

## Assessment Activity of $^{210}\text{Po}$ and $^{210}\text{Pb}$ in the Edible Tissues of Cultured Seabass (*Lates calcarifer*) at Peninsular Malaysia

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### Abstract

Analysis levels of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  were determined in the edible tissue of sea bass (*Lates calcarifer*) from 14 cages in the west and east coast Peninsular of Malaysia. The concentrations level in fish were found varies from  $1.35 \pm 0.22$  to  $6.20 \pm 0.99$  Bq/kg dry weight  $^{210}\text{Po}$  and  $3.30 \pm 2.69$  to  $51.71 \pm 19.26$  Bq/kg dry weight  $^{210}\text{Pb}$ . The level of this radionuclide was much related to the anthropogenic activities at the sampling locations neighbouring area, differences in metabolisms of fish and food intake pattern for each cage. Then the calculated daily intake value due to fish consumption was to be 7.69 mBq/d/person  $^{210}\text{Po}$  and 35.90 mBq/d/person  $^{210}\text{Pb}$ , which lower than those reported in others countries. In addition, the collective doses of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  were estimated to be 0.001 mSv/year and 0.009 mSv/year, respectively. This suggests that the dose received by Malaysian due to consumption of fish is rather small, and did not deteriorate human's health and safe for consumption.

**Keywords:**  $^{210}\text{Po}$ ;  $^{210}\text{Pb}$ ; sea bass; daily intake; committed effective dose

### 1. Introduction

$^{210}\text{Po}$  is extensively being studied in the marine environment because it represents the major natural source of internal irradiation for marine organisms (Cherry and Shannon, 1974; Carvalho, 1988; Brown *et al.*, 2004). The radiotoxicity of  $^{210}\text{Po}$  is connected with the fact that it emits alpha particles with a relatively high energy of about 5.3 MeV and that it is concentrated in the soft tissues, such as muscle, liver and others (Stewart *et al.*, 2008). Alpha emitter is considered the most important potential internal radiation exposure of living tissue especially among the natural radionuclides occurring in the ocean.  $^{210}\text{Po}$  is considered to be the most important contributor of radiation dose received by human via fish and shellfish consumption (Aarkrog *et al.*, 1997). Several studies have been demonstrated that the natural alpha emitting radionuclide of  $^{210}\text{Po}$  will accumulated to exceptionally high levels in tissues of a variety of marine organism, as well as above levels of the parent radionuclide  $^{210}\text{Pb}$  (Carvalho and Fowler, 1997; Stepnowski and Skwarzec, 1994). Meanwhile, natural radionuclide of lead has also great importance because it is toxic for living organisms, involved in biological cycle and normally presents in highly concentration. This radionuclide is proven to be assimilating through the food chain, which they pose

a threat for living organisms and man (Nonova *et al.*, 2009; Ariffin and Mohamed, 2010). Therefore, in order to estimate radiological risk to the environment, a greater knowledge of the concentration of radionuclide in a number of reference organisms, the transfer path, the spatial and temporal variations in activities and the concentration factor and also determination of doses received and an evaluation of any possible effects (Brown *et al.*, 2004).

*Lates calcarifer* or known as the white seabass in Asia Pasific is the most commonly cultured in Malaysia. Fish culturing was conducted in seawater, brackish water and freshwater had significantly increased the Malaysian economy. Malaysia also is the highest consumer of seafood in the Southeast Asian region due to term of per capita intake and percentage of protein (Alam and Mohamed, 2011). Measurement of natural background levels and estimation of dose to public in terms of health safety is essential, since these values form reference values for comparing radionuclide concentration due to anthropogenic activities. Some of the radionuclides such as  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  assume to have greater importance due to their high accumulation potential in seafood (Feroz Khan and Godwin Wesley, 2009). Much less information about  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  has been recorded in sea bass muscle despite of this fish is a popular fish extensively cultured in South East Asia

region (Cheong, 1989). Therefore, a study regarding the  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  concentration in edible muscle is very important in order to ensure the quality and health safety of this fish. The daily intake and radiation dose due to consumption of muscle are also the objective this study.

## 2. Material and Method

### 2.1. Sample and Sampling locations

Sampling was carried out on February 2010 to September 2010. These 53 samples were purchased from 14 cages (Fig. 1) in the west and east coast Peninsular Malaysia. Nowadays, urbanization and industrialization as come up rapidly in the east and west coast Peninsular Malaysia. The effluent discharges from this activities both treated and untreated will affect the aquaculture activity. The two combinations of two main types of fish feed used at every cage are moist feed or trash fish (e.g., Scombridae) and dry pellet. The average weight and length of the samples were taken and description of sampling site as shown in Table 1.

### 2.2. Analytical Method

The radiochemical separation method was used to estimate  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  in the samples (Flynn, 1986;

Harley, 1978). Briefly, the samples were dissected to obtain the muscle part and oven dried at  $60^\circ\text{C}$  temperature. Then about 0.5g of the dried sample was taken and  $^{209}\text{Po}$  of known activity and 20 mg of Pb carrier [ $\text{Pb}(\text{NO}_3)_2$ ] was added as a yield tracer. A mixture of concentrated  $\text{HNO}_3$ ,  $\text{HClO}_4$ ,  $\text{HCL}$  acids and  $\text{H}_2\text{O}_2$  were used for digestion (Yamamoto *et al.*, 1994). Polonium was then spontaneously deposited onto polished and pre-cleaned silver foil ( $2.0 \times 2.0 \text{ cm}$ ) in the 0.5M of  $\text{HCL}$  solution for a period of 3-4 hours at a temperature of  $70\text{-}90^\circ\text{C}$ . The activities of  $^{210}\text{Po}$  in samples were determined using the Alpha Spectrometry with a silicon-surface barrier detector by Canberra immediately after deposition process (Sabuti and Mohamed, 2011).

Next, the isotope of lead ( $^{210}\text{Pb}$ ) was collected via the electro deposition process by forming lead sulphate ( $\text{PbSO}_4$ ) precipitation. The precipitate was wrapped onto plastic disc and count for  $^{210}\text{Pb}$  via  $^{210}\text{Bi}$  beta activity using the gross alpha/beta counting system (model: Tennelec Series 5-XLB low background gas-flowing anti-coincidence alpha-beta counter) after one month to allow Bi ingrowths. Quality control procedure was applied using a fish standard reference material supplied by the IAEA-414 and the recovery was showed in Table 2.

## 3. Result and Discussion

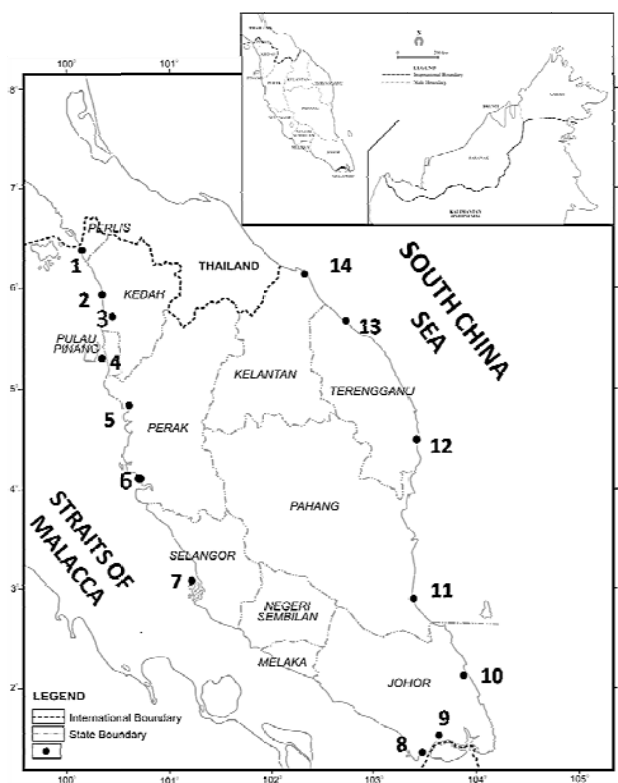


Figure 1. Map of Sampling Location

Table 1. Average length and average weight of samples with descriptions for all sampling locations

Station	Location	n	Sampling Date	Average Length (cm)	Average Weight (g)	Description
S1	Kuala Perlis	4	5-Aug-10	35.30 ± 1.97	667.50 ± 95.97	Rural area
S2	Merbok	4	5-Aug-10	39.03 ± 2.22	710.25 ± 129.09	Rural area
S3	Sg. Petani	4	5-Aug-10	45.40 ± 1.98	1275.00 ± 119.02	Near jetty and urbanization area
S4	Nibong Tebal	4	4-Aug-10	35.70 ± 0.54	653.00 ± 21.18	Near Juru industrial area
S5	Larut Matang	4	4-Aug-10	38.98 ± 0.88	702.50 ± 15.84	State mangrove reserve area
S6	Sg. Tambun	4	5-Aug-10	41.78 ± 1.58	886.00 ± 85.77	Near recreational area
S7	Port Klang	4	16-Sep-10	34.05 ± 0.56	740.00 ± 78.74	Urbanization area
S8	Gelang Patah	3	11-Feb-10	40.70 ± 1.64	1095.33 ± 207.04	Adjacent to Singapore urban area
S9	Sg. Danga	4	11-Feb-10	35.08 ± 0.59	514.25 ± 31.44	Near Danga Bay, recreational beach
S10	Sedili Kechil	3	12-Feb-10	33.65 ± 0.71	505.25 ± 47.07	Estuary of Sedili Kechil river, under state mangrove reserve area
S11	Pekan	3	12-Feb-10	35.23 ± 1.19	592.33 ± 43.36	Tributaries of Pahang river
S12	Paka	4	6-Aug-10	37.23 ± 0.42	602.75 ± 42.06	Near urbanization area
S13	Setiu	4	7-Aug-10	32.55 ± 1.13	493.25 ± 24.98	Mariculture area
S14	Tumpat	4	7-Aug-10	37.88 ± 1.79	717.75 ± 116.33	Near the boundaries of Thailand and recreational area
<b>Total (n)</b>				<b>37.33 ± 1.72</b>	<b>725.37 ± 1.04</b>	

n – The number of samples

Note: Fish feed - combination of trash feed and dry pellet used at each sampling location

3.1. <sup>210</sup>Po and <sup>210</sup>Pb activity concentrations in the edible tissue of sea bass

The activity concentrations of <sup>210</sup>Po and <sup>210</sup>Pb in tissue ranged from 1.35 ± 0.22 to 6.20 ± 0.99 Bq/kg and 3.30 ± 2.69 to 51.71 ± 19.26 Bq/kg respectively. Average activity concentrations of <sup>210</sup>Po and <sup>210</sup>Pb for each cage are shown in Table 3. The value showed a wide range of concentrations with a greater accumulation of <sup>210</sup>Pb relative to <sup>210</sup>Po found in all samples. Theses variations in activity concentration are due to the differences in metabolisms and food intake pattern for each cage (Al-Masri et al., 2000; El Samad et al., 2000). Feeding practise with trash fish will increased pollution due to the proportion of feed wastage can be higher because the fish can break up upon entry into the water. Thus, this feeding style can lead the increases nutrients and organic in water (Blyth and Dodd, 2002). In addition, activity of <sup>210</sup>Po and <sup>210</sup>Pb in this species varies according to the sampling site can be assumed that accumulation influenced by

environmental factor. The highest value of <sup>210</sup>Po was 5.30 ± 0.50 observed near the boundaries of Thailand and recreational area (S14) meanwhile the highest values of <sup>210</sup>Pb were 32.67 ± 11.54 at Juru industrial area (S4). Development of industries such as tourism, have a negative impact on fish cage near at S14. The direct waste from the hotel and resort near by might increase the nutrient and organic in water body of S14. According to Cherry and Heyraud (1981) <sup>210</sup>Po has a much higher affinity for organic matter in marine organisms compared to <sup>210</sup>Pb. El Samad et al. (2000) noted that the highest concentrations <sup>210</sup>Pb were found in industrialized areas whose effluents may increase the concentrations of naturally occurring radionuclides in the environment. Industrialization and urbanization area cause a lot of radioactive element extended to the river and directly through sea. Aysun Ugur et al. (2002) has studied the high level of <sup>210</sup>Po and <sup>210</sup>Pb observed in mussels could due to the extensive of coastal industrial source including petroleum and other chemical industries. The average activity concentration

Table 2. Result of <sup>210</sup>Pb(<sup>210</sup>Po<sup>#</sup>) activity in Fish Reference Sample IAEA-414

Certified Value (Bq/kg d.w)	Measured Value (Bq/kg d.w)	Recovery (%)
1.8 - 2.5	1.08 ± 0.18	83.74

# <sup>210</sup>Po is in equilibrium with <sup>210</sup>Pb at the time of measurement

Table 3. The average values of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  activity concentrations in fish (*Lates calcarifer*) muscle

Station	No. Samples	$^{210}\text{Po}$ (Bq/kg)	$^{210}\text{Pb}$ (Bq/kg)
S1	4	2.05 ± 0.33	6.16 ± 3.73
S2	4	2.48 ± 0.40	13.60 ± 5.30
S3	4	2.73 ± 0.44	16.72 ± 6.31
S4	4	1.74 ± 0.28	32.67 ± 11.54
S5	4	3.00 ± 0.48	23.06 ± 9.22
S6	4	4.20 ± 0.67	8.57 ± 3.98
S7	4	3.33 ± 0.53	19.31 ± 8.14
S8	3	3.03 ± 0.49	12.56 ± 7.29
S9	4	3.19 ± 0.51	13.86 ± 8.67
S10	3	4.65 ± 0.74	11.70 ± 7.26
S11	3	3.35 ± 0.54	15.95 ± 6.65
S12	4	2.46 ± 0.39	13.42 ± 5.96
S13	4	4.47 ± 0.72	11.60 ± 5.83
S14	4	5.30 ± 0.85	10.90 ± 5.46

of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  in fish, were comparable to those reported in other countries as shown in Table 4.

In general, concentration  $^{210}\text{Po}$  in muscle was always higher than  $^{210}\text{Pb}$  but in this study showed  $^{210}\text{Pb}$  in muscle was higher than the  $^{210}\text{Po}$ . This measurement agree with data in the literature such as *Euthynnus alletteratus* (Al-Masri et al., 2000), *Salvelinus namaycush* and *Coregonous clupeaformis* (Clulow et al., 1998), and *Nimipterus delagoae*, *Atule mate* and *Auxis thazard* (Zal U'yun et al., 2005). Generally, the wild fishes were used for previous studied compared cultured fish for this study. The wild fish inhabit natural environment and experience less influence from

anthropogenic impact. These cultured fish extensively cultured along the estuaries and littoral zone of Malaysia coastal waters. Therefore, they have been exposed to the variation contamination either from land based or sea based source. In addition, the differences level of radioactivity could be due to differences in species, metabolism and feeding pattern (Al-Masri et al., 2000). Though the samples accumulate high level of  $^{210}\text{Pb}$ , the variability in the accumulation reflected in the fish tissues is evidently due to the availability of  $^{210}\text{Pb}$  in the environment (Hameed et al., 2004). But Hameed et al. (2004) noted also the direct absorption of radioisotopes by the gill membrane could be the reason for this higher

Table 4. Range/average of  $^{210}\text{Pb}$  and  $^{210}\text{Po}$  activity concentrations in fish muscle from different countries.

Location	Species	$^{210}\text{Po}$ (Bq/kg)	$^{210}\text{Pb}$ (Bq/kg)	References
Malaysia (Mean)	<i>Lates calcarifer</i> <sup>a</sup>	3.26	15.25	This study
Kemaman, Malaysia	m.s. <sup>b</sup>	4.79-146.05	4.81-146.54	ZalU'yun et al., 2005
Besut, Malaysia	m.s. <sup>b</sup>	7.93	7.96	ZalU'yun et al., 2005
Kuala Selangor, Malaysia	m.s. <sup>b</sup>	0.10-11.77	0.13-4.00	Mohamed et al., 2006
Kapar, Malaysia	<i>Arius maculatus</i> <sup>b</sup>	0.06-5.64	-	Alam and Mohamed 2011
Lebanon	m.s. <sup>b</sup>	0.22-47.82	1.31-45.00	El Samad et al., 2010
Syria	m.s. <sup>b</sup>	0.27-27.48	0.05-0.38	Al-Masri et al., 2000
Japan	m.s. <sup>b</sup>	0.6-26	0.04-0.54	Yamamoto et al., 1994
Australia	m.s. <sup>b</sup>	0.9-44.1	-	Smith and Towler 1993
Portugal	m.s. <sup>b</sup>	0.2-11	-	Carvalho, 1988
South Africa	m.s. <sup>b</sup>	2.2-20.3	-	Cherry et al., 1994
America	m.s. <sup>b</sup>	0.4-153.3	0.1-7.0	Noshkin et al., 1994

m.s – multi species

<sup>a</sup> Cage fish

<sup>b</sup> Wild fish

activity. In addition, the carnivorous feeding could also be attributed for this higher activity since ingestion is the dominant means by which radioactive material are accumulated in aquatic organisms agreed with previous studies (Raja and Hameed, 2010; Hameed *et al.*, 2004). Lower concentrations of <sup>210</sup>Po in muscle are important, because human consume mostly the muscle of the fish. Thus, this accounts the low radiation dose (Iyengar *et al.*, 1980). Regarding the fish size, there is no apparent relation between <sup>210</sup>Po or <sup>210</sup>Pb and weight or length by using statistical analysis. In this study it is clearly showed that the fish size could not affect the concentration of <sup>210</sup>Po and <sup>210</sup>Pb. Negative correlation ( $r = -0.295, p < 0.05$ ) was found between concentration of <sup>210</sup>Po and <sup>210</sup>Pb.

3.2. Daily intake of <sup>210</sup>Po and <sup>210</sup>Pb via consumption of fish

Dietary intake of <sup>210</sup>Po and <sup>210</sup>Pb through the consumption of fish plays a major role in accumulation of <sup>210</sup>Po and <sup>210</sup>Pb in the human body. The daily intake of <sup>210</sup>Po and <sup>210</sup>Pb by the Malaysian adult population of 16.88 million (Ninth Malaysian Plan, 2005) through the fish consumer was calculated with the following equation;

$$\text{Daily intake, (Bq/day/person)} = [A \times B \times C] / [D \times E] \quad \text{----- (1)}$$

Where A is the activity of radionuclides in the muscle (Bq/kg), B is the annual production of aquaculture by cages reported by the Department of Fisheries Malaysia (2010), which was 24,236.31 ton, C is rate of edible part is the constant value edible part of fish (0.6), D is Malaysian population (16.88 million) and E is the time (365 days). An assessment of daily intake of <sup>210</sup>Po and <sup>210</sup>Pb was carried out to be 7.69 mBq/d/person and 35.9 mBq/d/person, respectively. This intake value was compared with other reported values given in Table 5.

Table 5. Daily intake of <sup>210</sup>Po and <sup>210</sup>Pb via consumption of fish muscle in different countries

Location	Daily intake (mBq/d/person)		References
	<sup>210</sup> Po	<sup>210</sup> Pb	
Malaysia	7.69	35.90	This study
Kuala Selangor, Malaysia	280	90	Mohamed <i>et al.</i> , 2006
Kapar, Malaysia	199.86	-	Alam and Mohamed 2011
Japan	480-690	22-42	Yamamoto <i>et al.</i> , 1994
Marshall Island	1900	230	Noshkin <i>et al.</i> , 1994
Poland	42	1.1	Pietrzak-Flis <i>et al.</i> , 1997
Poland	27	-	Skwarzec, 1997
Syria	6.46	0.24	Al-Masri <i>et al.</i> , 2000

In general, the Malaysian population’s consumption of seafood relatively low compared with other countries such as Japan. Thus, the daily intake of <sup>210</sup>Po and <sup>210</sup>Pb of Malaysian people also were relatively low than the other countries. From the reported values it was observed that intake values in present study is much less compared than other study; fish at Kuala Selangor, Malaysia by Mohamed *et al.* (2006) and Kapar coastal, Malaysia by Alam and Mohamed (2011). A comparatively higher value intake was observed on both previous studies because the source of the coal burning at the power plant. The lower intake value of this study may be due to lower annual fish cage production compare to the previous studies using the annual gross fish catch by fisherman. However, the daily intake for the Malaysian population was lower than that of the world reference value, which is 58000 Bq/d/person (IAEA, 1995).

3.3. Committed Effective Dose (CED) calculation.

Radiation dose deposition in human body due to consumption of seafood can be estimated by two methods (IAEA, 2006). The first method is based on the <sup>210</sup>Po and <sup>210</sup>Pb concentration in the seawater. The second method is based on the <sup>210</sup>Po and <sup>210</sup>Pb concentration in the edible tissue of the fish. Internal doses received through concentration of <sup>210</sup>Po and <sup>210</sup>Pb in the tissue of the fish for Malaysian were measured here. Dietary intakes of 7.69 mBq/d/person for <sup>210</sup>Po and 35.9 mBq/d/person for <sup>210</sup>Pb obtained were used in the calculation. The committed effective dose was calculated as follows:

$$\text{Committed Effective Dose, CED (mSv/year)} = A \times B \times C \quad \text{----- (2)}$$

Where A is the daily intake of <sup>210</sup>Po or <sup>210</sup>Pb (mBq/d/person), and B is the ingestion dose coefficient (dose equivalent per intake of unit activity, Sv/Bq) reported by the International Commission on Radiological

Table 6. Committed effective dose due to  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  reported on other countries

Location	Committed Effective Dose (mSv/year)		References
	$^{210}\text{Po}$	$^{210}\text{Pb}$	
Malaysia	0.001	0.009	This study
Kapar Coastal, Malaysia	0.04	-	Alam and Mohamed, 2011
Lebanon	0.01	0.27	El Samad <i>et al.</i> , 2010
Japan	0.05	0.05	Yamamoto <i>et al.</i> , 1994
Japan	0.73	0.06	Tomoko <i>et al.</i> , 2009
Syria	0.68	0.34	Al Masri <i>et al.</i> , 2000
Ontario, Canada	0.08	0.39	Clulow <i>et al.</i> , 1998

Protection (ICRP, 1994) to be  $2.4 \times 10^{-7}$  for  $^{210}\text{Po}$  and  $6.8 \times 10^{-7}$  for  $^{210}\text{Pb}$  and C is the exposure frequency (365 days/year).

The value of CED was calculate by applying the above dose conversion factor was to be 0.001 mSv/year  $^{210}\text{Po}$  and 0.009 mSv/year  $^{210}\text{Pb}$ , but low values of CED for  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  are due to less intake of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  in consumption rates However, the Japanese people consume more fish and shellfish than European, American and Asian people. Therefore, the CED value for Japanese is much higher than those for European, American and Asian population (Table 6). Interestingly, the effective dose of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  are below the safety limit recommended by ICRP (1mSv/year  $^{210}\text{Po}$ ; 5mSv/year  $^{210}\text{Pb}$ ) (ICRP, 2007). This result can be explained by the contribution of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  from fish, which are consumed in low quantities by Malaysian and decrease the effective dose. Thus, the sea bass intake was considered to be safe for Malaysian.

#### 4. Conclusion

This study provides a general view of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  activities in coastal area Peninsular of Malaysia. The concentration of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  found to be within in the range of other studies. On the basis of these findings, it was concluded that the  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  activities in the edible parts of the sea bass would pose no health hazards for the consumers. The daily intake and committed effective dose of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  was calculated and found to be lower than IAEA and ICRP. Therefore, low radiation dose expected for Malaysian population through the consumption of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  in the analyzed fish.

#### Acknowledgement

The authors would like to thanks all the individuals and laboratory members involved in this research, especially Mr Mazren for his cordial help during sampling and laboratory

works. This research is funded by the grants of Ministry of Science, Technology and Innovation (MOSTI) through the Science Fund grant No. 04-01-02-SF0117.

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*Received 30 October 2012*

*Accepted 5 November 2012*

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