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Assessment of Environmental and Human Health Risk for Contamination of Heavy Metal in Tilapia Fish Collected from Langat Basin, Malaysia

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Abstract: This investigation quantified spatial variability of heavy metals and followed methods of the U.S. Environmental Protection Agency (EPA) to estimate the hazard indices as well as cancer risks associated with consuming fish caught in the waters of the Langat river basin area, Malaysia. The calculation of metal pollution index (MPI) was carried out to classify the study area according to the level of contamination and the order of stations from highest to lowest MPI values was Langat river > Cempaka lake > Engineering pond > Pond B > Pond A > Jugra > Bandar. The level of exposure due to the consumption of each chemical in Tilapia fish tissue was estimated in an average daily dose equation. The calculated HI ranging from 0.24 to 1.88 indicated 71% stations were in the risk level. Potential carcinogenic risks associated with the ingestion of heavy metals in Tilapia fish were evaluated probabilistically by performing 10,000 trials for Monte Carlo simulation. Cancer risk calculations exceeding the U.S. EPA's acceptable risk level of 1 in 1,000,000 (or 10^{-6}) included Ni (7.3×10^{-4}) and Cd (2.1×10^{-6}). However, the average carcinogenic risk (2.4×10^{-4}) exceeded the accepted risk level to a great extent. The recommended daily ingestion rate of Tilapia for Malaysian people inhabiting Langat river basin area was calculated considering 95th percentile TR value of 10^{-6} as an acceptable risk where it is revealed that consumption of Tilapia should be reduced about 67% from the current level to have an acceptable risk of cancer.

Key words: Risk, HQ, HI, TR, metal, Langat.

Introduction

Heavy metals are considered as harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different parts of the body (Núria et al., 2009). These metals can enter into the food web through direct consumption of water or organisms, or through uptake processes, and be potentially accumulated in edible fish (Paquin et al., 2003) which is a lean source of protein, vitamins, minerals and unsaturated essential fatty acids and consumption of fish have been encouraged by health professionals (Burger et al., 2007; Storelli, 2008). Consumption of these contaminated fishes showed potential risk for humans (Mallin et al., 2011; Mansilla-Rivera and Rodríguez-Sierra, 2011; Storelli, 2008; USEPA, 2000). Similarly, it is reported that people can be exposed to toxic chemicals that accumulate in fish taken from contaminated waters that are consumed (Han et al., 1994; Svensson et al.. 1995). The average

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Cu intake from contaminated green oysters for female individuals was 14 times more than that of international limits (Han et al., 1994). Studies revealed that people consuming large amounts of contaminated seafood may have elevated concentrations of pollutants in their tissues compared to the general population (Asplund et al., 1994; Dewailly et al., 1994). According to the findings of Alam and Mohamed (2011), fish consuming population inhabiting coal burning power plant area were exposed to a higher health risk. As a result, there is a growing concern that metals accumulated in fish muscle can represent a health risk, especially for populations with high fish consumption rates (Burger and Gochfeld, 2009; Díez et al., 2009; Liao and Ling, 2003).

The Langat River basin is a unique basin of Peninsular Malaysia since it passes through three distinct administrative regions of Federal Territory of Putrajaya and Cyberjaya, State of Selangor, and State of Negeri Sembilan. The entire basin is slightly less than 2400 sq. km. The total length of this river has been recorded at 200 km and ends its journey into the Straits of Malacca. The Langat River catchment achieved tremendous growth in the manufacturing sector, and has become the most industrialized area in Peninsular Malaysia. Therefore, Langat Basin water resource is under stress due to poor water quality and the continuous degradation of water quality of the Langat River is a concern for the public and policy makers. Langat River is also an important water resource to aquaculture projects located at the downstream areas. Malaysia is among the countries with the highest fish consumption in the world which relies on fish as a main source of animal protein. Aquaculture has grown rapidly around Langat river basin where a total of 177 ponds covering an area of 52.3 ha are located (Mokhtar et al., 2009). Even though Malaysia is a highly fish consuming country, unfortunately there are not enough studies conducted for the accepted level of fish consumption. The objective of this study is, therefore, to assess the environmental and human health risk due to the pollution of toxic heavy metals in the area of Langat river basin.

Materials and Method

Data Source

Tilapia (*Oreochromis* spp) is a favoured species of edible fish in Malaysia which is supplied from natural water bodies and cultured ponds. Moreover, as this fish species can survive in bad environmental conditions because of their resistance to disease (Zhou et al., 1998), it is considered to be an ideal species of organism for an assessment study on the effect of heavy metal contamination in aquaculture ponds (Mokhtar et al., 2009). Therefore, in this study, data of metal concentrations for Tilapia fish species, collected from different locations of Langat river basin, were obtained from the published result of Taweel et al. (2011) and Mokhtar et al. (2009) which are presented in Table 1.

Calculation of Metal Pollution Index (MPI)

Metal Pollution Index (MPI) is a procedure which reflects the status of heavy metal contamination in the environment. To compare the total metal content in the different sampling sites investigated in this study, the metal pollution index (MPI) was calculated according to Usero et al. (1997) with the following formula:

Table 1: Mean concentration of heavy metals in Tilapia fish (*Oreochromis* spp) in different location of Langat river basin

Location	*Heavy metal concentration (µg/g dry weight)*					
	Pb	*Cd*	*Ni*	*Cu*	*Cr*	*Zn*
Bandar	0.42±0.09	0.02±0.00	0.05±0.01	0.31±0.04	0.71±0.08	1.92±0.06
Jugra	0.40±0.02	0.01±0.00	0.11±0.02	0.32±0.02	0.81±0.07	2.32±0.07
Pond A	0.11±0.01	0.01±0.0	2.8±0.25	0.313±0.76	6.21±0.6	31±2.8
Pond B	0.10±0.01	0.01±0.0	2.7±0.17	2.33±0.16	6.1±0.29	29±1.6
Langat River	0.18±0.04	0.02±0.0	3±0.22	5.47±0.49	5.92±0.32	33±5.3
Cempaka lake	0.15±0.01	0.03±0.0	3.2±0.33	3.4±0.74	6±0.15	37±0.06
Engineering lake	0.14±0.05	0.03±0.0	3±0.43	2.36±0.4	5.7±0.22	45±0.8

Source: Taweel et al., 2011 and Mokhtar et al., 2009.

$$\text{MPI} = (Cf1 \times Cf2 \times \cdots \times Cfn)^{1/n} \quad (1)$$

where *Cfn* is the concentration of the metal *n* in the sample.

The MPI of the organisms was calculated by obtaining the *n*-root from the *Cfn* that were obtained for all the metals.

Health Risk Assessment Procedure

Human health risk assessment is the characterization of the potential adverse health effects of human exposures to environmental hazards (USEPA. 2012). This process employs the tools of science, engineering, and statistics to identify and measure a hazard, determine possible routes of exposure, and finally use that information to calculate a numerical value to represent the potential risk (Lushenko, 2010). A human health risk assessment involves four steps which are: hazard identification, dose-response assessment, exposure assessment, and risk characterization. The concerning chemicals in a risk assessment fall into one of two categories, non-carcinogen or carcinogen, which determines the procedure for how the chemical is assessed and potential risks calculated. Non-carcinogenic chemicals are assumed to have a threshold; a dose below which no adverse health effects will be observed where an essential part of the dose-response portion of a risk assessment includes the use of a reference dose (RfD). On the other hand, carcinogens are assumed to have no effective threshold. This assumption implies that there is a risk of cancer developing with exposures at low doses and, therefore, there is no safe threshold for exposure to carcinogenic chemicals. Carcinogens are expressed by their Cancer Potency Factor (Lushenko, 2010).

Since the dietary intakes for humans are reported in terms of wet weight ingestion, the wet weight conversion is applied to conduct the risk assessment and the calculated values are presented in Table 2. Equations for converting between dry and wet weight concentrations are obtained from OhioEPA (2008) and presented below:

$$\text{Wet Weight} = (\text{Dry Weight})\ (1 - (\text{Percent moisture content}/100)) \quad (2)$$

In the present study, the non-carcinogenic human risk assessment was calculated according to Onsanit et al. (2010) using the estimated daily intake (EDI) and reference dose (RfD) and estimated using the following equation:

$$\text{EDI} = M_C \times [\text{IR}/\text{BWa}] \quad (3)$$

where M_C = average trace element concentration in organism muscle (μgg^{-1} wet weight), IR = Fish consumption ($gday^{-1}$) per capita, and BWa = average body weight of target population. The hazard quotient (HQ) is considered to be an estimate of the risk level (non-carcinogenic) due to pollutant exposure which is calculated from the following equation:

$$\text{HQ} = \text{EDI}/\text{RfD} \quad (4)$$

A summation of the hazard quotients for all chemicals to which an individual is exposed was used to calculate the hazard index (USEPA, 2011).

$$\text{HI} = HQ_{Pb} + HQ_{Cd} + HQ_{Ni} + HQ_{Cu} + HQ_{Cr} + HQ_{Zn} \quad (5)$$

where HI is the hazard index; HQ_{Pb} is the target hazard quotient for Pb intake; HQ_{Cd} is the target hazard quotient for Cd intake; HQ_{Ni} is the target hazard quotient for Ni intake; HQ_{Cu} is the target hazard quotient for Cu intake; HQ_{Cr} is the target hazard quotient for Cr intake; and HQ_{Zn} is the target hazard quotient for Zn intake.

Carcinogenic risk was evaluated by target cancer risk (TR). The method for estimating TR was provided in USEPA Region III Risk-Based Concentration Table (USEPA, 2011) and the model is shown as:

Table 2: Concentration of heavy metal in analysed Tilapia fish

Location	*Heavy metal concentration (µg/g w/w)*					
	Pb	*Cd*	*Ni*	*Cu*	*Cr*	*Zn*
Bandar	0.10	0.00	0.01	0.08	0.18	0.48
Jugra	0.10	0.00	0.03	0.08	0.20	0.59
Pond A	0.03	0.00	0.70	0.08	1.55	7.75
Pond B	0.03	0.00	0.68	0.58	1.53	7.25
Langat River	0.05	0.01	0.75	1.37	1.48	8.25
Cempaka lake	0.04	0.01	0.80	0.85	1.50	9.25
Engineering lake	0.04	0.01	0.75	0.59	1.43	11.25

$$TR = (M_C \times IR \times 10^{-3} \times CPSo \times EF \times ED)/(BWa \times ATc) \quad (6)$$

where TR is the target cancer risk; M_C is the metal concentration in fish (μgg^{-1}); IR is the fish ingestion rate ($gday^{-1}$); CPSo is the carcinogenic potency slope, oral ($mg/kg\ bw\text{-}day^{-1}$); and ATc is the averaging time, carcinogens (days $year^{-1}$). The distribution of carcinogenic risk was estimated for Ni, Pb and Cd as these are the elements for which an oral slope factor is derived. Table 3 shows the input parameters used in the health risk estimation. An averaging time of 365 d/yr for 73 yrs (i.e., ATc = 26845.75 d) was used to characterize lifetime exposure for cancer risk calculation (USEPA, 2011). The USEPA has concluded that a lifetime cancer risk of 10^{-6} (1 in a million) or less can generally be considered as acceptable, whereas a lifetime risk of 10^{-3} or greater is considered serious and requires attention. Risk level between 10^{-6} to 10^{-4} (1 in 10,000) may also be up to standard but requires a case-specific judgment. The health protection standard of lifetime non-carcinogenic risk for HI is 1 (USEPA, 2011).

Results and Discussions

Environmental Risk Assessment

Spatial analysis trends for Tilapia fish metals at seven sites around Langat river basin area were determined using the metal pollution index (MPI). The MPI values of six heavy metals in Tilapia fish of this study area are summarized in Figure 1. The concentrations of most of the metals in the Tilapia fish varied to a large extent depending on the locations of sampling sites and the highest MPI was recorded in the Langat River. This index provides a classification of the study area according to the level of contamination and the order of stations from highest to lowest MPI values was Langat river > Cempaka lake > Engineering pond > Pond B > Pond A > Jugra > Bandar. The calculated values of present study are slightly higher than the values of Tilapia, collected from Ogun river catchment which ranged from 0.16 to 0.21 (Adeniyi et al., 2008). The MPI for two fish species (*S. rivulatus* and *S. sargus*) fluctuated between 0.9 and 1.8 in EI-Mex and Eastern Harbour (Khaled, 2004) which is in a good agreement with the present study. A much higher level of MPI was recorded for *P. viridis* collected from peninsular Malaysia (Amin et al., 2005) because the concentration of heavy metals in organisms exhibited the following decreasing order: cephalopod > bivalve > crustacean > fish (Ahdy et al., 2007).

There is a long history of pollution in Langat River. In the year 2000, the Langat River was classified as averagely polluted (water quality index, WQI = 36-89). Except for the upstream at the Hulu Langat area before Sg. Lui where the river pollution is still relatively low and WQI is in class I, the downstream section of the Langat after the tributaries of Sg. Balak and Sg. Batang Benar is polluted with WQI reaching class III to IV

Table 3: Summary statistics of input parameters in the health risk estimation

Symbol	*Description*	*Unit*	*Value*
MC	Average trace element concentration in organism muscle	μgg^{-1} wet weight	Presented in Table 2
IR	Fish consumption per capita	$gday^{-1}$	Per capita fish consumption for Malaysia was 45.1 $kgyr^{-1}$ = 123.56 $gday^{-1}$ (Statistic of Agro Food, 2010).
EF	Exposure frequency	days $year^{-1}$	350 (Liu et al., 2007)
ED	Exposure duration	Years	30
RfD	Reference dose	$\mu gg^{-1}day^{-1}$	Pb = 0.003 (EC, 2004; Tu et al., 2008), Cd = 0.001, Ni = 0.05, Cu = 0.04, Cr = 0.003, Zn = 0.03 (USEPA, 2011)
BWa	The average body weight of target population	kg	The average body weight of Malaysian population was 59.23 kg (Lim et al., 2000).
ATc	Averaging time carcinogens	Days	26845.75
CPSo	Carcinogenic potency slope, oral	$\mu g\ g^{-1}\ day^{-1}$	Ni = 1.7 (USEPA, 2011), Pb = 0.009, Cd = 0.6 (OEHHA, 2011)

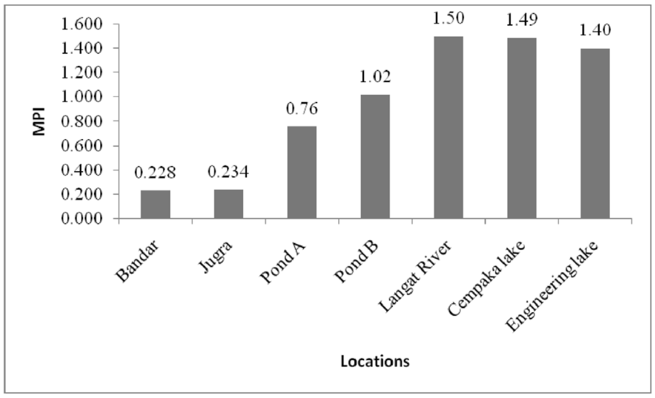


Figure 1: Calculated values of MPI in different locations of Langat Basin area.

(Khairuddin and Abd Malek, 2002). The Department of Environment (DOE) Malaysia has announced the Sungai Langat basin as a polluted river in 2006 due to rapid growth of industrialization in areas along the Sungai Langat basin (DOE. 2006). According to *The Star* (2006), the drains from different kinds of premises lead to a larger drain and empties out into Sungai Langat. Moreover, the sewage from these premises is not channeled into any sewage treatment plant before the wastewater is released into Sungai Langat.

In 2007, almost one million citizens in the State of Selangor suffered because of the ammonia pollution in Sungai Langat and Sungai Selisik which are the main water supply intake points (Yusof, 2007). In 2009, Salak Tinggi Water Treatment Plant was shut down for a total of 2480 h because of poor water quality (PNSB, 2010). Lately in September 2010, the water treatment plant in Sungai Semenyih which is the main tributary of Sungai Langat basin was closed. The raw water supply from Sungai Kembong was polluted due to the solid waste dumping in the nearby landfill area (Bernama, 2010). Moreover, it is recorded that sediments of the Juru and Langat rivers were contaminated by Pb and Zn, while the Langat River was heavily contaminated by Cd (Shazili et al., 2006). Besides that, a study conducted by Mohamed et al. (2009) reported that agricultural and industrial activities were identified as the main pollution sources to groundwater and soil ecosystem in the Langat basin.

The average concentration of Pb, Cd, Fe and Cu in water samples obtained from the Langat river basin ranged from 0.074 to 0.100 mg/l, 0.0016 to 0.032 mg/l, 0.82 to 4.87 mg/l, and 0.034 to 0.201 mg/l, respectively (Yusuf and Nordin, 2003) that exceeded the Interim National Water Quality Standards (INWQS) by Ministry of Health Malaysia which are 0.05, 0.01, 1.0 and 0.20 mg/l, respectively. Furthermore, it is recorded that the average level of Ni and Zn obtained from rivers in the Langat Basin ranged from 16.42 to 31.83 μg/l and 14.63 to 91.56 μg/l, respectively (Yusuf and Nordin, 2003) which are quite high compared to the INWQS limit (0.05 and 5.0 mg/l respectively). This may indicate that the higher accumulation of heavy metal in Tilapia is because of the water pollution of Langat River. However, the 2nd most polluted water body is Cempaka Lake, which is a man-made freshwater lake where the water supply comes from the rain water and mixes with sewage water from the adjacent restaurants that is drained finally through spillways to Langat River (Said et al., 2012). According to Taweel et al. (2011), the concentration of heavy metals in fish collected from natural river and lakes can be higher than that collected from cultured ponds due to the fact that natural water sources are more exposed to contamination than controlled artificial ponds. Hence, the observed MPI values of natural water Tilapia fish are comparatively higher than cultured ponds.

Health Risk Assessment

Non-carcinogenic Risk Assessment

The heavy metal concentration for each chemical was used to estimate adverse non-carcinogenic health risk. Table 4 displays the calculated values of HQ and HI of Tilapia collected from different study locations. HQ larger than 1 implies the estimated exposure exceeded the USEPA reference dose for the contaminant of interest. Among all the analyzed heavy metals, Cr had the HQ value greater than 1 for Culture pond A, Culture pond B, Langat River, and Cempaka Lake. The HQ value for Pb reported in the current study ranged from 0.017 to 0.073 which were much lower than those measured in Tri states mining districts where the HQ ranged from 0.1 to 4.6 (Schmitt et al., 2006). A study done by Mishra et al. (2007) in the Trans-Thane Creek area of Mumbai, measured the trace element in different types of marine organisms and reported the HQ values of 0.01 (50th percentile) and 0.005 (95th percentile) in case of the ingestion of Cd. The same study also revealed lower HQ values for Cr, Ni, Zn and Cu and suggested that consumption of fish were within the safe limit (Mishra et al. 2007). Similar to the findings, Tu et al. (2008) worked on the concentration of Cr, Cu, Zn and Cd, and measured HQ values of less than 1 which indicated that the local residents were not exposed to potential risk via consumption of shrimp. On the other hand, Schmitt et al. (2006) reported a higher range of

Table 4: Calculated values of HQ and HI in Tilapia fish

Locations	*HQ*						*HI*
	Pb	*Cd*	*Ni*	*Cu*	*Cr*	*Zn*	
Bandar	0.073	0.008	0.001	0.004	0.124	0.033	0.243
Jugra	0.069	0.003	0.001	0.004	0.142	0.041	0.261
Pond A	0.019	0.005	0.029	0.004	1.084	0.541	1.683
Pond B	0.017	0.005	0.028	0.030	1.065	0.506	1.652
Langat River	0.031	0.010	0.031	0.072	1.033	0.576	1.754
Cempaka lake	0.026	0.016	0.034	0.045	1.047	0.646	1.813
Engineering lake	0.024	0.016	0.031	0.031	0.995	0.785	1.883

HQ values for Cd (0.1-0.5) and Zn (0.1-12.6) in carp fishes.

In the case of current study, although the observed values of HQ for Pb, Cd, Ni, Cu and Zn were lower than the safe standard of 1, but ∑HQ of these metals (HI) were higher than 1. The calculated HI ranged from 0.24 to 1.88 which indicates that 71% of stations are in the risk level while Bandar and Jugra were the only stations analyzed with HI values of less than 1. Samples of black-chin Tilapia, collected from Sukumo lagoon of Ghana, were analyzed for the concentration of heavy metals and the calculated values of HI indicated that the Tilapia did not pose any health risk to humans (Laar et al., 2011).

As contaminated fishes pose health risks, consumption advisories may recommend that people limit or avoid eating certain species of fish caught in certain places (USEPA, 2012). Therefore, every year since 1993, the EPA has made available to the public a compendium of information on locally issued fish advisories and safe eating guidelines. This information is provided to EPA by states, U.S. territories, Indian tribes, and local governments who issue fish consumption advisories and safe eating guidelines to inform people about the recommended level of consumption for fish caught in local waters. Similarly, OEHHA's fish advisories provide "safe eating guidelines" to help people choose the safest fish to eat and avoid fish species with high levels of chemicals in them which are based on sampling results for common fish species that people catch and eat from California's water bodies. Unfortunately, this information is not well developed in Malaysia. Therefore, the concept of OEHHA has been used in the present study to categorize the risk of fish consumption collected from different locations of study area and presented in Figure 2. In OEHHA's advisories, fish are divided into three categories based on their level of contamination (OEHHA, 2007). According to OEHHA, fish in the left panel are "green" and have a low level of contaminant. Fish in the middle panel are "yellow" and have a medium chemical level, whereas fish in the right panel are red and have a high chemical level. In the present study, the Tilapia fish collected from different locations are divided into three groups—A: Bandar and Jugra; B: Pond A and Pond B; and C: Langat River, Cempaka lake, and Engineering lake. Based on the values of the risk assessment, it is found that ingestion of Tilapia collected from Langat river, Cempaka lake, and Engineering lake (group C) may result in non-carcinogenic risk in consumers. Therefore, it is recommended that the fish consumption from these areas should be reduced.

Carcinogenic Risk Assessment

Of the six-targeted chemicals, carcinogenicity values were only reported for Ni, Pb and Cd as no values of carcinogenic potency slope were available for the rest. Usually, the 5th, 25th, 50th, 75th and 95th percentiles of risk are considered to assess likelihoods of exceeding risk levels (Han et al., 2000; Jang et al., 2006; Liao and Ling, 2003). This study performed 10,000 trials for Monte Carlo simulation for risk assessment by using Excel 2010 for all area data. The simulation assumed normal distribution of data with mean (0.000739317) and standard deviation (0.000488501). The data are tested both with one tailed and two tailed. It is most logical that the health risk cannot be negative. Thus, the outcome of one tailed is more preferable than two tailed. The TRs for Ni calculated from 5th, 25th, 50th, 75th and 95th percentiles are 7.76×10^{-5}, 4.12×10^{-4}, 7.21×10^{-4}, 1.05×10^{-3} and 1.5×10^{-3}, respectively (Figure 3a). As these values are over one millionth, it is assumed that potential risk exists. The risk calculated for Pb was found to be low and the 50th and 95th percentile was 3.87×10^{-7} and 7.99×10^{-4} (Figure 3b). The calculated risk

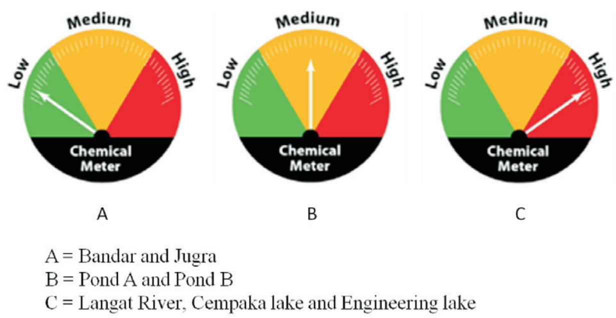
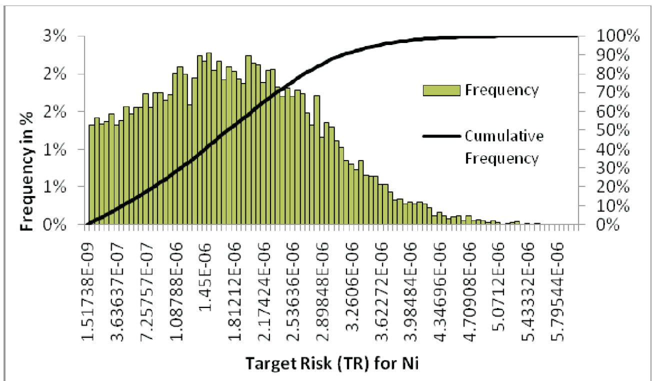


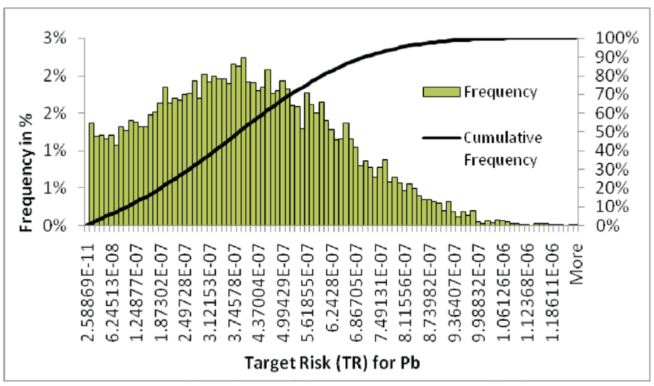
Figure 2: Fish consumption advisory diagram for Langat basin area.

for Cd slightly exceeded the acceptable risk standard at 75th and 95th percentiles (Figure 3c).

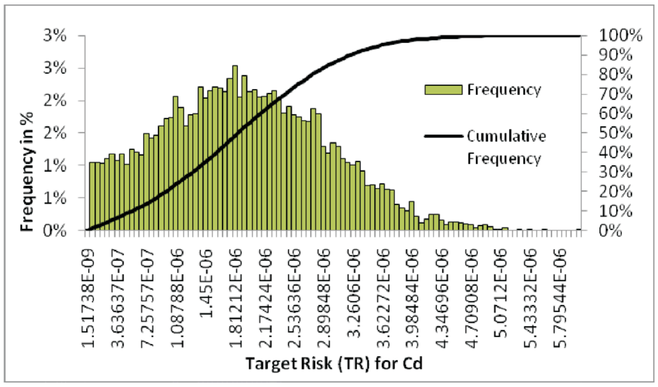
The average carcinogenic risk (2.4×10^{-4}) derived from the intake of metals greatly exceeded the generally accepted risk level of 10^{-6}. This risk level is basically due to the dietary intake of Ni through Tilapia collected from natural sources. There is very limited research about the TRs values of Ni. The average value of TR for Ni was 3.4×10^{-4} for Tilapia collected from tropical wetland in India (Bhupander and Mukherjee, 2011). Comparing this result to the current study (7.3×10^{-4}), the cancer risk for tropical wet land fish is less than



(a)



(b)



(c)

Figure 3: The frequency distributions of the simulation (one tailed) for Ni, Pb and Cd.

the present study. Similarly, TR calculated for Clam consumption in southern Taiwan ranged from 0.28×10^{-6} to 4.52×10^{-6} in the case of arsenic which are also lower than the present study (Liu et al., 2007). The oyster samples from Taiwan showed TRs values of $12.6\text{-}38.2\times10^{-6}$ at 95th percentile which are well above the present study (Liu et al., 2006). However, there is no published data available for the carcinogenicity of Pb and Cd.

Considering 95th percentile TR value of 10^{-6} as an acceptable risk, the associated recommended daily ingestion rate of Tilapia for Malaysians can be calculated by Equation (6). As Pb did not demonstrate any significant risk, only Ni and Cd were considered. Taking into account the mean concentration of Ni and Cd, the safe daily intake was calculated as 40.25 g/day/person (Figure 4). Therefore, it can be assumed that Tilapia consumption should be reduced by about 67% from the current level to have an acceptable health cancer risk (10^{-6}) from the exposure to Ni and Cd through the consumption of Tilapia collected from the Langat river area.

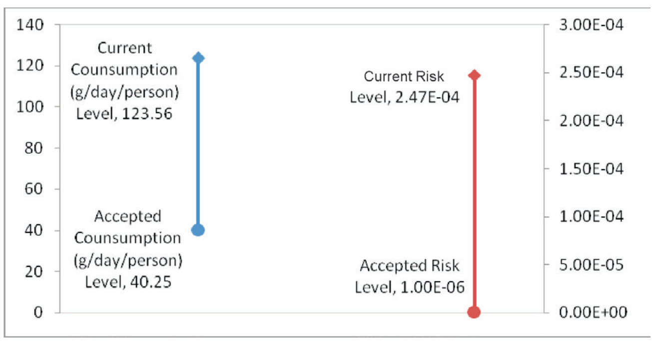


Figure 4: Gap between accepted and current level for fish consumption and health risk of Malaysian people.

Conclusion

This work studied the environmental and human health risk due to pollution caused by toxic heavy metals at different places around the Langat River. Among all the studied locations, Tilapia of Langat River showed the highest MPI values and Bandar the lowest. It is assumed that the higher accumulation of heavy metals in Tilapia of Langat River is because of the long history of water pollution. Results from this study's human health risk assessment showed that there is an elevated risk, due to several chemicals, associated with the consumption of Tilapia fish at per capita ingestion rates of 45.1 $kgyr^{-1}$. The estimation of risk conducted in this study showed that adverse health effect may occur when consuming Tilapia fish mostly from the natural water bodies. Therefore, it is strongly recommended to take appropriate steps to identify ways to reduce the risk. However, the data collected and analyzed in this study epitomized the need to establish an ongoing monitoring programme at Langat basin area. As no detailed data in different environmental aspects were available in the study area during this investigation, this study was not able to confirm the source of contamination for Tilapia. Therefore, more research should be performed in the Langat river area to establish precise fish consumption data and inspect contaminant concentrations in more fish species. The fish risk assessment of the present study was the first of its kind done in Malaysia and has provided a good platform to begin development of future research projects. That is why, it is recommended to continue this kind of research in order to create consumption advisory for Malaysian populace for any possible health risks.

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