VERTICAL PROFILE OF ^{210}PB IN THE SEDIMENT CORE OF KUALA SELANGOR, MALAYSIA

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Abstract

The activities of ^{210}Pb was measured to establish the sediment accumulation rates and mixing layer at four studies location (river, estuary and ocean) in the coastal water of Kuala Selangor on February 2, 2005. Sediment cores were collected using a gravity core, which the core sample were taken by inserting a PVC plastic pipe enclosed in a cast-iron tube and it pushed manually as far down as possible. Sediment cores were cut at 3 cm interval for each layer. About 1 ml of 1000 ppm Be, 1 ml of 20 mg/ml $PbNO_3$ and 1 ml of 25 mg/ml $FeCl_3$ were spiked into 1-2 g of dried homogenized sediment and continue purify with the cation resin column. The precipitation of ^{210}Pb was counted using the alpha-beta spectrometry at Malaysian Institute Nuclear for Technology. Sedimentation and mixing rates were ranged from 0.10 cm/yr to 0.2 cm/yr and 0.338 cm^2/yr to 2.267 cm^2/yr, respectively. The thickness of mixing layer at locations ranged from surface to 20 cm depth.

Abstrak

Penentuan aktiviti ^{210}Pb dilakukan untuk mendapatkan kadar pemendapan dan lapisan pencampuran sediment di empat lokasi (sungai, muara dan laut) di persisir pantai Kuala Selangor pada 2 Februari 2005. Turus graviti diguna untuk mendapatkan teras sedimen, dimana paip PVC di masukkan ke dalam tiub besi dan kemudian dijatuhkan ke dasar laut sedalam yang boleh secara mekanikal. Teras sediment dipotong 3 cm untuk setiap lapisan. Sebanyak 1 ml 1000 ppm Be, 1 ml 20 mg/ml $PbNO_3$ dan 1 ml 25 mg/ml $FeCl_3$ dimasukkan ke dalam 1-2 g sedimen kering yang homogen dan seterusnya ditulinkan dengan mengguna turus resin kation. Precipitasi yang mengandungi ^{210}Pb dibilang dengan Spectrometri Alfa-Beta di Institut Nuklear Malaysia. Kadar sedimentasi dan pencampuran berjulat dari 0.10 cm/yr hingga 0.2 cm/yr dan 0.338 cm^2/yr hingga 2.267 cm^2/yr, masing-masing. Ketebalan lapisan pencampuran berjulat dari permukaan hingga kedalaman 20 cm.

Introduction

The isotope of ^{210}Pb is the decay product of ^{222}Rn, which escapes from the earth crust to the atmosphere. The ^{210}Pb has a short residence time in the atmosphere, falls into a lake or ocean, tends to bury in the sediment, over a few month becomes permanently fixed on the sediment particles. After deposited, it can be used as a tool for determine sedimentation rate over 100 years [1,2]. Determination of sedimentation rates can provide more insight into the origin of particulate matter, sediment mixing and the amount of the deposition.

Sediment mixing, accumulation and radioactive decay can affect the radiochemical profiles in the sediments. These processes are included in the following steady-state equation [3]:

$$D\frac{\partial^2 A}{\partial z^2} - S\frac{\partial A}{\partial ?} - lA + P = 0 \qquad (1)$$

A is the total activity concentration of the radionuclide (Bq/g), D is a coefficient characterizing the sediment mixing rate (cm^2/y), z is depth below the sediment-water interface (cm), S is sediment accumulation (cm/yr), ? is decay constant (yr^{-1}), and P is the production from parent radionuclide (Bq/g/y). By using the excess activity to the production term may be omitted. This equation can be rearranged to calculate accumulation rates.

$$S = \frac{??}{\ln\,(A_0 / A_z)} - \frac{D}{z}\left[\ln\left(\frac{A_0}{A_z}\right)\right] \qquad (2)$$

If mixing is present, equation 2 demonstrates that sole consideration of sediment accumulation and radioactive decay yields on overestimate of true accumulation [4]. If ?D » S^2, where mixing is intense or rapid and accumulation is low. Equation 2 can be further simplified to equation (3)

$$D = ?\left[\frac{?}{\ln\,(A_0 / A_z)}\right]^2 \qquad (3)$$

Eventually sediment reaches a depth where it is no longer affected by sediment mixing. Below the region affected by sediment mixing the accumulation rate can be calculated ignoring the mixing term using the following equation:

$$S = \frac{??}{\ln\,(A_0 / A_z)} \qquad (4)$$

The goal of this study is to investigate the sediment accumulation and sediment mixing rates occurred in the coastal water of Kuala Selangor using ^{210}Pb activities.

Sampling and Analytical procedure

The sediment core samples were collected at four stations in Kuala Selangor. Core samples were taken by inserting a one meter long PVC pipe enclosed in a cast-iron tube and it pushed manually as far down as possible. Sediment cores were cut at 3 cm interval for each of cores. About 1 ml of Be (1000 ppm), 1 ml of $PbNO_3$ (20 mg/ml) and 1 ml of $FeCl_3$ (25 mg/ml) were spiked into 1-2 g of dried homogenized sediment. Procedure purification was done using published procedural [5]. The precipitation of ^{210}Pb effluence was counted by alpha-beta spectrometry (ORTEC) at MINT to determine the activity of ^{210}Pb

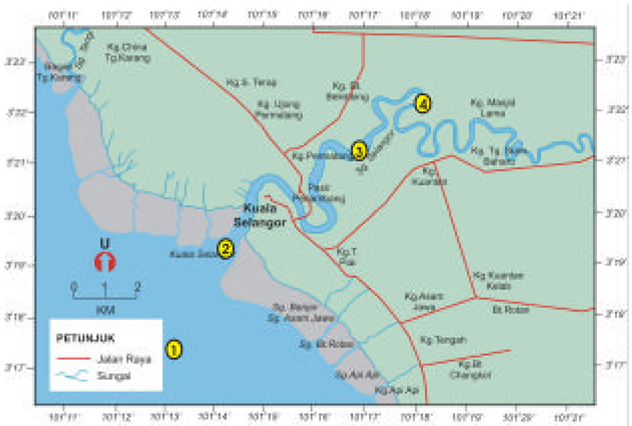


Figure 1. The Map of sampling station in Kuala Selangor

Result and Discussion

Sampling location, sample intervals and ^{210}Pb activity concentration are shown in Table 1. Accumulation and mixing rates of each core are shown in Table 2. Activity profiles for each core are shown in Figures 2. Mixing rates (Diffusive mixing coefficients) were calculated using equation (3). Sediments accumulation rates was determined from the slope of the least-squares regression line from the ^{210}Pb activity with depth below the sediment mixed layer using equation (4). All sediment cores were success determine the accumulation and mixing depth.

Table 1. Activities concentration of ^{210}Pb in the sediment cores of Kuala Selangor.

Depth (cm)	Station 1 (Bq/g)	Station 2 (Bq/g)	Station 3 (Bq/g)	Station 4 (Bq/g)
0-3	0.0076 ± 0.0016	0.0085 ± 0.0017	0.0233 ± 0.0065	0.0436 ± 0.0111
3-6	0.0122 ± 0.0025	0.0087 ± 0.0018	0.2425 ± 0.0619	0.0145 ± 0.0034
6-9	0.0650 ± 0.0183	0.0128 ± 0.0026	0.0926 ± 0.0293	0.0233 ± 0.0063
9-12	0.0065 ± 0.0013	0.0408 ± 0.0097	0.0377 ± 0.0096	0.1492 ± 0.0433
12-15	0.0058 ± 0.0011	0.0720 ± 0.0209	0.0147 ± 0.0388	0.1682 ± 0.0444
15-18	0.0038 ± 0.0007	0.1124 ± 0.0258	0.0437 ± 0.0104	0.0143 ± 0.0037
18-21	0.0991 ± 0.0204	0.1125 ± 0.0249	0.0180 ± 0.0047	0.1045 ± 0.0285
21-24	0.0032 ± 0.0006	0.0320 ± 0.0078	0.2713 ± 0.0693	0.0113 ± 0.0028
24-27	0.0086 ± 0.0193	0.1649 ± 0.0379	0.2568 ± 0.0697	0.0206 ± 0.0058
27-30	0.0224 ± 0.0048		0.0453 ± 0.0119	
30-33	0.0647 ± 0.0133			
33-36	0.0066 ± 0.0014			
36-39	0.0149 ± 0.0032			

In station 1 core, the ^{210}Pb activity concentration varied between 0.0066 ± 0.0014 Bq/g and 0.0991 ± 0.0204 Bq/g. The activity concentration of ^{210}Pb profile for the sediment core station 1 has mixed down to 19.5 cm. The sediment mixing and sedimentation rate within this section is 1.283 cm^2/yr and 0.199 cm/yr, respectively based on the ^{210}Pb activities. In station 2, the ^{210}Pb activity concentration varied between 0.0087 ± 0.0018 Bq/g and 0.1649 ± 0.0379 Bq/g. The activity concentration of ^{210}Pb profile for the sediment core station 2 has mixed down to 16.5 cm. The sediment mixing and sedimentation rates within this region are 2.267 cm^2/yr and 0.256 cm/yr, respectively based on the ^{210}Pb activities. In station 3, the ^{210}Pb activity varied from 0.0147 ± 0.0388 Bq/g to 0.2713 ± 0.0693 Bq/g. The activity concentration of ^{210}Pb profile for the sediment core station 3 has mixed down to 13.5 cm. The sediment mixing and sedimentation rates within this region are 1.927 cm^2/yr and 0.245 cm/yr, respectively based on the ^{210}Pb activities. Meanwhile as station 4, the ^{210}Pb activity concentration also varied from 0.0113 ± 0.0028 Bq/g to 0.1682 ± 0.0444 Bq/g. The activity concentration ^{210}Pb profile for the sediment core station 4 has mixed down to 13.5 cm. The sediment mixing rate and sedimentation rates within this region are 0.327x10^{-3} cm^2/yr and 0.338 cm/yr, respectively based on the ^{210}Pb activities (Table 2; Figure 2).

Table 2. Accumulation and mixing rate for each core

Location	Accumulation rates (cm/yr)	Mixing Rate (cm^2/yr)
Station 1	0.199	1.283
Station 2	0.256	2.267
Station 3	0.245	1.927
Station 4	0.102	0.338

Sediment accumulation, inventory and Sediment texture

If the sedimentation rates were constant with time during the past 100-200 years for each core, the activity of excess ^{210}Pb in the sediments should decrease exponentially with depth except in the surface layer which is affected by bioturbation. The bioturbation normally affects only the top few cm of the core. The assumption that biological and physical mixing was restricted to the surface mixed layer (SML). According to the calculation using ^{210}Pb, the sediment accumulation rates were less than 1cm/yr. Therefore, it was not necessary to collect the sediment cores of depths greater than 100 cm. Sedimentation were ranged from 0.10 cm/yr to 0.2 cm/yr. Maximum accumulation rates were in sediment core station 2 (estuary). The pattern of sedimentation rates estimated by ^{210}Pb at Kuala Selangor coastal water can be summarized as estuary > river > ocean. When river sediments enter the estuary, the river flow is opposed by the tide and tidal current. This gives the heavier sediment particles a chance to settle at the bottom. Therefore, a large part of the sediment will never make it to the sea but accumulate in estuary. Consequently, it may react traps for sediment and sedimentation rates estuary will higher due to play the major role in the transport sediment from rivers to seawater.

The inventory of ^{210}Pb is commonly influenced by many factors such as sediment texture, water depth, sedimentation rate and sediment resuspension. ^{210}Pb inventory is commonly higher in fine sediment due to the higher scavenging efficiency by clays. High sedimentation rate is commonly liked to higher ^{210}Pb inventory.

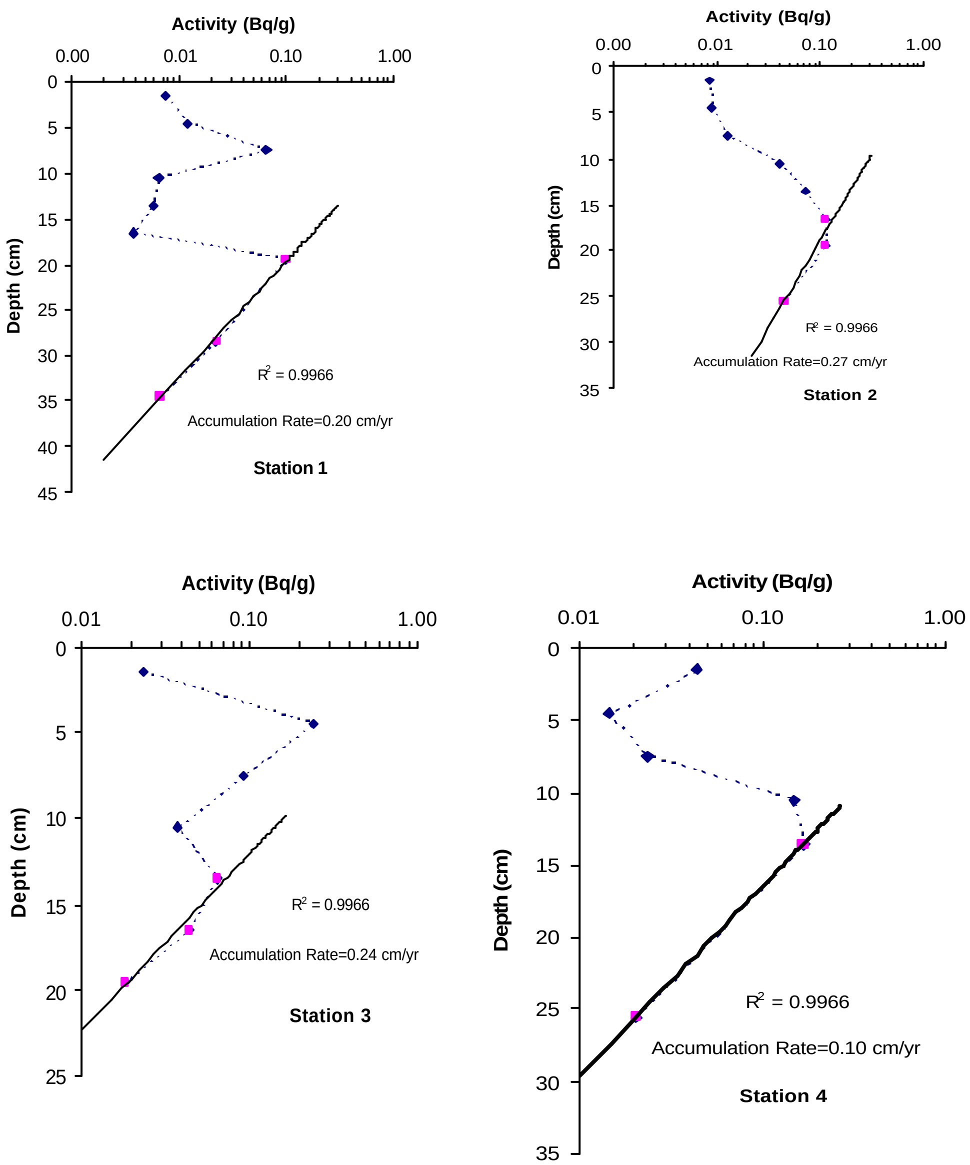


Figure 2. Activity profiles and accumulation rates for each core

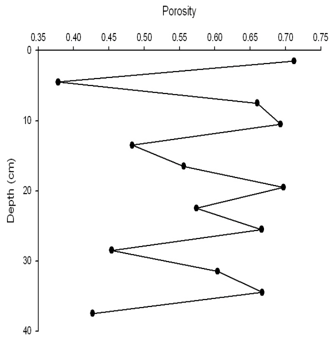
Table 3. Calculated inventory and fluxs of ^{210}Pb at study area

	^{210}Pb inventory (Bq/m^2)	^{210}Pb fluxs (Bq/m^2/yr)
Station 1	33.93	14185.57
Station 2	106.08	3410.97
Station 3	168.47	54171.58
Station 4	117.26	33934.32

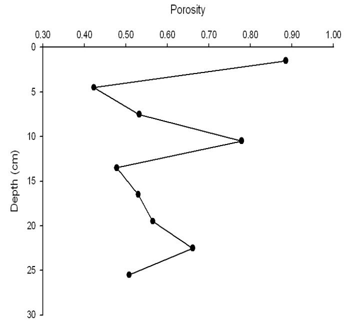
^{210}Pb inventory in this study area are highest in station 1. Core sediment station 3 and 4 had ^{210}Pb inventory of 168 Bq/m^3 and 117.26 Bq/m^3, whereas station 1 and station 2 had ^{210}Pb inventory of 33 Bq/m^3 and 106.08 Bq/m^3. Highest sedimentation rates in station 2 (estuary) is not solely linked to ^{210}Pb inventory and may be due to other factors. ^{210}Pb inventory appear positively dependent of increased flux ^{210}Pb and mixing.

Sediment texture can describe by size distribution, porosity, skewness and sortedness of the sediment. Figure 3 and Table 4 list the result from porosity and grain-size measurement, where four sediment cores are exhibits poorly sorted coarse sand. Stations 2 and 4 have a negative skewed whereas the other station positive skewed.

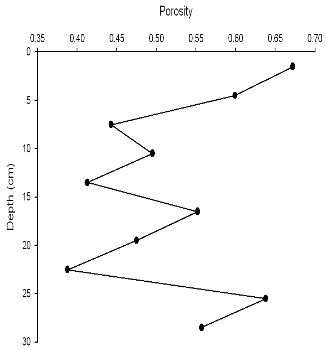
Porosities in the surface core were the highest of all analyzed. Porosity was varied, with a tendency to increase and decrease with the thickness sediment. Porosity was ranged from 0.885 to 0.374. Porosities did not depend on grain size, but is sensitive to sediment sorting. In this study, core sediment was poor sorted. Normally, poor sorted material attains lower porosities, because fine-seized grains fill voids left by larger grains. These observations were not corresponding in our study due to grain size determinations only on surface layer.



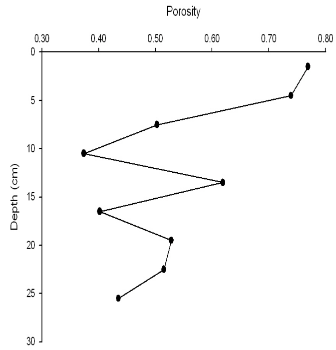
Station 1



Station 2



Station 3



Station 4

Figure 3. Porosity in station of Kuala Selangor.

Table 4 Grain size, sortedness, skewness and porosity core sediment in Kuala Selangor.

Distribution	Station 1	Station 2	Station 3	Station 4
Mean Size, Ø	0.93	2.17	1.17	2.63
Sortedness, s	1.23	1.57	1.29	1.69
Skewness, *sk*	0.26	-0.06	0.04	-0.35
Porosity, ?	0.71	0.88	0.67	0.77

Conclusion

Each sediment core in Kuala Selangor was successful determine the accumulation rate and mixing rate. The range of accumulation rates and mixing rates of each sediment core was 0.102 to 0.199 cm/yr and 0.338 to 2.267 cm^2/yr.

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