Assessment of Heavy Metal Pollution in Malaysia's Smallest State: Perlis

Perlis is the smallest populated city in northwest Malaysia, situated near the Thailand border and is one of the developing states in Malaysia (Ripin, Hasan, & Kamal, 2014). Studies have shown chemical degradation processes from heavy metal have an effect on soils in Perlis. Heavy metals are the most dangerous of the anthropogenic environmental pollutants due to their toxicity and persistence in the environment, and low mobility even under high precipitation (Abegunde, 2011; Guo, Wu, Xie, & Zhang, 2012; Koz, Cevik, & Akbulut, 2012). Heavy metal contamination of soils is becoming a severe issue around the world, including Malaysia, as a result of anthropogenic activities such as mining, smelting, burning of fossil fuels, motor traffic, chemical fertilisers and pesticide use (Qin et al., 2014; Suzhen Cao, 2014; L. Zhao, Xu, Hou, Shangguan, & Li, 2014). Rising metal concentration in soils is a serious and current concern for governmental and regulatory bodies for environmental and human risk assessment (Maas et al., 2010). The assessment of heavy metal contamination can be conducted using various methods such as total heavy metal concentration (H. Zhao, Xia, Fan, Zhao, & Shen, 2012). The present study assessed heavy metal pollution in soils by employing a Pollution Index (PI).

> *"Increasing anthropogenic influences on the environment, especially pollution levels, have caused negative changes in natural ecosystems, decreased biodiversity, simplified structure and lowered productivity. Consequently, it is imperative to continually assess and monitor the levels of heavy metals in the environment"*

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This research is done with a goal of a assessing heavy metal pollution in soil tested around Perlis. The result can then be used as a basis for improving the situation and guide environmental planners and government in reducing pollution in Malaysia.

Experimental

Figure 1 shows a map of sampling points in the study area for sample collection (depth: 0-15cm) using a hand auger. Chemical analysis was via the EPA method 3050B (HNO_3 : H_2O_2) (E. Lutz, 2012). Analysis of the samples including soils digests and blanks was set up in duplicates.

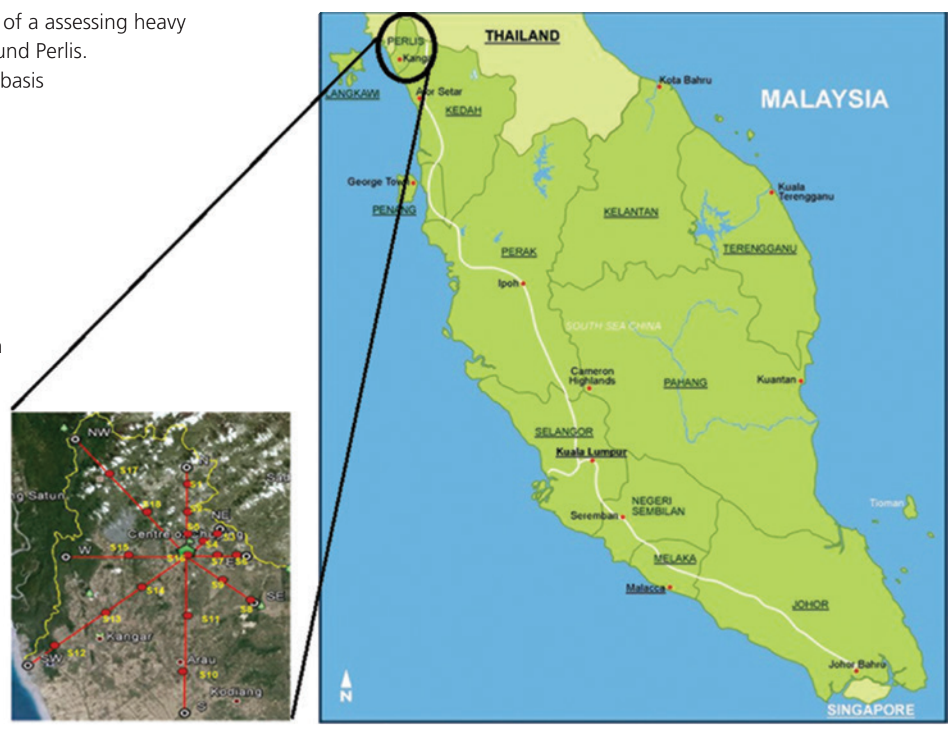

Figure 1: Map of sampling points

Pollution Index Methods Used

Pollution index is an approach used to assess contamination level of the studied heavy metals.

PI = Cn/ Bn ------------ Equation 1(Binggan Wei, 2009)
Where Cn (mg/kg) is the measured concentration of each heavy metal and Bn is background value for each metal. The PI of each metal was classified as either low (P≤ 1), moderate (1< PI≤ 3) or high contamination (PI>3).

Result and Discussion Heavy metal in soil

Heavy metal concentrations for this study were compared with the allowable limits (Table 1) from the Netherlands (Wang et al., 2012) and China (ECDGE 2010) since there is no available information in Malaysia on soil background values for heavy metal concentrations (Foo Toon Fong, 2008; Wang et al., 2012).

Heavy metal	Netherlands[b]	Environmental Quality Std of Soils GB15618-1995a	This study
Cu	0.5	0.6	063
Pb	40	100	240.59
Cd	40	350	27.47
Cr	15	60	2.40
Ni	30	250	3.92

Table 1 Allowable limits of heavy metal concentrations in soil (mg/kg)

Based on the result computed from ICP-MS, maximum concentrations of Cu (240.59 mg/kg) and Cd (0.63mg/kg) levels were higher compared with limits from the Netherlands and China. Thus, attention must focus on controlling the high level, because it may result in dangerous effects in the future. Meanwhile, Pb, Cr and Ni were relatively below limits from other countries (Table 1). Thus, we can summarise that most of the Perlis state soils are still within a safe level of heavy metal contamination, with the exception of certain locations that demonstrate high values of Cu and Cd which exceed current allowable limits.

Figure 2: Soil sampling process using hand auger

Distribution of heavy metals in the study area

All 5 elements (Cu, Pb, Cr, Ni, Cd) were highly distributed around the center of the sampling location which is on station 2,4,5,7 and 16. This centralised area was located near the Chuping industrial area which has a lot of cement, chemical and quarry activity, and is also near a major road that has a heavy traffic burden. This industrial activity leads to the emission of heavy metals as reported in previous studies (Limei Cai & Hongfu Wan, 2012; Snežana Dragović & Milan Kilibarda, 2013; Suzhen Cao, 2014; Yuan, Sun, Han, Li, & Lang, 2014; L. Zhao et al., 2014). Cu generally has the highest value while Cd generally has the least, and therefore the observed order for this study, from highest to lowest level of heavy metal contamination, is Cu>Pb>Cr>Ni>Cd. Previous reports have found that heavy metals emitted from the cement industry, which undergo process and production, require energy from the burning of fossil fuels (Arpita Mandal, 2011; Li & Feng, 2012) and vehicle emissions (Arpita Mandal, 2011; Guo et al., 2012; Limei Cai & Hongfu Wan, 2012). This activity is considered as a major emission source for both the ambient atmosphere and soil (Guo et al., 2012). Thus, from the overall result, we can state that contamination levels in Perlis are still within controllable levels, though certain locations, near industrial areas and major roads, show high levels of heavy metal pollution. For further views on contamination levels in the study area, a heavy metal assessment index was carried out and is explained in further detail below.

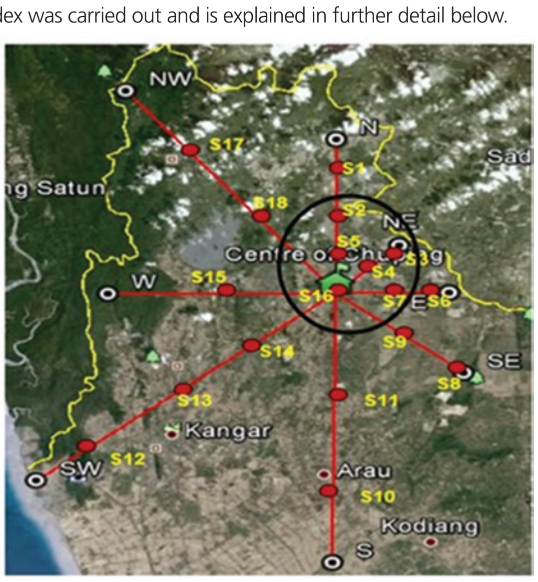

Figure 3: Centralised area affected by heavy metal.

	Cu	Cd	Cr	Ni	Pb
PI> 3	11%	6%	0%	0%	0%
1< PI≤ 3	6%	0%	0%	0%	6%
PI≤ 1	72%	94%	100%	100%	94%

Table 2 Heavy metal percentage based on the Pollution Index

Heavy metal assessment

Various sources, both anthropogenic and natural, have influenced heavy metal levels in the study area. The Pollution Index (PI) approach applied to the dataset was used to discover possible sources that might influence the different distribution of elements over the study area around Perlis. The Pollution Index was calculated relative to the background values of heavy metals in the soils and the result is as shown in table 2.

High PI values (higher than 3) were observed in 11% of the samples for Cu, and 6% for Cd (Table 2), indicating high contamination. Cu and Cd pollution is relatively serious in Perlis soil when compared with other elements. The PI values were relatively high in the central area, which encompasses stations 2,4,5,7 and 16 in the areas where there are both heavy traffic impacts and numerous industrial activities (higher than in other districts), indicating the presence of serious heavy metal pollution (K. B. Mmolawa, 2011; Yang, Lu, Long, Bao, & Yang, 2011). Therefore, highly contaminated samples have clearly been polluted by anthropogenic emissions (Lu et al., 2012). About 6% of Pb samples are classified as moderately or heavily contaminated (table 2) indicating there is potential Pb pollution in the area. Cr and Ni are 100% at low contamination level (table 2) indicating no obvious pollution for Cr and Ni.

From table 2, we can see that, generally speaking, the majority of the study area is still in a relatively secure state where more than 70% of all study areas for each element indicate low contamination (PI≤ 1). Meanwhile, less than 15% of Cu, Pb and Cd samples show moderate and high contamination levels.

Conclusion

Levels of heavy metals in soil near the central Chuping industrial areas give maximum values when compared with other locations in Perlis. In respect of the Pollution Index, only Cu (11%) and Cd (6%) samples were classed as heavily contaminated. Meanwhile, 6% of samples for Cu and Pb from all stations gave moderately contaminated results and the other elements show low contamination. Results of combined heavy metal concentrations and heavy metal assessment indicate that industrial activities and traffic emissions represent the most important sources for Cu, Cd and Pb whereas Cr and Ni are mainly from natural sources. Increasing anthropogenic influences on the environment, especially pollution levels, have caused negative changes in natural ecosystems, decreased biodiversity, simplified structure and lowered productivity. Consequently, it is imperative to continually assess and monitor the levels of heavy metals in the environment due to anthropogenic activities for the accurate evaluation of human exposure and for the sustainability of the environment.

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