CHAPTER VI
CONCLUSIONS

Based on the results of the application of geographic information system (GIS) to analyses on heavy metal erosional and depositional rate in the SKL study area, conclusions and recommendations have been reached as started below.

6.1 Conclusions

The first part of this work, includes the collection and reviewing the literatures for getting the basic concepts and methodology. The next step is to collect all the available data from many sources. Pprevious maps, unpublished, and published papers included in this step. Then, all of data will be manipulated in the same type of map and updating the data using ArcGIS 8.3 software program.

Next, the following step can be separated in to two parts, namely, soil erosion and heavy metal distribution in the SKL catchment area and sedimentary deposition and heavy metal distribution in the SKL aqueous environment.

The rate of soil erosion (tons/hectare/year) were estimated from RUSLE model that can be estimated in using 6 criteria, namely, rainfall erosivity, soil erodibility, slope steepness, slope length, cover and management practices, and supporting practices. Rainfall, soil, digital elevation model (DEM), land use, and Landsat TM5 data were applied along with. The rate of soil erosion in this area in year 2002 is about 26.15 tons/ha/yr or about 1.63 mm/yr. The highest erosion area is located along the Nakorn Si Thammarat range in the western part. The Tha Chiat subcatchment area is the highest erosion area among three subcatchment areas in the study area. Results from calculation of sediment yield are about 150 x 10^3 tons/yr in year 2002 and 133 x 10^3 tons/yr in year 1981. It can be estimated that, within about two decades, sediment yields changed about 12% due to land use modification.

Heavy metal distribution and variation analyses in the SKL catchment area is the other task within this step of work. Heavy metal data were obtained from Department of Mineral Resources (2006) both in 100 samples of soil and 400 samples of stream sediment. Seventeen elemental analyses of metals and non-metals were used for the current database. However, only six elements (i.e., As, Cr, Cu, Ni, Pb, and Zn) are selected for consideration due to their high contents and human concerns. Statistic techniques including histogram and accumulation curve are used to analyze anomalies of heavy metals before the distribution of heavy metals are complied in the maps using spatial analysis of GIS application. Consequently, the heavy metal distributions are overlain into several thematic maps, i.e., subcatchment area, landform, land use, geology and soil erosion, to identify the sources and transportations of the heavy metal in specific areas. The results show that there are high concentrations of heavy metals in some specific areas. Tha Chiat subcatchment area contains significantly abundant As, Cu, and Ni while Pru Por subcatchment area yields high concentrations of Cr and Pb. In addition, only Zn content is high in Pa Bon subcatchment area. For heavy metal in stream sediments, Pru Por subcatchment shows high concentrations of Cu, Ni, Pb, and Zn, whereas high As and Cr concentrations are discovered in Pa Bon and Tha Chiat subcatchments.

For the results of sedimentary deposition and heavy metal distribution in the lake, conclusion can be drawn below.

The total of fifty nine core samples from the SKL study area are provided by Department of Mineral Resources. These samples were examined for lithological log, chemical analyses and Thermo Luminescence (TL) dating. Additionally, these samples are sampled selectively for grain size analysis. Drilled-hole locations are mainly from 4 littoral areas including (a) Ao Ba Teng, (b) Khlong Khop Khang, (c) Khlong Ok, and (d) Ao Bang Teng, it can be concluded that 6 layers of the SKL sediments are identified including

- Organic-clay and brown clay layer (recent to 3,400 years ago),
- Greenish to light gray clay layer (3.400 to 9,000 years ago),
- Red to pinkish gray clay layers (9,000 to 19,000 years ago),
- Light brown to yellow clay layer (19,000 to 37,500 years ago),
- Greenish gray clay (semi-consolidated) layer (more than 37,000 years ago).

The average rate of the Holocene sedimentation in this area are calculated from TL-dating data is about 0.36 to 0.38 mm/yr for all Holocene sediment deposition rate.

Heavy metal distribution analysis is to review the geochemical analyses in 100 samples within 27 drill holes. Among elemental data from DMR (2006), six elements (i.e., As, Cr, Cu, Ni, Pb, and Zn) were selected for their distribution and contamination. The selected heavy metal data were investigated using 3D interpolation by kriging techniques. The results show distribution of heavy metals in each specific area. The results obtained from this step are used to search and estimate the concentration of heavy metals in the lake sediment and also accumulation rate of heavy metals as described as bellows;

The Ao Ba Teng location in the northern part shows the high concentration of Arsenic, Lead, and Zinc with the average concentrations of these elements are about 13, 32, and 95 ppm, respectively. The Khlong Ok location yields the high concentrations of Chromium (18 ppm) and Copper (52 ppm). The Ao Bang Teng location has high concentration of Nickel (12 ppm).

The organic clay layer has high arsenic and nickel concentration (17 and 13 ppm, respectively). Light to greenish grey clay has high lead and zinc concentrations (38 and 87 ppm, respectively). Pinkish to red clay and light brown, light grey to yellow clay layer have high copper and chromium concentrations of about 44 and 22 ppm, respectively.

It can be concluded that based on the overall results, the SKL sediment in the lake show no seriously contamination, and most heavy metal contents are lower than those of the Hong Kong standard values for lake excavation. Only few sample from organic clay layer yield arsenic and copper contents slightly higher than the standard, which is negligible. The result suggests that excavation can be performed without any harmfulness to the study lake environment.

6.2 Recommendations

As discussed earlier, the sediment deposition of the Songkhla Lake is about 0.2 mm/yr, this number leads to the fact that Songkhla Lake will be shallower, and it seems to be at the faster rate than that of the old age (about more than 100 years ago or so). Therefore within the next 50 years from present, the Songkhla become much shallower, and at that depth, it is difficult for transportation and usages. Again as mentioned earlier, two or three possibly way to remedy this situation are herein recommended.

The first is the direct and faster way which involves the deepening of the lake surface bottom. These routes are additional to what have been performed annually by Royal Seaport Department. Because this department has been digging the bay mouth of the river flowing to the Songkhla Lake for few years

The second alternative way is to reduce the upland erosion. Because it is clear that violently accelerated erosion has been made by non-pointed human activities, not only in the forms of deforestation but also illegal plantation. The best ways to do are to enforce the laws related to land-use, environmental, forest and mining issues, to reorganize the land use by local administrations, and to educate villagers for land conservation and management.

The third way is to make uses of dumped lake sediments on land due to the fact that the lake sediments do not contain high heavy metal contents, and they are not polluted or dangerous materials. Site selections are required for dumping areas and they must be environmentally saved. So it should be the local government's role for environmental protection. Research projects should have been launched for making uses of Songkhla Lake sediments being dug. As observed in drilled cores for preliminary physical test, clay have good plasticity for ceramic properties and some are burnt without cracks (Nutt Suksanguan 2007, personal communication). However, this requires a 1-2 year short-term research project for ceramic or other construction purposes.