# Chapter 5

# DISCUSSION, CONCLUSIONS AND SUGGESTIONS

## 5.1 Discussion and Conclusions

### 5.1.1 Natural Radioactivity in Lignite

The specific activities of U-238, Th-232 and K-40 in lignite samples obtained in this work are comparable with the values found in other countries. It can be seen that they are in good agreement except K-40 which is relatively high particularly when the samples contain very high ash contents. The comparison is summarized in Table 5.1.

Considering the average ratio of activity of Pb-214 to Bi-214 (1.07) and that of Ac-228 to Tl-208 (0.98), it can be concluded that they exist in equilibrium with their parents and it agrees with the results of most studies[10-13]. Thus the activity of their parents can be assumed from their daughter activities.

The upward trend of U-238 and Th-232 activity toward the increasing ash content in lignite shown in Figures 4.1 and 4.2 and that of K-40 in Figure 4.3 lead to the conclusion that, in lignite, the natural radioactivity increases with increasing ash content, particularly at high percentage of ash. It can be assumed from this conclusion that the natural gamma-ray activity due to the presence of potassium and decay products of uranium and thorium can be used to estimate the ash content of a coal or lignite. This assumption agrees with most studies carried out in many countries. In some countries,

techniques based on this information have been developed successfully to monitor the ash content of coal[33] in field study.

In Figure 4.4, the trend of U-238 and Th-232 activity toward K-40 activity is upward. Therefore, if K-40 activity increases, the activity of U-238 and Th-232 is expected to increase as well.

Table 5.1 Comparision of U-238, Th-232 and K-40 Actvities Between the Worldwide Values and the Values Found in Lignite from Mae Moh Mine

| Source of coal or lignite | | Activity (Bq/kg) | | |
|---|---|---|---|---|
| | | U-238 | Th-232 | K-40 |
| Worldwide[3-6] | Coal | 20 | 20 | 50 |
| (typical | range) | 10-600 | 10-600 | 37-440 |
| | Fly ash | 240 | 130 | 265 |
| U.K.[7] | Coal | 14.5 | 12.5 | 150 |
| Australia[8] | Coal | 9-47 | 17-29 | 23-140 |
| | Fly ash | 64-114 | 57-130 | 170-615 |
| India[9] | Coal | 18.5-40.7 | 29.6-66.6 | 77.7-388.5 |
| | Fly ash | 70.3 110.0 | 118.4-177.6 | 181.3-521.7 |
| Mae Moh Mine | Lignite | 14.8 | 21.2 | 194 |
| | (range) | (5.0-36.5) | (7.6-61.2) | (24-687) |
| | Bottom ash | 44.8-60.0 | 47.4-61.1 | 528-560 |
| | Fly ash | 50.5-68.3 | 54.1-68.8 | 631-665 |

It is observed that in lignite from Mae Moh Operation Mine, the specific activities of radionuclides as well as the ash contents vary greatly in wide range. This observation agrees quite well with the information mentioned in Coal Mining Plan[28] which classified lignite, found at Mae Moh Mine, into 5 catagories due to the variation of the quality, particularly on heating value, sulfur content and ash composition.

A subsidiary finding is that for lignite from Mae Moh, the activity of Th-232 is slightly higher than that of U-238 except for a few samples.

### 5.1.2 Natural Radioactivity and Enrichment Factor in Bottom Ash and Fly Ash

The analysis of fly ash should be also done on the post electrostatic precipitator (post-ESP) fly ash because it is the actual fly ash release from the stack to the environment. However, due to to the inconvenience in collecting the post-ESP samples, only the ESP fly ash was analysed.

Secular equilibrium within the U-238 series and Th-232 series can be expected in lignite but not in bottom ash and fly ash. The combustion process may disrupt the decay chains since many daughter radionuclides have different chemical and physical characteristics. In this study, it was found, for both bottom ash and fly ash, that for U-238 series, Pb-214 and its daughter, Bi-214 are in equilibrium because their activities are not significantly different. For Th-232 series, Ac-228 and its decay products from Th-228 to Tl-208 seems to be in equilibrium because the ratio of Ac-228 to Tl-208 is near unity. However, More data are needed to conclude the equilibrium

status of the whole series.

The enrichment factor values in three samples of bottom ash and three samples of fly ash, when normalized with K-40, show slightly enrichment of Pb-214 and Bi-214 whereas for Ac-228 and Tl-208 slightly depletion is indicated. K-40 is used in normalization because it remains more or less constant in lignite and its ashes since it does not decompose during and after the combustion.[31]

### 5.1.3 General Discussion

The method used in this experiment, gamma spectrometry with hyper-pure germanium detector coupled with SPECTRAN-F programme, is very useful and convenient. However, care must be taken because, during a long period of measurement (5-10 hours), the energy peak positions may slightly change and thus, increase the error. The energy calibration should be done very often to update the relation between energy and channel number. The background contribution should be counted, with the blank sample container on the detector, at least once a week or whenever the energy shifts occur so as to minimize the error arising from contamination during sample changing and position shifts of energies.

Although the activity of U-238 and Th-232 can be determined using the photopeaks of their daughters, only some certain peaks of their daughters can be selected since in lignite the levels of radionuclides of both series are relatively low. The peak with energy less than 200 keV, for example: 63 keV of Th-234 and 186 keV of Ra-226 in U-238 series, cannot be used because the gamma-ray yields are low (5.7 % for 63 keV and 4.0 % for 186 keV) whereas the Compton continuum from higher energy as well as the background contribution

is very high. In addition, when energy peaks below abbout 100 keV are used, correction factors for self-absorption in the samples must be applied. Some peaks are ignored because they are very close to their neighbour peaks. The examples in this case are the peaks at 239 keV of Pb-212 and 242 keV of Pb-214. In this work, 352 keV of Pb-214 and 609 keV of Bi-214 were used to represent their parent, U-238, because in the vicinity of these peaks, there are no other peaks close enough to cause interference. Moreover, the gamma-ray yields are quite high (36 % for Pb-214 and 41.2 % for 609 keV). For Th-232, the peaks at 583 keV of Tl-208 and 911 keV of Ac-228 were selected because of the similar reasons.

In conclusion, The natural radionuclides in lignite, both of U-238 and Th-232 series exist in secular equilibrium with thier parents. Their activities are not greatly different from the average for coal of the worldwide values. Therefore, the dose derived from these values are negligible compared to the dose received from the same naturally occurring radionuclides due to normal environmental radiation exposure.[13-17]

## 5.2 Suggestions

1. In the measurement of sample with low level radioactivity, a good shielding material is needed to avoid the interference caused by background contribution. Low background lead with thickness of 10 cm or more is preferable to minimize the background count rate. Compton suppression system should be used if neccessary.

2. Further study on enrichment factor of particular nuclides should be carried out on fly ash with differnt particle sizes for both ESP and post-ESP fly ashes because these values can be used to estimate the radiation dose from fly ash released from the stack to the environment.

3. Since the quality of lignite at Mae Moh Mine varies greatly due to the ash composition, the study should emphasizes on particular location.

4. In order to obtain data on some naturally occurring radionuclides which do not emit gamma rays, particularly Po-210, U-238, U-235 and Th-232 which emit principally alpha particles, such techniques as radiochemical separation, alpha spectrometry and neutron activation should be combined with gamma spectrometry.