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Lead in Blood and Hair of Population near an Operational and a Proposed Area for Copper Mining, Malaysia

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Lead toxicity is one of the known human health problems. Lead accumulates in biological systems and its mechanism of action is slow. Generally, lead could cause protoplasm poisoning (Berman 1980). The toxicity of lead at high levels of exposure is well known, but a major concern of today is the possibility that continual exposure to relatively low level of lead may entail adverse health effects. Lead impairs the renal, hemopoietic and nervous systems and it has been suggested that lead is causally related to deficiency in cognitive functioning (Bergback *et al.* 1992).

Hair has been used indicator filaments for lead accumulation in human because lead concentration in hair is probably correlated to lead storage in bones (Eltayeb and Grieken 1990). Lead circulates in human body system through the blood circulation. Lead concentration in blood (PbB) is an important parameter in the assessment of lead exposure and its toxicity effects to humans. Blood is a good indicator of the current level of lead in human body but not a good indicator of the total lead body burden (Ahmed and Elmubarak 1990). Lead concentration in blood depicts the dynamic equilibrium between exposure level, rates of take, distribution and excretion (Racliffe 1981).

In this study the concentration of lead in blood and lead in hair from a selected population living in the vicinity of a copper mine in Ranau district and population living in the vicinity of a proposed copper mine in Bidu Bidu was measured. Figure 1 shows the location of study areas. The copper mine in Ranau has been operational since 1975. It is situated upstream of Labuk and Sugut rivers in Lohan Valley, an agricultural area which is drained by Labuk, Sugut, Liwagu, Mamut, Merali, Langanan, Pangakatan, Lohan and Bongkud rivers. Lohan, Mamut and Merali rivers are tributaries of Sugut River. The upstream area of Sugut River is made up of igneous and metamorphic rocks which are rich with minerals containing gold, silver, zinc, copper and chromium (Rakmi *et al.* 1984). A mine tailings dam called Lohan Dam is situated within one km of Bongkud Village (KB) and about 16 km from the open cut mine. The waste failings are transported to this dam via pipes.

Previous physicochemical studies around the copper mine area reported elevated levels of heavy metals in water, sediment, plants and aquatic organisms samples suggesting a possible contamination due to mining activities (Rakmi *et al.* 1984, Murtedza and Hanapi 1984, Jumat and Maimunah 1989), Mokhtar and Hazan (1990) reported their preliminary findings of elevated trace metals (including lead) in hair samples of the population living in the vicinity of the copper mine in Ranau.

MATERIALS AND METHODS

A total of 424 blood samples and 360 hair samples were obtained from populations of Singgaron Baru Village (KSB) and Bongkud Village (KB), both situated near the operational copper mine in Ranau (Fig. 1); Sualog Village (KS), Kiabau Village (KK), Perancangan Village (KP), Bambangan Village

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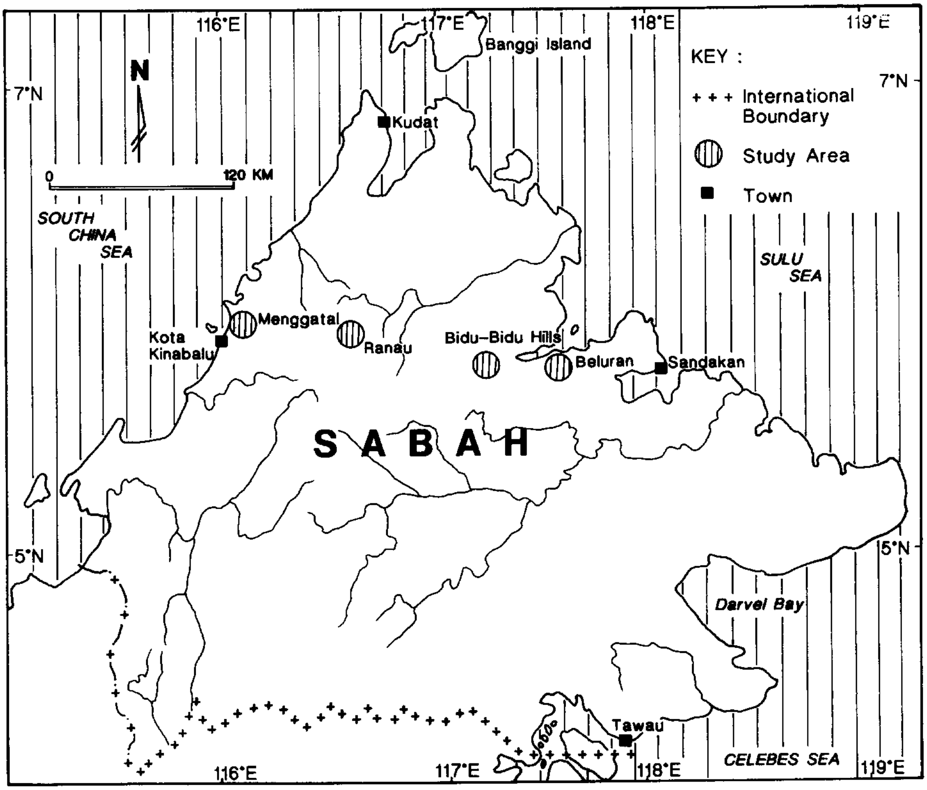

Figure 1 : *Map of study area.*

(KD) and Beluran Town (B), all these around Bidu Bidu Hills. Blood samples of the population in the Sabah Campus of the Universiti Kebangsaan Malaysia (UKMS) were also obtained for comparison purposes. UKMS is situated about 20 km from Kota Kinabalu and about 100 km from Ranau.

Blood samples were digested in concentrated nitric acid, neutralised with acetate solution, complexed with Ammonium Pyrolidine Dithiocarbamate (APDC) and then extracted into Methyl Isobutyl Ketone (MIBK) Quantification of Pb in MIBK was done using the flame atomic absorption spectrophotometer (AAS) Perkin-Elmer model 2380.

Hair samples were washed with distilled water, Triton X100 (an non ionic detergent), ethylenediaminetetraacetic acid disodium (EDTA) solution and rinsed with distilled water again. Cleaned hair sample (about 1 g) was digested in nitric and perchloric acids, cooled and diluted to the mark of a 100 ml volumetric flask with distilled water. Concentrations of Pb in these solutions were then measured using the flame AAS. Concentration of Pb in hair and blood samples are expressed in units of µg/g dry weight and µg/ml, respectively.

RESULTS AND DISCUSSION

Table 1 shows the mean PbB values for adults at all study locations. Mean PbB values for adults in each location are all still below 0.4 µg/ ml. The recommended maximum level (RML) of lead in blood values for adults is 0.4 µg/ml (NRC 1973). About 15% of the blood samples of adults in KSB has PbB values which exceeds RML, but none exceeds 0.8 µg/ml. According to Walter 1980, lead poisoning seldom occurs in adults with PbB < 0.8 µg/ml. However, the degree of tolerance towards lead varies in different individuals. Overall, the means of children-PbB in this study were still below RML.

Statistic tests (t-test) showed that PbB values for male are 15-25% higher than female ($p<0.05$) for all study locations except KK and UKMS. For females in KS and males from KSB, KB and KD it was found that PbB values increased with age ($p<0.05$). Females and males from other locations of this study did not show any significant difference in PbB values with increase in age ($p>0.05$). PbB concentrations for smokers in KS, KD, UKMS and KSB were found to be about 2x higher than non-smokers ($p<0.05$). In other locations of this study smokers did not show any significant difference in PbB concentrations than non-smokers.

The mean PbB values for combined population without discriminating the age groups and sexes for all locations in this study is shown in Table 2. The mean PbB value for the two villages near the copper mine (KSB and KB), 0.35 µg/ml was found to be higher than the mean of 0.29 µg/ml reported by a study in Belgium (Sartor and Rondia 1980); about the same with the mean of 0.34 µg/ml reported for a group of laboratory workers in Pakistan (Talib et al. 1990); and lower than the mean of 0.8 µg/ml for acid battery plant workers in Sudan (Mohamed et al. 1986).

The mean PbB value for children in the vicinity of the copper mine (KSB and KB) of 0.30 µg/ml,and a mean PbB value of 0.16 µg/ml for children in Bidu Bidu Hills were found to be higher than a mean of 0.10 µg/ml for a group of children in Ontario Canada (Wang *et al.* 1989), but lower than the mean of 0.33 µg/ml for children of acid factory workers in London (Elwood *et al.* 1977).

Table 3 shows the means for PbH values of KSB, KB, KK, KP, KD and B, without discriminating age

Table 1. Mean concentrations of blood-lead (PbB) in children and adults of this study

Location	PbB in µg/ml Children (<12 yr)	Adults (>12 yr)
Sualog Village (KS)	0.15 ± 0.05 (n=15)	0.25 ± 0.07 (n=36)
Kiabau Village (KK)	0.19 ± 0.05 (n=17)	0.26 ± 0.08 (n=48)
Perancangan Village (KP)	-	0.24 ± 0.06 (n=23)
Bambangan Village (KD)	0.13 ± 0.04 (n=7)	0.23 ± 0.07 (n=34)
Beluran (B)	-	0.26 ± 0.05 (n=14)
UKMS	-	0.13 ± 0.01 (n=34)
Singgaron Baru Village (KSB)	0.31 ± 0.01 (n=42)	0.33 ± 0.01 (n=52)
Bongkud Village (KB)	0.29 ± 0.02 (n=51)	0.37 ± 0.01 (n=51)
Recommended Maximum Level	0.3 (Ratcliffe 1981)	0.4 (Selander and Cramer 1970)

Table 2 . Mean concentration values of blood-lead (PbB) for all locations in this study without discriminating sexes and ages.

Location	No. of samples	Mean PbB concentration (μg/ml)
Sualog Village (KS)	51	0.22 ± 0.08
Kiabau Village (KK)	65	0.24 ± 0.10
Perancangan Village (KP)	23	0.24 ± 0.05
Bambangan Village (KD)	41	0.22 ± 0.08
Beluran (B)	14	0.26 ±0.05
UKMS	34	0.13 ± 0.06
Singgaron Baru Village (KSB)	94	0.32 ±0.11
Bongkud Village (KB)	102	0.33 ± 0.16

Table 3. Mean concentration values of hair-lead (PbH) for all locations in this study without discriminating sexes and ages.

Location	No. of Samples	Mean PbH values (μg/g)
Kiabau Village (KK)	70	23.45 ± 13.63
Perancangan Village (KP)	29	23.51 ± 11.21
Bambangan Village (KD)	41	25.24 ± 16.57
Beluran (B)	14	28.37 ± 10.50
Singgaron Baru Village (KSB)	97	39.92 ± 17.28
Bongkud Village (KB)	109	45.71 ± 43.17

groups and sexes. No significant difference was observed in PbH values between different age groups for a particular sex at all locations of study ($p>0.05$); and also between males and females at KSB, KK, KP, KD and B. However in KB, the mean female-PbH value is about 2x higher than male-PbH ($p<0.05$). Mean PbH for KSB and KB was found to be more than RML (30μg/g) whereas mean PbH for all locations in Bidu Bidu Hills were still below RML.

Table 4 shows the mean values of PbH for children and adults in this study. The recommended maximum level for adult and children-PbH values is 30μg/g (Fergusson *et al.* 1981). PbH values which are greater than 90μg/g are considered dangerous (Fergusson et al 1981). Mean PbH values for adults in KSB and KB is about 1.3x higher than RML, whereas the mean PbH values for Bidu Bidu Hills are

Table 4. Mean concentrations of hair-lead (PbH) in children and adults of this study

Location	PbH in $\mu g/g$ Children (<12 yr)	Adults (>12 yr)
Kiabau Village (KK)	21.63 ± 6.96 (n=17)	22.42 ± 8.50 (n=53)
Perancangan Village (KP)	22.90 ± 12.94 (n=8)	23.75 ± 11.10 (n=21)
Bambangan Village (KD)	22.84 ± 7.20 (n=7)	23.31 ± 13.28 (n=34)
Beluran (B)	-	28.37 ± 10.50 (n=14)
Singgaron Baru Village (KSB)	42.42 ± 17.29 (n=46)	37.66 ± 17.30 (n=51)
Bongkud Village (KB)	54.48 ± 51.99 (n=58)	35.74 ± 28.14 (n=51)
Recommended Maximum Level	30 (Fergusson *et al.* 1981)	30 (Fergusson *et al.* 1981)

still below RML. On the whole, the mean PbH values for adults in KSB and KB (both near the copper mine) were found to be higher than a baseline value of 23.79 $\mu g/g$ reported for population in the vicinity of a copper mine in Papua New Guinea (Jones *et al.* 1987). However, it was still lower than a mean of 90.30 $\mu g/g$ for a group of fishermen living near a smelting plant in Santo Amaro, Brazil (Carvalho *et al.* 1984). The mean PbH value for children of KSB and KB (near the copper mine) of this study, 48.45 $\mu g/g$, and a mean of 22.46 $\mu g/g$ for children in Bidu Bidu Hills, were found to be higher than a mean of 7.30 $\mu g/g$ for a group of Arab children (Ahmed *et al.* 1990) and 6.80 $\mu g/g$ for a group of children in Amsterdam (Wibowo *et al.* 1980).

A simple linear regression corrrelation test between PbB and PbH results for KSB, KB, KK, KP, KD and B was performed using matched samples and it was found that there was no good correlation. A number of researchers in other countries have also reported the absence of this correlation between PbB and PbH values (Chattopadhyay *et al.* 1977). Nevertheless, this does not deny the usefulness of using blood and hair samples as biopsies for assessing the extent of contaminant exposure towards humans.

This study showed that the concentration of lead in blood (PbB) for males are higher than females ($p<0.05$) for all the study locations except KK and UKMS. Smokers have higher PbB values than non smokers in KS, KD, UKMS and KSB ($p<0.05$). Lead in hair (PbH) was found to be independent of age groups, sexes and smoking activity at all study locations ($p>0.05$). PbB and PbH values for KSB and KB, both locations near the copper mine, were found to be higher than other locations of this study. There was no clear linear correlation between PbB and PbH values of selected matched samples.

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