

Impacts of the Urban Environment on Area Water Source: The Klong Mae Kha- Chiang Mai, Thailand

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1. Introduction

Though the expansion and development of urban environments can signal opportunity and economic growth of a country or region, poverty and environmental degradation are just as likely to be found alongside prosperity. Water quality can be especially impacted in an urbanized environment. Monitoring is an important first step in understanding the impacts of natural and anthropogenic activities on a water body, which may in turn improve future planning, mitigation and regulation management.

The primary purpose of this research project was to determine, through sampling and land use identification, whether there were any significant changes in the water quality of the Klong Mae Kha as it passes through the city of Chiang Mai, Thailand. The Mae Kha obtains its water from sources to the north and west of the city, as well as canals within the city. Over the years it has become a sort of open sewer flowing through the heart of the city. The water of the Mae Kha is in class 5 for navigation according to the standard surface water quality criteria of Thailand (Sirirattanawarangkul, 1999). This is the lowest quality class and as such there are no actual water quality standards. People live and work immediately along the Mae Kha (Figure 1). Field observation indicated that effluent discharges directly into the klong from these residences and businesses.



Figure 1 Land use along Mae Kha



Figure 2 Sample sites

2. Study Area

Chiang Mai province, with a population of approximately 1.6 million, is the second most populated province in Thailand; 26.5% of the population lives in the municipal area of Chiang Mai City, making it second only to the capital of Bangkok in terms of urban

occupancy. Sangawongse et al. (2005) noted that the urban area of Chiang Mai has progressively increased from 15 km² in 1952 to 339 km² in 2000. The city is located in a valley and there is a clear orographic rainfall effect related to the adjacent Suthep Mountains.

Six sites were identified for water sampling; four were located within the city of Chiang Mai, and two were located to the north of the city (Figure 2). The four city sites (Sites 1-4, Figure 2) served as the test sites to determine if water quality changed as it progressed through the urban environment. Site 3 is particularly denoted by tourist-aimed businesses (i.e. hotels, shops, restaurants, bars, spas). The land along the Mae Kha between sites 2 and 3 is serviced by a sewer system. Visually, Site 4 appeared the most polluted. The two sites located to the north of the city served as non-urban control sites. Site 5 was located on the Ping River and Site 6 was in a major irrigation canal.

3. Methods

The study was conducted at the onset of the rainy season (June, 2006). Grab samples (60-70 mL) were collected in the mornings at each site and there were seven sample collection days in total (June 14, 16, 17, 19, 21, 23, and 26, 2006). The June 17th sample was after a brief rain event within the city and was collected at Site 4 only. In addition, samples were collected through a storm event on July 7, 2006. For that day, samples were taken from Sites 1-4 only and taken in three consecutive cycles, approximately one hour apart.

E. coli levels were analyzed using Coliscan Easygel kits with the samples being incubated for 48 hours at room temperature prior to counting. Total phosphorus (T.P.), copper (Cu), and chromium (Cr) were tested for using a Hanna Instruments C-200 multi-parameter photometer. Total suspended solids (TSS) concentration was determined by filtration with glass fiber filters. Dissolved oxygen (D.O.), conductivity, pH, and temperature were recorded every sample day at each site using a YSI 6600 EDS Datasonde and continuously (15 minute time steps) at Site 4 with a Hydrolab Datasonde 4a. The land use was observed through field visits around each site, as well as digital data layers in ArcView GIS.

4. Results

Sample data are summarized in Table 1. There was a statistically significant difference ($\alpha=0.05$) in mean pH between Sites 1 and 4 as well as the control sites (5 and 6), although all pH measurements were within a generally neutral range of 7.3-7.9. Statistically significant differences ($\alpha=0.05$) in mean conductivity were found between Sites 1 and 4, as well as between Sites 4 and 6. The city (Sites 1-4) had the highest conductivity, but conductivity also varied from site to site within the city. Dissolved oxygen (D.O.) decreased as the water progressed through the city. There was a statistically significant difference ($\alpha=0.05$) between mean D.O. at Site 1 (3.32 mg/L) versus the mean D.O. at Site 4 (0.80 mg/L). The mean values of Sites 5 and 6 were 5.82 mg/L and 6.87 mg/L respectively. A statistically significant difference in chromium (Cr) levels was found between Sites 1 and 4. No significant difference was found for copper (Cu) between Sites 1 and 4 nor between Site 4 and the controls. Although no significant difference ($\alpha=0.05$) was found for total phosphorus (T.P.) between Sites 1 and 4, the mean values qualitatively demonstrated a trend of increasing phosphorus levels as the Mae Kha water moved through the city. Similarly, although no statistically significant difference ($\alpha=0.05$) was found for *E. coli* between sites, qualitatively, *E. coli* levels increased through the city (Figure 6).

The Hydrolab data showed that rain and runoff events have an impact on water quality, notably D.O., conductivity, and turbidity (see Figures 3-5; note 6/20-21/06 for example). Unlike a study done in Buffalo, which included comparing dry weather and wet weather levels of metals (Irvine et al., 2005) the “first-flush phenomenon” was not observed for the storm event of 7/7/06.

Table 1 Mean Water Quality Values*

| | Site 1 | | Site 2 | | Site 3 | | Site 4 | | Site 5** | Site 6** |
|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|-------------|
| | Single grabs | 7/7/06 event | Single grabs | 7/7/06 event | Single grabs | 7/7/06 event | Single grabs | 7/7/06 event | Single grab | Single grab |
| T. P. | 0.80(0.8) | 0.62(0.5) | 0.82(0.5) | 0.93(0.4) | 2.9(1.7) | 0.83(0.4) | 2.15(1.7) | 1.1(0.3) | 0.2(0.4) | 0.96(0.9) |
| Cr | 3(5.6) | 0.33(0.6) | 11.6(12.7) | 17.6(17.5) | 19.3(31) | 15.3(13) | 19.6(11.5) | 35(19.1) | 5.4(9.1) | 6.4(7.7) |
| Cu | 71.3(86.4) | 197(92.5) | 26.2(23.9) | 114.3(52.3) | 44(49.6) | 105(72) | 96.8(84.6) | 196.5(77) | 92(63.8) | 104(17.5) |
| E.coli | 11,747 | ** | 172,396 | ** | 98,663 | ** | 188,977 | ** | 1,242 | 1,957 |
| TSS | 30.6(10.9) | ** | 22.2(8.14) | ** | 19.2(9.4) | ** | 19.3(13.1) | ** | 86(72.4) | 55.8(48.9) |
| D.O. | 3.32(1.2) | ** | 1.03(0.92) | ** | 2.36(2.1) | ** | 0.8(0.75) | ** | 5.82(3.1) | 6.87(0.22) |
| Temp | 27.2(0.7) | ** | 28(1.05) | ** | 28.6(1.7) | ** | 28.8(1.7) | ** | 28.3(0.5) | 28.2(0.6) |
| pH | 7.48(0.04) | ** | 7.35(0.06) | ** | 7.47(0.1) | ** | 7.41(0.04) | ** | 7.68(0.2) | 7.88(0.08) |
| Cond | 0.3(0.01) | ** | 0.49(0.09) | ** | 0.38(0.06) | ** | 0.4(0.08) | ** | 0.21(0.1) | 0.17(0.01) |

*standard deviation in parentheses **no storm event data E.coli is a geometric mean
T.P.(mg/L), Cr(ug/L), Cu(ug/L), E. coli(colonies per 100 mL), TSS(mg/L), D.O.(mg/L), Temp(C°),
Cond(mS/cm)

5. Discussion

The data set collected is relatively small and represents a short time period, which means the results should be interpreted with some caution. It should be noted that although the grab samples between the dates of June 14-26 represented dry weather at the time of sampling, rain occurred for the majority of sample dates either in the mountains surrounding the city or within the city itself, the evening before sampling. The orographic effect of the mountains made it particularly difficult to define true dry weather for the sample period. In general, though, it can be concluded that there was an impact on the water quality of the Klong Mae Kha from the urban environment. The E. coli levels at the non-urban sites (Sites 5-6) were comparable to those from three irrigation canals to the north of the city sampled in July, 2004 (Krueger et al., 2004). Proper infrastructure seems to help mitigate some of these urban impacts on the water of the Mae Kha canal. For example, the sewage pipes installed between Sites 2 and 3 appear to improve the quality of water at Site 3 compared to Site 2 in terms of higher D.O and lower E. coli (Figure 6). No such improvement between the city sites was seen for chromium as the levels progressively increased from Sites 1 to 4. The Thai surface water quality standards for Class 2-4 water bodies for chromium (50 ug/L) was not exceeded on average at the urban sites. However, mean copper levels exceeded guidelines for Class 2-4 water bodies (100 ug/L) at all sites for the event of 7/7/06. Construction of a pump station recently was completed and the city plans to flush the Mae Kha with cleaner water as a management solution to some of the water quality problems noted in this study.

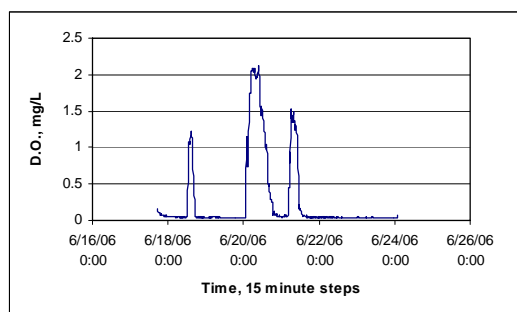


Figure 3- Hydrolab Site 4-D.O., mg/L-note increases in D.O. during runoff events (e.g. 6/20-21/06)

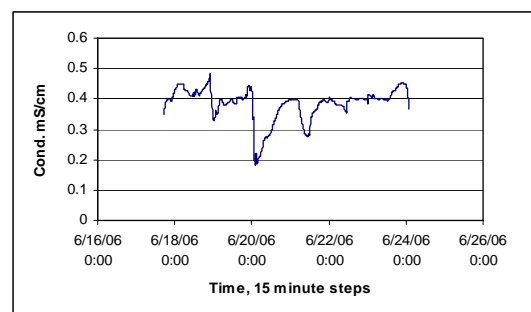


Figure 4- Hydrolab Site 4- Conductivity, mS/cm-note dilution during runoff events(e.g. 6/20-6/21/06)

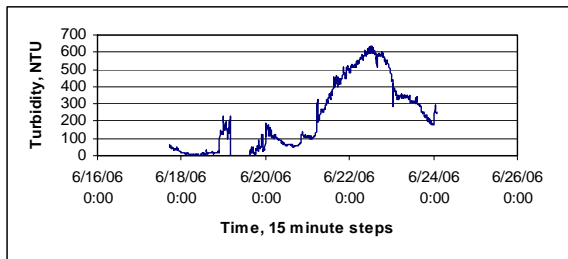


Figure 5- Hydrolab Site 4-turbidity in NTU – note increase with runoff

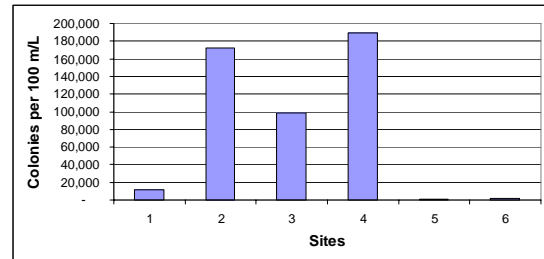


Figure 6- E. coli geometric means by site

6. Conclusion

The city of Chiang Mai appears to negatively impact water quality of the Mae Kha. Bottom-up initiatives have had positive impacts on pollution issues and social/housing issues, but there needs to be a better intimate relationship between government and community. An example of this would be the ongoing relationship between informal settlements and the local government. Informal settlements are communities which the local government deems as illegal “squatting” (in this case along the canal) and management of these communities presents social challenges. Although it may help to improve water quality, the social justice of community re-location can be a thorny issue. Glassman and Sneddon (2003) suggested that contrary to government hopes, decentralized industrialization has not provided a sustainable urban environment in Bangkok and has served to negatively impact Chiang Mai’s urban environment. The management of water quality should consider not just hard engineering solutions, such as the pumping of water to flush the Mae Kha, but should include outreach to the community to implement pollution prevention best management practices. Future studies should include a continued sampling program, and the monitoring of municipal and grassroots initiatives, such as the city’s future pumping program, and government-community coalitions involving Mae Kha water quality.

7. References

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