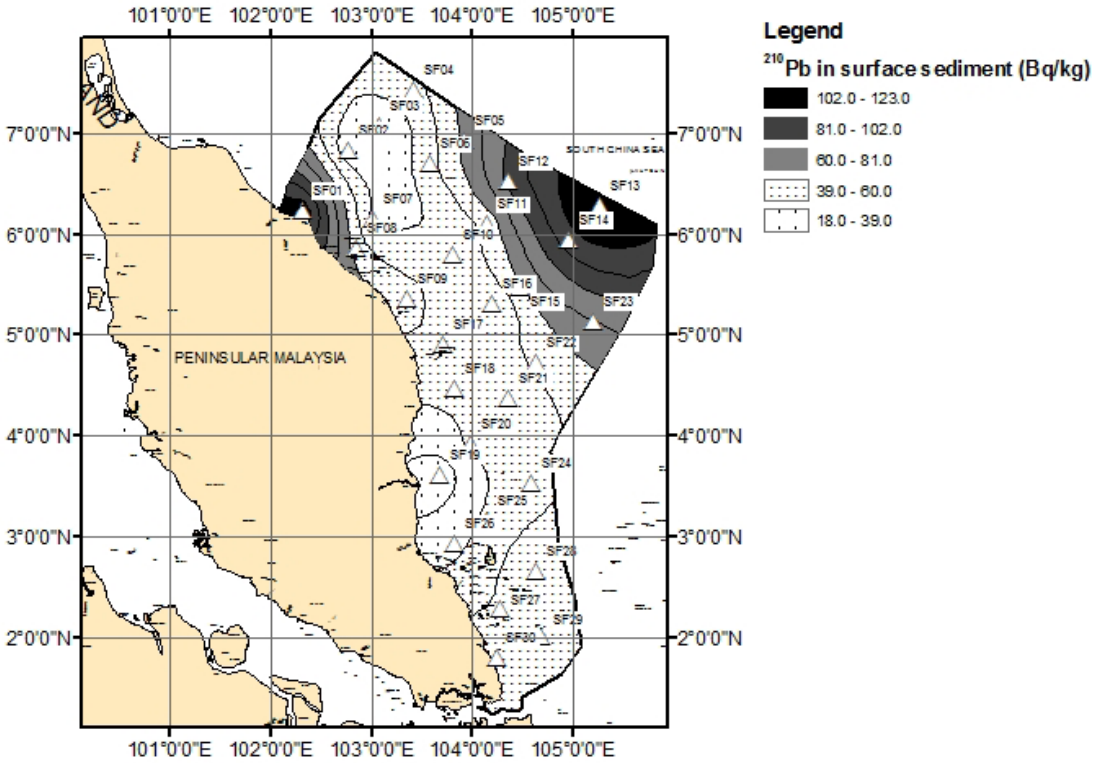

Figure 1: Spatial distribution of ^{210}Pb in surface marine sediments

The activity concentrations of ^{210}Pb in surface marine sediments show a slightly declining trend from north to south. This trend is similar to those observed in the previous study in 2003 [5]. This is especially true to sampling sites in the coastal area. The highest activity concentration is found at station SF01 (123.1 ± 0.2 Bq/kg). This is due to input from terrestrial source as the station is very close to the river Sungai Kelantan. The lowest activity was found to be in station SF19 (18.3 ± 0.1 Bq/kg). This station is close to Pekan coastal area which is about 25 km from the mouth of Sungai Pahang. The low activity concentration observed was rather surprising given that previous study at the mouth Sungai Pahang showed much higher activity concentration [5]. This might be due to minimal sediment transport from Sungai Pahang to the station site, which means little fresh sediment being introduced to the area.

The activity concentration from west to east, which is from coastal area towards open seas initially showed a declining trend. This is expected as less input of ^{210}Pb from terrestrial sources as it further away from land, and thus less ^{210}Pb activity concentration in surface sediments. However, from about 140 km from shore onwards (stations SF12, SF15, SF23, SF14 and SF13) the ^{210}Pb activity concentration show an increasing trend. The furthest station is SF13 which is 261 km from land. Yet this station showed the second highest activity concentration of all the stations (122.5 ± 0.2 Bq/kg). This level of activity concentration is similar to those in SF01. Terrestrial input from natural process cannot explain such high level of activity concentration. It could be that such high activity concentration is lithogenic to that area. ^{226}Ra activity concentration needs to be determined to calculate the ratio between ^{210}Pb and ^{226}Ra. The ratio between ^{210}Pb and ^{226}Ra can help in determining whether the ^{210}Pb activity concentration is of lithogenic or anthropogenic origin [1]. The activity

concentration of ^{210}Pb observed could also be caused by human activities such as oil exploration. Human activities would also cause elevated heavy metal contents in the area. Therefore further analysis need to be carried out to determine the cause of this high ^{210}Pb activity concentration.

Correlation with physical data

A Pearson correlation of ^{210}Pb and the physical data as presented in Table 2 was done using SPSS. No significant correlation was found between the parameters. This means ^{210}Pb activity concentration found was not affected by physical parameters as tabulated in Table 2.

Table 3: Correlation (R) value between ^{210}Pb and various physical parameters

	Temperature	**Salinity**	**OBS**	**Depth**
^{210}Pb	0.037	0.498	0.033	0.134

Comparison to other studies

Table 4: ^{210}Pb activity concentration in surface marine sediments at various locations

Area (Sampling Date)	**Min ^{210}Pb (Bq/kg)**	**Max ^{210}Pb (Bq/kg)**	**Reference**
South China Sea (2008)	18.3	123.1	This Study
South China Sea (2003)	35.3	144.2	[5]
Straits of Malacca (2004)	7.3	136.0	[6]
Sabah & Sarawak Waters (2004)	13.5	220.2	[7]
Kuala Selangor	7.6	43.6	[8]
Kapar	0.1	36.0	[9]

In comparison, the current study does not show any significant differences of ^{210}Pb activity concentration against the previous study carried out at same area. This shows that there is no major change in natural processes and human activities between 2003 and 2008 in the area that could affects the marine environment.

Compared to Straits of Malacca, the results obtained in this study is slightly lower. This could be due to fact that the South China Sea being less an enclosed system compared to Straits of Malacca [10]. This would lead to more sediment movement in South China Sea compared to Straits of Malacca. There are also more rivers and more human activities in the West Coast Peninsula Malaysia that could lead to more terrestrial input into Straits of Malacca.

The ^{210}Pb activity concentration is Sabah & Sarawak waters are significantly higher compared to this study. This could be due to the various rivers in Sabah and Sarawak that contribute to terrestrial input into the sea.

Quality Control of Data

The reference material IAEA-368 Marine Sediment was used as a quality control and quality assuarance to evaluate the quality of data obtained. The reference material was processed and analysed alongside the samples. The result obtained then compared with the certified value (IAEA-368 23.2 ± 1.8 Bq/kg).

Table 5: Results of IAEA-368 analysis

Reference Sample	Measured Value	U-Score
1	23.0 ± 1.0	0.09
2	22.9 ± 1.0	0.13
3	23.2 ± 1.0	0.02
4	23.8 ± 1.1	0.27
5	25.6 ± 1.1	1.09
6	23.2 ± 1.0	0.02
7	24.1 ± 1.1	0.44
8	22.9 ± 1.0	0.13
9	27.6 ± 1.2	1.96
10	24.0 ± 1.1	0.36
11	26.8 ± 1.2	1.63
12	25.6 ± 1.1	1.12
13	24.2 ± 1.1	0.46
14	22.4 ± 1.0	0.37
15	23.6 ± 1.1	0.20
16	24.1 ± 1.1	0.42
17	25.8 ± 1.2	1.21
18	26.1 ± 1.2	1.33
19	27.2 ± 1.2	1.80

The majority of U-score calculated are below 1.64. This means that the ^{210}Pb measured in the reference material does not differ significantly with the certified value.

Table 6: Physical Meaning of the U-Score Values

Condition	Probability	Status
$u < 1.64$	Greater than 0.1	The reported value does not differ significantly from the certified value
$1.95 > u > 1.64$	Between 0.1 and 0.05	The reported value probably does not differ significantly from the certified value
$2.58 > u > 1.95$	Between 0.05 and 0.01	It is not clear whether the reported value differ significantly from the certified value
$3.29 > u > 2.58$	Between 0.01 and 0.001	The reported value is probably significantly different from the certified value
$u > 3.29$	Less than 0.001	The reported value significantly differs from the certified value

Conclusion

The activity concentration of ^{210}Pb in surface sea sediments in coastal area of the East Coast Peninsula Malaysia Exclusive Economic Zone (EEZ) are generally similar to those observed in previous studies. The high activity concentration of ^{210}Pb in the most eastern part of the EEZ require further analysis of ^{226}Ra and heavy metals to determine whether the high ^{210}Pb activity concentration is the result of natural processes or due to human activities.

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