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SHORT REPORT

TRACE METALS IN THE MAE KHA CANAL AND THE MAE PING RIVER IN CHIANG MAI, NORTERN THAILAND

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ABSTRACT

The study was conducted by collecting water and sediment samples form the Mae Kha Canal and the Mae Ping River at the ends of the rainy and dry seasons in 1994. The Cd, Cu, Pb and Zn contents in the samples were analyzed by atomic absorption spectrophotometry.

Various sample pretreatment procedures were employed prior to the analysis depending on the samples concerned. Metal ions in the water samples were complexed with the mixture of pyrrolidinecarbodithioic acid ammonium salt (APDC) and diethylammonium N,N-diethyldithiocarbimate (DDDC), and the complexes were then extracted with isobutyl-methylketone (MIBK) and the metal ions were back extracted into the aqueous solution. The sediment samples were digested by HNO3:HCl (1:3/v/v) solution.The results showed that Cd, Cu, Pb and Zn contents in the Mae Kha Canal were much higher than those in the Mae Ping River even though the distribution of such metals was not uniform. The contents of the four elements in the sediment samples were also higher than the average abundance of them in the granite rock which is a geological characteristics of the Chiang Mai Basin. Metal contents in the water samples in both the Mae Kha Canal and the Mae Ping River were lower than the Thai national standard levels for a second class surface water indicting that the water was still acceptable in terms of the Cd, Cu, Pb and Zn pollution. However, the water in the Mae Kha Canal can not be recommended as drinking water even after appropriate water treatment is applied.

INTRODUCTION

Urban aquatic ecosystems suffer from very serious heavy metal pollution. The sources of heavy metals in the urban environment , such as solid wastes, domestic effluent, urban stormwater runoff, are very extensive, resulting in elevated concentration levels of copper, lead, zinc and to lesser degree cadmium[1].

The Mae Kha Canal passes through the most crowded part of Chiang Mai City, carrying solid urban wastes and wastewater downstream and finally discharging them into the Mae Ping River. The hypothesis is that the heavy metal contents in the Mae Kha Canal are higher than those in the Mae Ping River. The comparative study of heavy metal contents in water and sediment will be of very great importance in discussing the influence of urban wastes and wastewater discharge on surrounding aquatic ecosystems.

MATERIALS AND METHODS

Study site

Nine study sites were chosen in Chiang Mai, northern Thailand, of which five were on the Mae Ping River, three on the Mae Kha Canal, and one on Doi Suthep, the last serving as the control site. Figure 1 shows a map of the locations of the study sites.

The Mae Kha Canal was originally dug centuries ago as a water supply and drainage system for Chiang Mai City[2]. It has been rerouted and modified several times since its original construction and throughout the years has become increasingly polluted with the growth of the city. The water is typically polluted and filthy as shown in Figure 2. Another scene is the amazing detergent-foam-iceberg as shown in Figure 3.

The Mae Ping River is not as obviously contaminated as the Mae Kha Canal, but in recent years has not only decreased in flow volume, but also has increased in sediment and pollution load. The water is generally turbid, brown-colored as shown in Figure 4.

Sampling

Water and sediment samples were collected on two occasions, *viz.* the 3rd September and the 27th December 1994, representing respectively the rainy season and the dry season.

The experiments were conducted in the Water Research Center of the Chemistry Department and the Geological Chemistry Laboratory of the Geology Department, Faculty of Science, Chiang Mai University.

Pretreatment of sediment samples

Sediment samples were put into an oven and dried at 105°C for about 10 hours until they were dried. The dried samples were crushed (pestle and mortar) and sieved. Fractions passing the sieve were put into the oven again and dried at 105°C for 10 hours. Three grams of each sifted and dried samples were accurately weighed into a 250 ml conical flask. Then 10 ml 65% HNO_3 and 30 ml 37% HCl were added to each flask. The samples were heated on a hot plate for not less than 1 hour. The sample solutions were filtered into 100 ml volumetric flasks[3].

Pretreatment of water samples

The water samples were filtered immediately on arrival at the laboratory using 0.45 mm filter paper. Five-hundred ml of each water sample was transferred to a separatory funnel before which the pH was adjusted with NaOH solution to 4.5. Five ml of APDC-DDDC chelating reagent and then 10 ml MIBK organic solvent were added. The flasks were shaken for 2 minutes and then left to stand for 5 minutes to ensure complete separation of phases. After removal of the organic extract, the aqueous phase was extracted again in the same way. The two organic extracts were combined. The organic phase was rinsed with 10 ml deionized water. Then 0.1 ml 65% HNO3 was added to the organic phase and 20 minutes were allowed for reactions. Then 4.9 ml of deionized water were added to the extract which then was shaken for 1 minute after which the aqueous phase was collected.

Determination of trace elements

Measurements were made on a Perkin-Elmer 2380 Flame AAS machine.

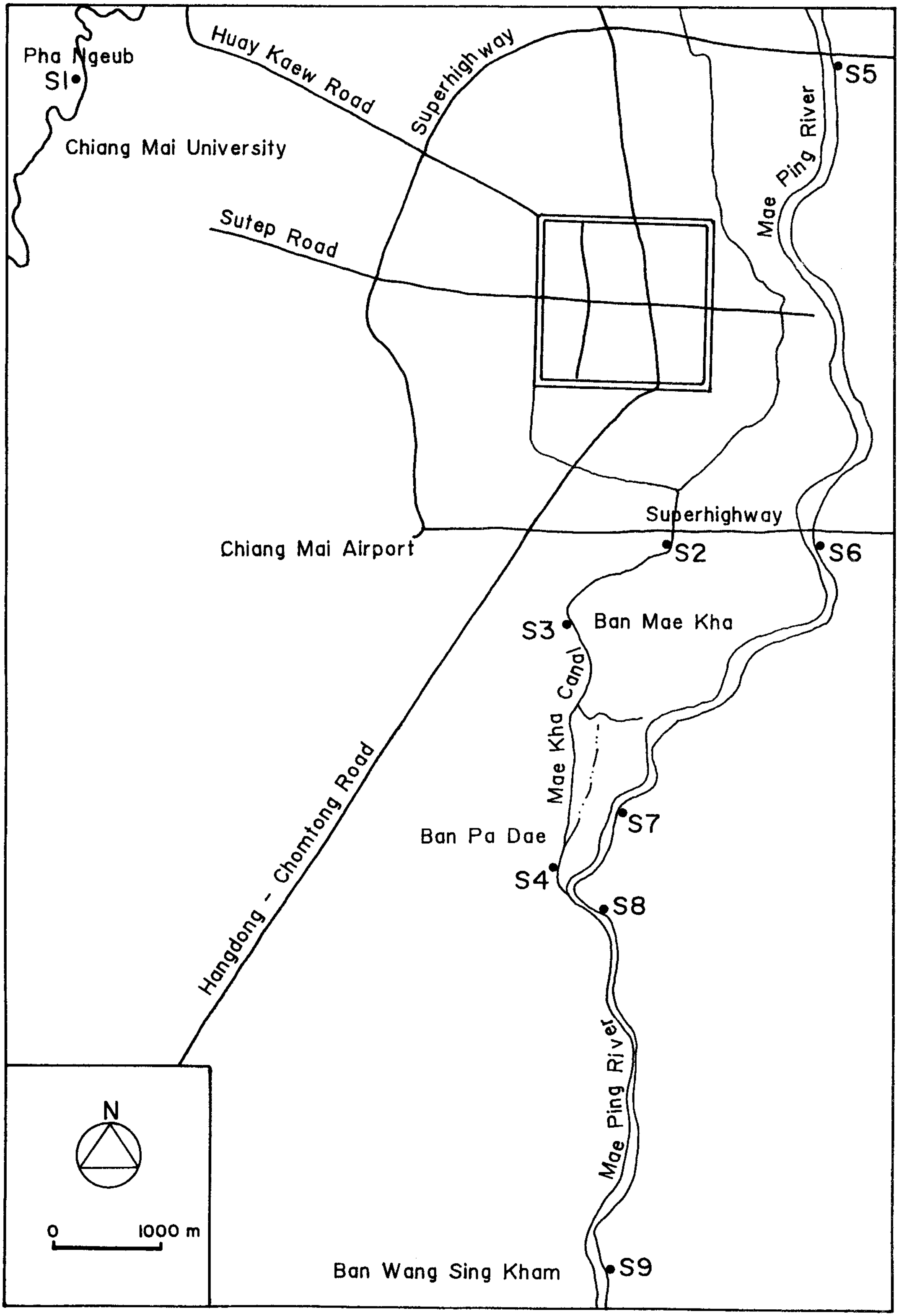

Fig.1. Map showing the locations of the study sites.

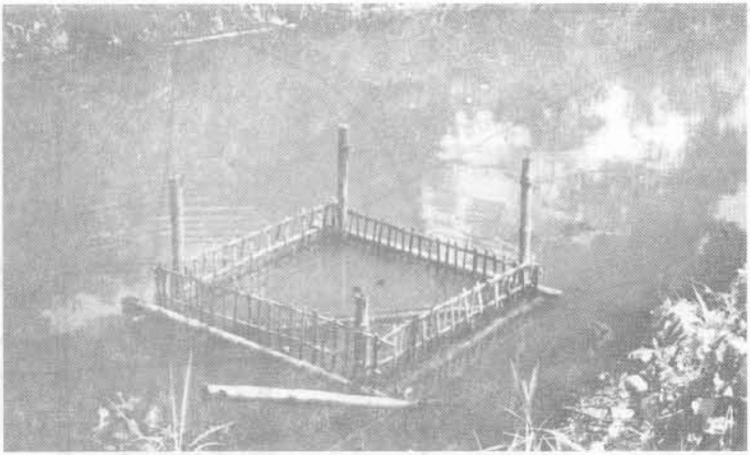

Fig.2. Photo taken at site 2 in the Mae Kha Canal, which is typically polluted and otherwise filthy. The bamboo frame was used to contain two species of aquatic plants from the Ping River which were studied in this research.

Fig.3. Photo taken below site 4, showing detergent wastes which are often so concentrated in the Mae Kha Canal that foam is produced when the water is agitated.

Fig.4. Photo showing the suspended sediment content, i.e. turbidity, of the Ping River causing the water to be brown.

RESULTS AND DISCUSSION

1. Distribution of metal contents in the Mae Kha Canal and the Mae Ping River

1.1 Distribution of metal contents by site

Figure 5 and Figure 6 show the relative levels of the four elements in water and sediment samples as found both in rainy and dry seasons at different sites. It can be seen that all the three sites on the Mae Kha Canal exhibited higher contents of the four elements than at all the sites on the Mae Ping River, in both seasons. This is especially clear when comparing the results of sediment sample analysis.

1.2 Influence of the Mae Kha Canal on the Mae Ping River

Figures 5-6 also show that in most cases, there was an increase in metal contents between site 7 and 8, which means that there was an influence from the Mae Kha Canal on the Mae Ping River in terms of metal pollution.

1.3 Self-purification of the Mae Ping River

From Figures 5-6 it can also be seen that the concentration levels of most of the elements in both seasons decreased at site 9 compared to at site 8, which means a purification process occurred along the river.

1.4 Seasonal variation

Figures 7 and 8 show the seasonal variation of the element contents in water samples and in sediment samples. At all sites water Cu levels were higher in the rainy season than in the dry season The reason for this might either be that precipitated and adsorbed elements were leached from land and were washed into the water body or else that the bottom sediments were disturbed by the flood and finally collected and acidified with the water samples.

Sediment is a relatively stable medium1. Within a short historical period, the metal level will not change so much. This was also found in this study. However, the metal contents in the sediment will absolutely change when the terrestrial and the aquatic ecosystem change to a certain extent.

2. Risk Assessment

2.1 Evaluation by using the water data

Concentrations of the 4 elements in water samples were all lower than the specified levels by Thai national standard for a second class of surface water[4]. The comparison is shown in Table 1. This means that the waters were very clean fresh surface water resources in terms of Cd, Cu, Pb and Zn. This indicates that in consideration of these four elements, the waters in both the Mae Kha Canal and the Mae Ping River could be used for consumption, for aquatic organism conservation for living and assisting for fishery, and for fishery and recreation, after the ordinary water treatment process for other parameters specified by the water quality criteria for the aforementioned purposes respectively.

The waterbody of the Mae Kha Canal is badly polluted not only by heavy metals such as Cd, Cu, Pb and Zn, but by organic matter as well. Dissolved oxygen in water reached zero mg/L at all the three sites during both the rainy and dry seasons. Figure 9 shows the distribution of the dissolved oxygen level at the two seasons. The stink from the filthy water (refer to Figure 2) can be smelled miles away which is a nuisance and is maybe detrimental to the health of the local people and people passing by. Proper wastewater treatment measures

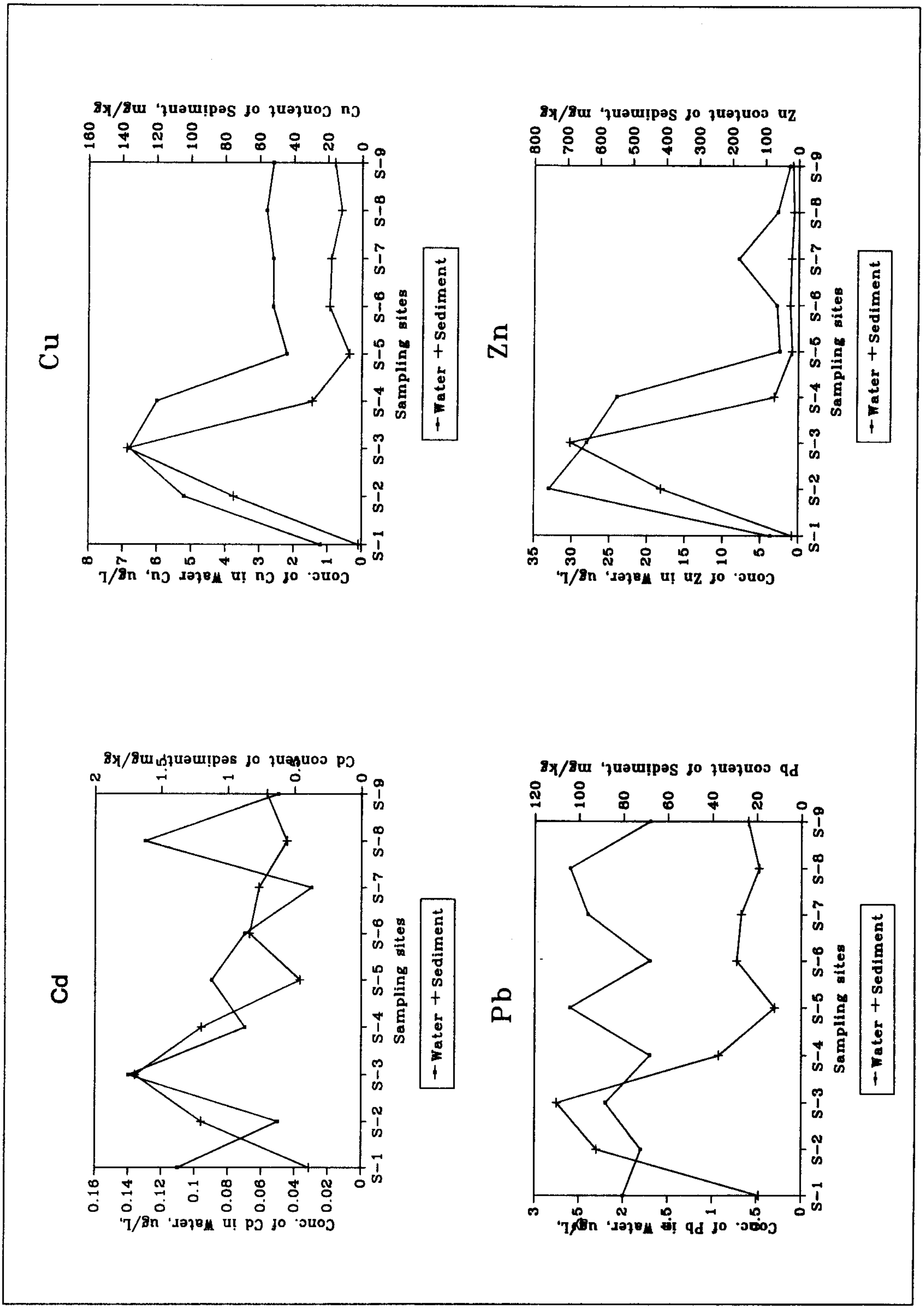

Fig.5. Cd, Cu, Pb and Zn contents in water and sediment of the rainy season.

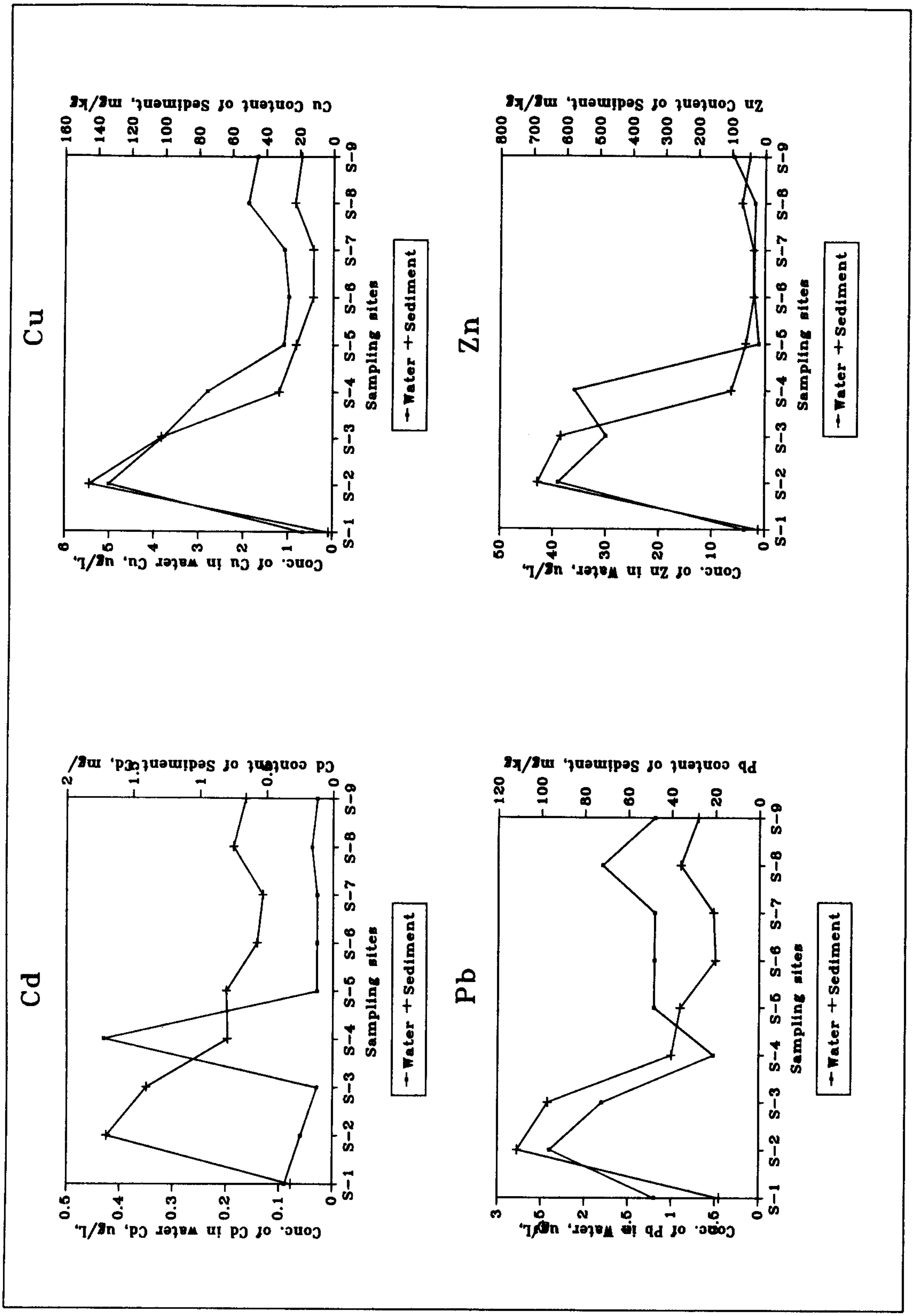

Fig.6. Cd, Cu, Pb and Zn contents in water and sediment of the dry season.

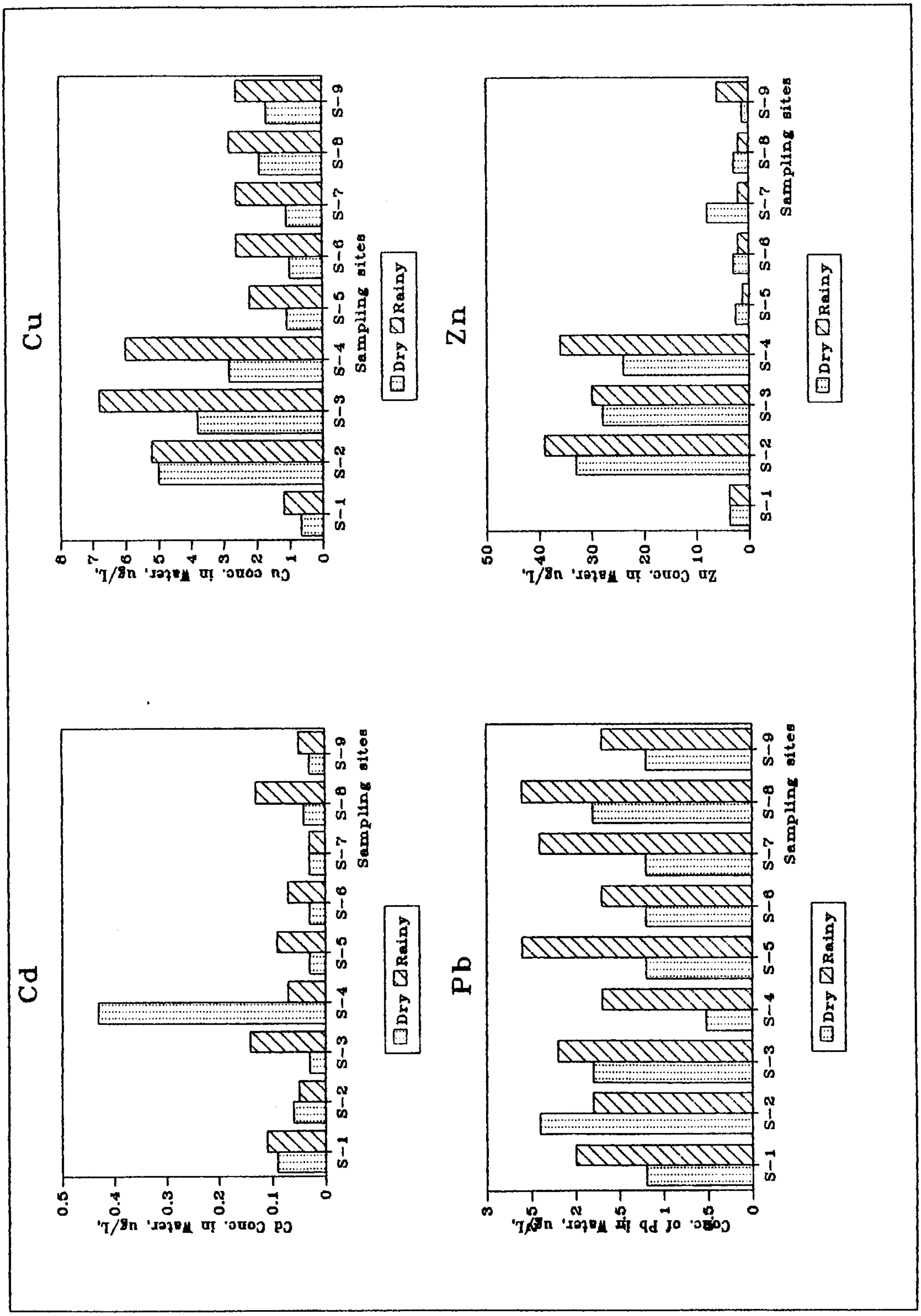

Fig.7. Cd, Cu, Pb and Zn contents in water of the two seasons.

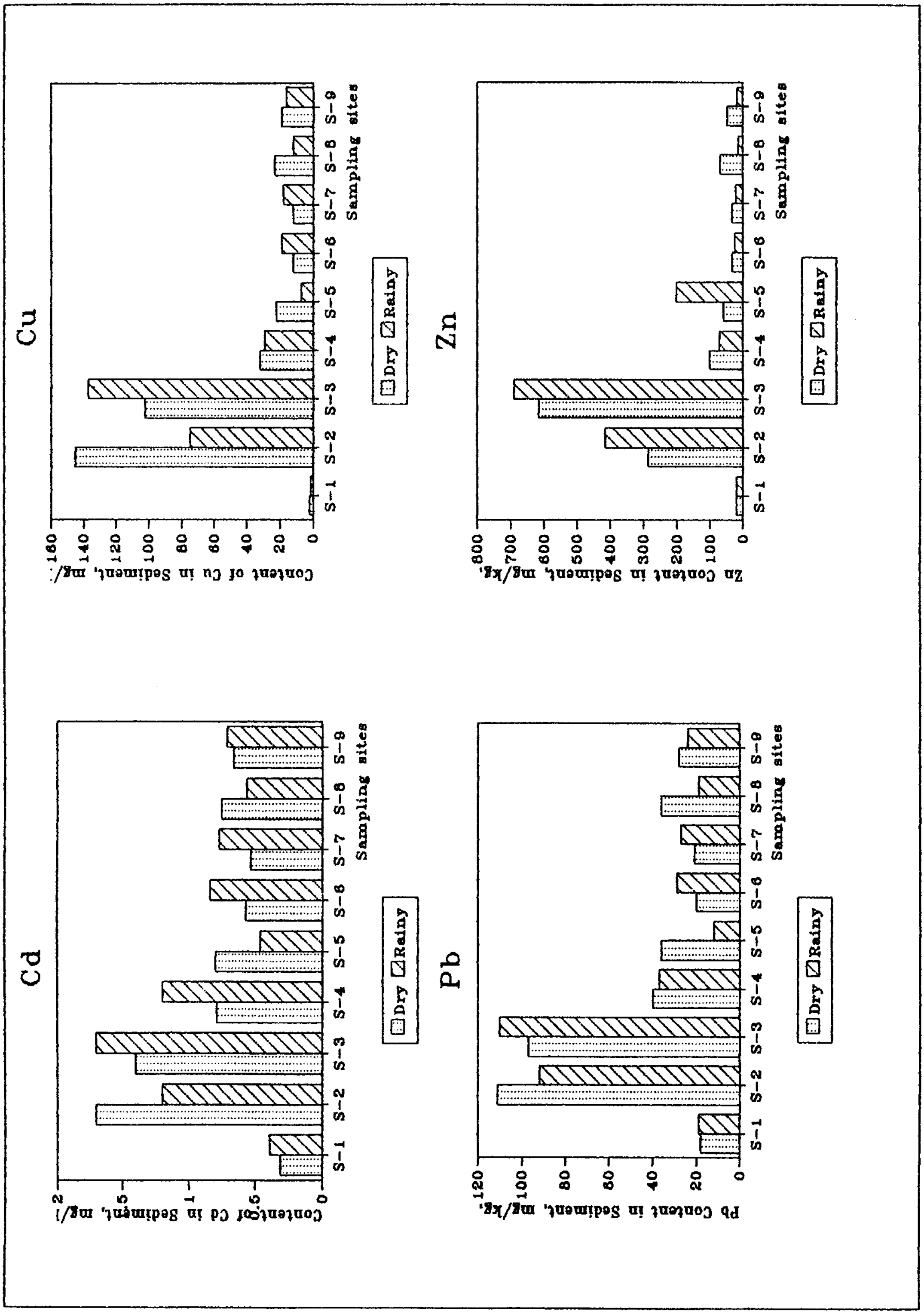

Fig.8. Cd, Cu, Pb and Zn contents in sediment of the two seasons.

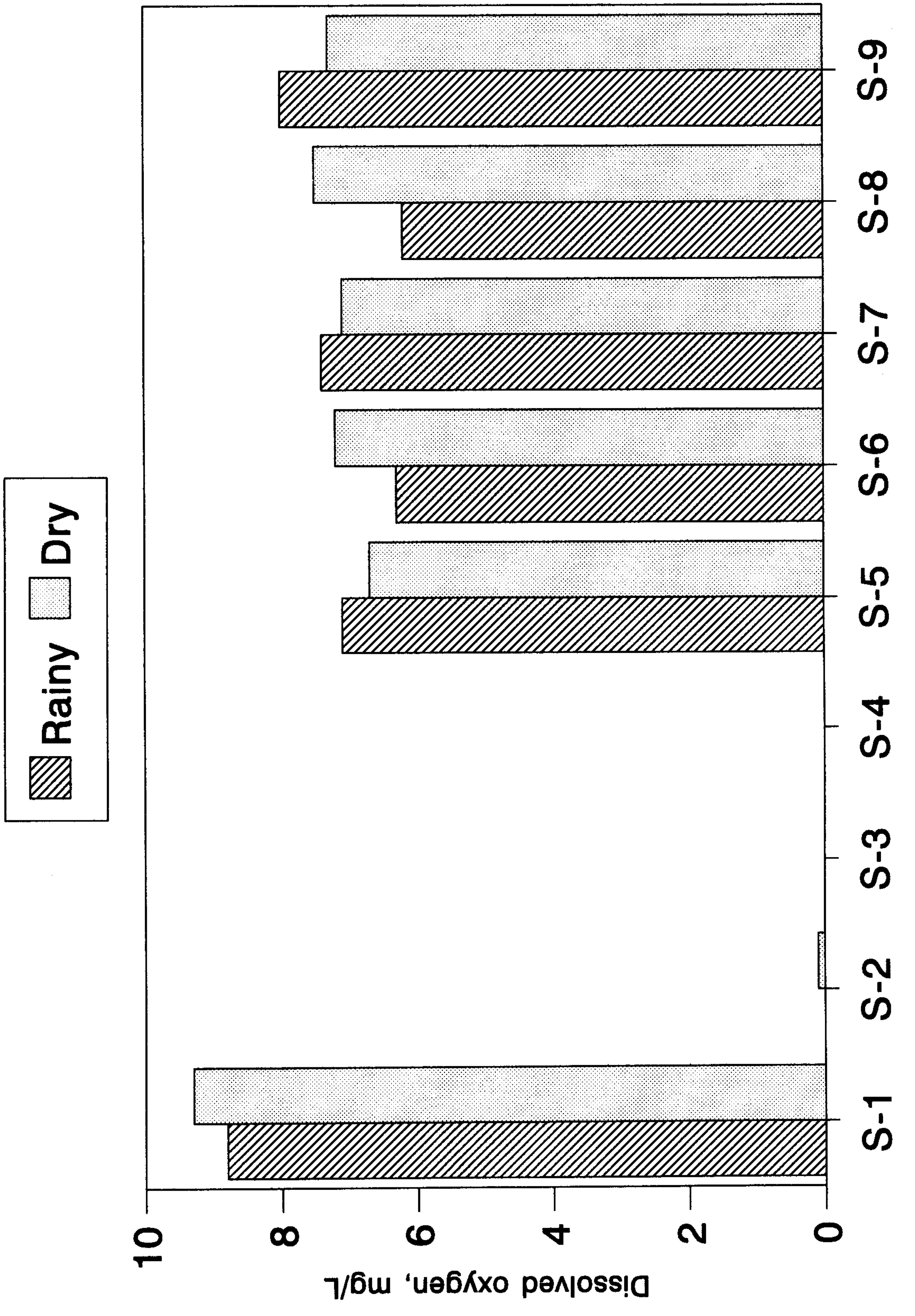

Fig.9. Distribution of dissolved oxygen over site.

are needed immediately after the discharge of the wastewater from the central part of the city in order to maintain a healthy environment of the Mae Kha Canal. The excessive phosphorus content made the occurrence of eutrophication of the fresh water ecosystems (refer to Figure 3).

2.2 Evaluation by Sediment samples

The comparison of the relevant data is in Table 2. It can be seen that at some of the sites sediment samples contained very much higher levels of these four elements than the recorded reference data and that at the control site, indicating that there have been sources of Cd, Cu, Pb and Zn from the urban waste and wastewater. It is supposed that there is a risk from the improper available treatment of sediment.

Sediment is a sink of heavy metals and other pollutants. The high contents of Cd, Cu, Pb and Zn in the sediment make it a great risk if it is not properly managed. Heavy metals will be mobilized and released from the sediment dredged and dumped along the road and other places due to the change of redox condition, and further pollute the surrounding ecosystems and groundwater body. Therefore, the management of sediment should be careful.

Sediment can also be a source of heavy metal pollution of the overlying water column even when it is at the bottom of the rivers, canals and lakes. With fast water flow and turbulence, sediment is disturbed causing the heavy metal contents in water column to be elevated.

Table 1. Comparison of maximum metal contents found in water with standard.[4]

Element	Maximum conc. (mg/L)	Standard value (mg/L)
Cd	0.00043	0.005*, 0.05**
Cu	0.0068	0.1
Pb	0.0026	0.05
Zn	0.039	1.0

Where: * Hardness<100 mg/L, $CaCO_3$

** Hardness not less than 100 mg/L, $CaCO_3$

Table 2. Comparison of maximum and minimum metal contents in sediments with reference data.[5]

Element	Reference mg/L	Control mg/L	Max conc. mg/kg	Min conc. mg/kg
Cd	0.1	0.31	1.7	0.46
Cu	12	1.7	145	7.4
Pb	20	18	111	12
Zn	50	19	690	15

CONCLUSION

There is a heavy metal pollution threat in the Mae Kha Canal and the Mae Ping River which is from sediments, from urban wastewater discharge, and from storm water runoff. However, the distribution of metals is not uniform since the discharges are scattered rather than from a single source.

There is a higher level of cadmium, copper, lead and zinc in the Mae Kha Canal compared to the Mae Ping River. However, Cd, Cu, Pb and Zn concentrations in water of both the Mae Kha Canal and Mae Ping River conform to those levels specified for the second class surface water by the national surface water classification standard of Thailand.

The environment (water and sediment) of the Mae Kha Canal is much more worse than that of the Mae Ping River not only in terms of heavy metals (Cd, Cu, Pb and Zn), but also other parameters such as odour, colour and DO. The pollution problem of the Mae Kha Canal mainly arise from domestic effluents. This problem can be overcome by proper wastewater treatment.

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