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SENIOR PROJECT

Title	Heavy metals concentration in water and accumulation in water mimosa (*Neptumia oleracea Lour*.) grown in the Tha Chin River
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Project advisor	Associate Professor Naiyanan Ariyakanon, Ph.D.
Department	Environmental Science
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Faculty of Science, Chulalongkorn University

Heavy metals concentration in water and accumulation in water mimosa (*Neptumia oleracea Lour.*) grown in the Tha Chin River

ความเข้มข้นของโลหะหนักในน้ำ และการสะสมโลหะหนักในผักกระเฉดที่เจริญเติบโตในแม่น้ำท่าจีน

Chotinut Jamwatthanachai

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Accepted by Department of Environmental Science, Faculty of Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Bachelor's Degree of Science

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ABSTRACT

The heavy metals contamination in water and water mimosa (*Neptumia oleracea* Lour.) grown in the Tha Chin River were investigated. The study sites were Song Pee Nong district, Suphan Buri Province and Sam Pran District, Nakhon Pathom Province. The water quality including pH, temperature, Dissolved Oxygen (DO), Electric conductivity (EC), Total Dissolve Solids (TDS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and salinity were analyzed. All of parameters was in the ranged of the water quality standards for surface waters of Thailand except BOD at Sam Pran District. The heavy metals including copper, cadmium, lead, nickel and zinc concentration were determined. The results showed that the heavy metals contamination in water were in order as follow: zinc>lead>cadmium>copper>nickel, which were lower than the surface water quality standards values. The results indicated that water mimosa accumulated zinc in the highest levels in roots. The heavy metals accumulation in the water mimosa were in order as follow: zinc>lead>copper>nickel. The highest concentration of zinc, lead, copper and nickel accumulated in water mimosa were 452.60 ± 3.15, 128.97 ±. 13.70, 106.48 ± 7.06 and 17.28 ± 0.64 mg/kg dry weight, respectively.

Keyword: Heavy metal, Water mimosa, Tha Chin River

หัวเรื่อง	ความเข้มข้นของโลหะหนักในน้ำ และการสะสมโลหะหนักในผักกระเฉดที่เจริญเติบโตในแม่น้ำท่าจีน
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บทคัดย่อ

การศึกษานี้ได้ตรวจวัดการปนเปื้อนของโลหะหนักในน้ำ และโลหะหนักที่สะสมอยู่ในผักกระเฉด (*Neptumia oleracea* Lour.) ที่เจริญเติบโตในแม่น้ำท่าจีน พื้นที่ศึกษาคือ อำเภอสองพี่น้อง จังหวัดสุพรรณบุรี และอำเภอสามพราน จังหวัดนครปฐม คุณภาพของน้ำที่วิเคราะห์ ได้แก่ ความเป็นกรดด่าง อุณหภูมิ ออกซิเจนละลาย การนำไฟฟ้า ปริมาณของแข็งละลายทั้งหมด ความต้องการออกซิเจนทางชีวเคมี ความต้องการออกซิเจนทางเคมี และความเค็ม พารามิเตอร์ที่ตรวจวัดทั้งหมดอยู่ในช่วงของค่ามาตรฐานคุณภาพน้ำผิวดินของประเทศไทย ยกเว้นค่าความต้องการออกซิเจนทางชีวเคมีที่อำเภอสามพราน ส่วนการวิเคราะห์หาปริมาณโลหะหนักในน้ำ ได้แก่ ทองแดง แคดเมียม ตะกั่ว นิกเกิล และสังกะสี พบว่าการปนเปื้อนของโลหะหนักในน้ำเป็นดังนี้: สังกะสี> ตะกั่ว>แคดเมียม> ทองแดง>นิกเกิล ซึ่งต่ำกว่าค่ามาตรฐานคุณภาพน้ำผิวดิน ส่วนปริมาณโลหะหนักที่สะสมในผักกระเฉด พบว่าพืชจะสะสมสังกะสีได้ที่รากได้มากที่สุด การสะสมของโลหะหนักในผักกระเฉดสามารถเรียงลำดับได้เป็นดังนี้: สังกะสี>ตะกั่ว>ทองแดง>นิกเกิล โดยผักกระเฉดจะสามารถสะสมสังกะสี ตะกั่ว ทองแดงและนิกเกิลได้มากที่สุดเท่ากับ 452.60 ± 3.15, 128.97 ± 13.70, 106.48 ± 7.06 และ 17.28 ± 0.64 มิลลิกรัมต่อกิโลกรัม น้ำหนักแห้ง ตามลำดับ

คำสำคัญ: โลหะหนัก, ผักกระเฉด, แม่น้ำท่าจีน

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Chotinut Jamwatthanachai

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
DO	Dissolved Oxygen
EC	Electric conductivity
TDS	Total Dissolve Solids
TSS	Total Suspended Solids
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
mg	Milligram
kg	Kilogram
mm	Millimeters
µg	Microgram
°C	Celsius
psu	Practical Salinity Unit
NTU	Nephelometric Turbidity Units
mmHg	Millimeter of mercury
‰	Parts per thousand
Cu	Copper
Cd	Cadmium
Pb	Lead
Ni	Nickel
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Background

Water pollution by heavy metals is one of the serious problem in Thailand since industrial century. The sources of wastewater are from community, agriculture and industrial. Heavy metals in wastewater can directly change aquatic animal behavior consumption in food web to unbalancing ecosystem. Moreover, low concentration of heavy metal might contaminate raw water for utilization in produce drinking water for people. Heavy metals affect the human health that are carcinogenic and change DNA to malfunction of cells called mutations. It affects the reproductive system which can observe from pregnant females. The symptoms of the baby are birth defects and reduced reproductive capacity. Besides that, it causes continuously damage to nervous system in every period of ages. When farmland uses chemical in overdose range, it will affect pH of water from neutral to acidic and increase availability of heavy metals (Shehata, 2019).

Tha Chin River is the second major river branching from the Chao Phraya River. The 82.15% of land use along the Tha Chin River is used for the agriculture. Water Quality Index analysis (WQI) was rated that reflected the effect of different quality (Şehnaz et al., 2017). The WQI analysis of the Tha Chin River showed that the average of the river was bad, especially the lower part of the river was the very bad (Ministry of Natural Resources and Environment, 2554), because of wastewater from many activities. Land use affected the change in water quality, which polluted water was discharged to the river. According to the report of Pollution Control Department, the contamination level of heavy metal in the Tha Chin River was ranged from highest to lowest as follow: As> Ni> Pb>Hg (Weerayaporn, 2015).

Water mimosa *(Neptunia oleracea* Lour.) is a popular vegetable for cooking in Thailand. It can grow along riverside without adding any fertilizer required. Tha Chin

River is a famous planting area for water mimosa which can be found from Suphanburi to Nakhon Pathom. Water mimosa can be grown naturally with barriers by using a plank of wood to prevent them from floating away. However, consumers must consider the amount of heavy metal that accumulates in water mimosa. Water mimosa can absorb heavy metals, including Cd, Pb and Hg greater than water spinach (Division of Soil Science, 2531). The accumulation of heavy metals is related to pH which affects to dissolve of heavy metals in water resources (Shehata, 2019). Spreading of heavy metal is based on the difference in concentration of each area. Additionally, the different types of plants can accumulate heavy metal differently (Bryan, 1969) and in different parts of the plant.

1.2 Objectives

1.2.1 To determine the concentration of Cu, Cd, Pb, Ni and Zn in water in Tha Chin River.

1.2.2 To evaluate the accumulation of heavy metals in roots, stems and leaves of water mimosa.

1.3 Scope

1.3.1 The water quality including pH, temperature, Dissolved Oxygen (DO), Electric conductivity (EC), Total Dissolve Solids (TDS), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and salinity at Station 1 (community and agricultural area) and Station 2 (community agricultural and industry area) were measured.

1.3.2 The amount of Cu, Cd, Pb, Ni and Zn in water and plants in each study site was analyzed.

1.4 Benefits

1.4.1 To evaluate the heavy metal concentration in the Tha Chin River.

1.4.2 To clarify the accumulation of heavy metal in each part of water mimosa.

CHAPTER 2

LITERATURE REVIEW

2.1 Heavy metal contamination in river

Currently, the environment in Thailand has a toxicity effect from heavy metal. It can occur from naturals such as volcanic activity, domestic, agricultural, medicine and technological etc. Their toxic element into the human body through food and beverage in small concentration can affected on all body system. However, the toxicity of heavy metals depends on many factors such as age, gender, genetic, chemical species, dose and route of exposure. Another group of factors may be poison to all organisms within ecosystems is metal contaminants things, such as As, Cd, Cu, Pb and Zn, that get deposited at riverbed sediment (Rashmi et al., 2013). The concentrations of Pb and Cu in the river water in some areas of the Tha Chin River were found to be higher than the standard values. During the wet season, high concentrations of Zn was excessed of standard values. The native aquatic plant species water spinach (*Ipomoea aquatica*) and water mimosa (*Neptunia oleracea*) were found to accumulate high concentrations of the same heavy metals. Statistical analysis revealed that Cu in water spinach had a positive correlation with Cu in the surrounding water (Oning V. et al., 2012).

2.2 The Tha Chin River

The Tha Chin River, a branch of the Chao Phraya River, begins at Makham-Thao subdistrict of Chainat Province. It flows through Suphanburi, Nakhonpathom and drains to the Gulf of Thailand at Samuthsakorn Province. It is about 325 kilometers long route (Weerayaporn, 2015). Heavy metals, which are components of tools, equipment, and chemicals used in everyday life, distributed into the river. According to the pollution control department report, the water quality index of the Tha Chin river showed an average of 57 (Bad) on 5 August 2019. Water quality index calculates form dissolved oxygen (DO), biological oxygen demand (BOD), total coliform bacteria (TCB), fecal coliform bacteria (FCB).

2.3 Water mimosa

Water mimosa (*Neptunia oleracea* Lour.) is a wetland plant which has a taproot that attaches to edges of rivers and brae and pantropical nitrogen-fixing perennial legume. The plant has purple-green stems, which can grow up to 1.5 meters. It has a spongy, fibrous white covering at the nodes called an aerenchyma, is an air-conducting tissue. Growth of water mimosa is interwoven, buoyant on the surface water. The stems are clad with bi-pinnate that small olive-green leaves separated in opposite pairs and sensitive leaves that close when touched. The leaves have an oblong shape measure around 4 to 14 mm and breadth 1 to 3 mm. The flowers are tiny greenish-yellow densely crowded into feathery orbicular inflorescences that bloom in summer.

The using of water mimosa for the treatment of water pollution because it is a plant that has property of high absorption of organic and inorganic substances and can grow in wastewater. In addition, water mimosa is sensitive to the environment in a narrow range.

Figure 2.1 Water mimosa

2.4 Water mimosa plantation in the Tha Chin river

Along the river, the people who live by the river, where the shore is not too steep, tends to grow the water mimosa as their occupation. The water mimosa is grown by using bamboo to make a trench. Growing the water mimosa at the Tha Chin River is not require using any chemical substances because the water is flowing all the time. The water mimosa gets most of nutrients from the river. The water mimosa can be grown by binding the rhizome of the water mimosa with the column. After 20-25 days the water mimosa will be ready for the harvest.

Figure 2.2 Water mimosa plantation in the Tha Chin River at Sam Pran station

2.5 Heavy metal accumulation capacity of water mimosa

Water mimosa (*Neptunia oleracea*) is one of a wetland plants that can remove metals from contaminated water. This plant grows easily and spreads rapidly on the water surface, buoyed by the white spongy tissue in the stems. Apart from that, this plant is known for its use in human consumption and its usage also extends to herbal medicine (Aini et al., 2014). Water mimosa has an ability to accumulate heavy metals such as Pb, Cu, Cd and Zn and is a good accumulator for Cd and Cu (Oning, 2012).

Most heavy metals were found to be accumulated in the roots and in lesser concentrations in aboveground parts including stem and leaves (Aini et al., 2014). The indicators of water quality and biomass determined after 30 days of treatment with water mimosa showed increased biomass and the BOD and COD of water in farm reduced overtime (Oning, 2012).

Using water mimosa for phytoremediation is new and unpopular applied. This plant can uptake heavy metals into organelles good capability. Although the water mimosa has properties to accumulation in each heavy metal is different. It can treatment wastewater. So, there are still cause health risks which not recommend being eaten without boiling processing. The boiling is the process that can decrease the concentration of heavy metals in water mimosa that breaking cell membrane and leached into water (Aini S., 2014).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study sites

The study sites were selected by using a land-use map. The first station was Bang Lan Subdistrict, Song Pee Nong District, Suphan Buri (14.155965, 100.127340). It was a representative of agricultural area. The second station was at Ban Mai Subdistrict, Sam Pran District, Nakhon Pathom (13.69237489, 100.239269). It was a representative of the industry of the Tha Chin River. The water and plant sampling were collected in April 2020.

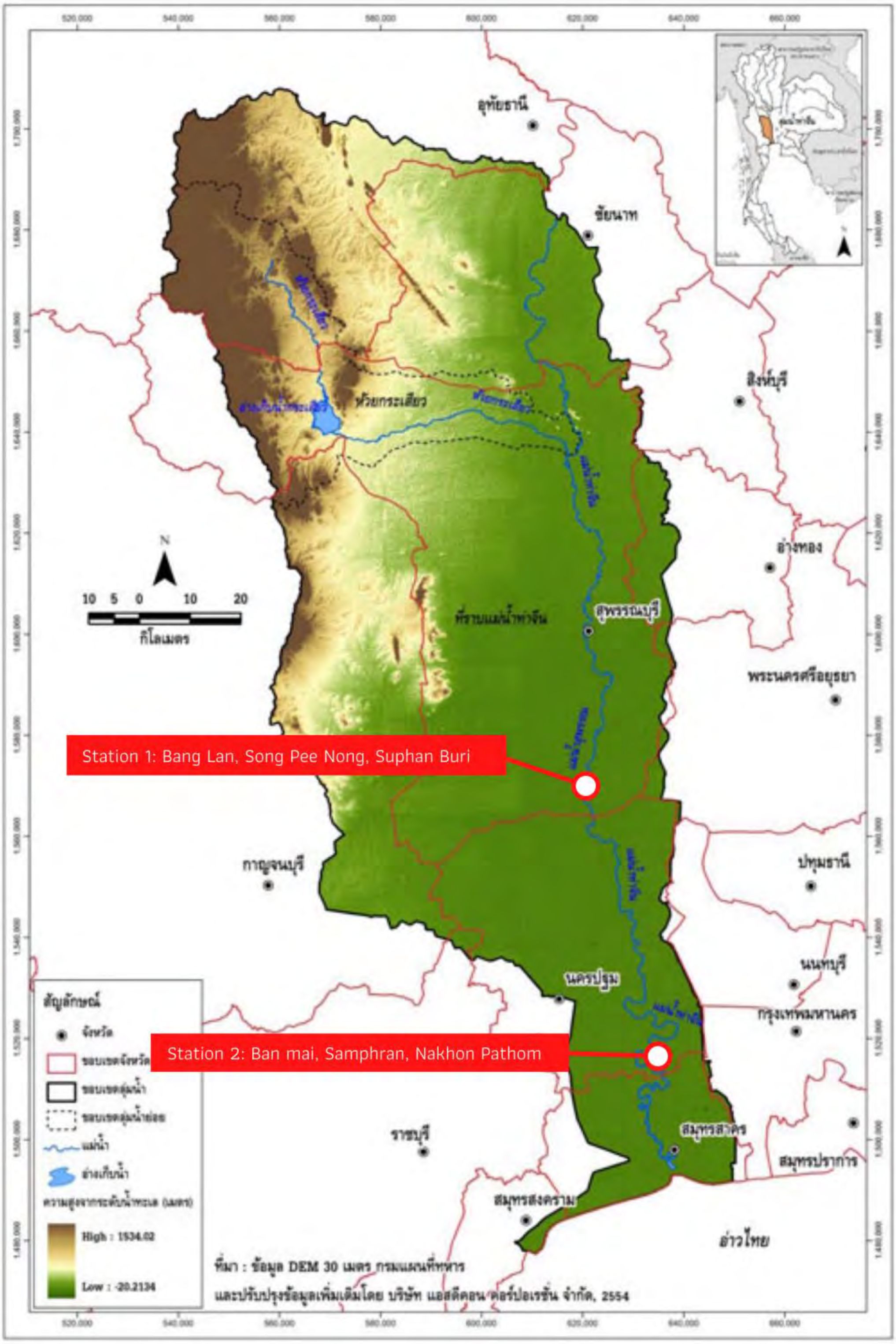

Figure 3.1 Study site map of heavy metals in the Tha Chin River

3.2 Water sampling

Water sampling was done at the water mimosa planting area, at 30 centimeters depth from the water surface. The water was collected in polyethylene bottle and taken to the laboratory. Then, the water sample was kept under 4 °C. In-situ and ex-situ analysis was performed in order to evaluate parameters, as presented in the table 3.1.

Table 3.1 Parameters for measuring water quality in the Tha Chin River

In-situ	**Parameter**	**Method**
	pH	pH meter
	Temperature (Air)	Thermometer
	Temperature (Water)	Thermometer
	DO (Dissolved Oxygen)	DO meter
	EC (Electric Conductivity)	Conductivity meter
	Salinity (psu)	Salinity meter
	Turbid (NTU)	Turbidity meter
	Atmospheric pressure (mmHg)	Barometer
	Humidity (‰)	Hygrometer
Ex-situ	**Parameter**	**Method**
	Biological Oxygen Demand (BOD)	Azide Modification
	Chemical Oxygen Demand (COD)	Close Reflux
	Total Dissolved Solids (TDS)	Gravimetric method
	Total Suspended Solids (TSS)	Glass Fiber Filter Disc
	Cu	AAS
	Cd	AAS
	Pb	AAS
	Ni	AAS
	Zn	AAS

3.3 Analysis of heavy metal concentration in water

The 45 mL of water sample and 5 mL of 65% HNO_3 were added in digestion vessel. The vessel was placed microwave digester (Mileston, Series 135931, Italy) and heated at 165°C for 20 minutes (EPA 3015). Then, vessel was cooled down and the solution was filtrated by using Whatman No. 42. Finally, the solution was diluted with deionized water in volumetric flask 50 mL and analyzed for Cu, Cd, Pb, Ni and Zn by Atomic Absorption Spectrophotometer (Agilent 240AA, U.S.A.).

3.4 Plant sampling

Plant was collected from the water mimosa planting area by simple random sample using 1 x 1 m^2 quadrat for every site and packed into polyethylene bags. Plants were taken for analysis to the laboratory. Plant samples were rinsed with tap water until clean for 5 minutes, followed by deionized water for 2 minutes. Then, water mimosa was separated into 3 parts, roots, stems and leaves and measured the length. All parts of the water mimosa were dried in an oven at 65°C within 48 hours. The dried water mimosas cut into small pieces and through sieve 1.0 mm until size like a powder. Then, each parts of plants were mixed into homogeneous and stored in zip-lock PE bags.

3.5 Plant analysis

The dried water mimosa was weighed about 0.5 g and placed in digestion vessel with 10 mL 65% HNO_3. The vessel was placed microwave digester (Mileston, Series 135931, Italy) and heated at 175°C for 25 minutes (EPA 3051). Then, vessel was cooled down and the solution was filtrated by using Whatman No. 42. Finally, the solution was diluted with deionized water in volumetric flask 50 mL and analyzed for Cu, Cd, Pb, Ni and Zn by Atomic Absorption Spectrophotometer (Agilent 240AA, U.S.A.).

3.6 Data analysis

All data from experiment was analyzed by using the one-way ANOVA (SPSS for windows 10 version 22)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Water Quality in Tha Chin River

The water quality in the Tha Chin River in a plantation of water mimosa in April 2020 showed high temperatures in water at Song Pee Nong district (33.4°C) than in Sam Pran district (29.8°C). The pH of water in Sam Pran station (6.8) was greater than Song Pee Nong station (6.4). The pH of both stations was in the range of water quality standards for surface water of Thailand. The dissolved oxygen (DO) of Song Pee Nong station was 3.3 mg/L and classified as type 3. The DO of Sam Pran station was over water quality standards for surface water so it was classified as type 4. The electric conductivity at Sam Pran station (1,508 µg/cm) was significantly higher than Song Pee Nong station (574 µg/cm). The salinity at Sam Pran station (0.6 psu) was three times greater than Song Pee Nong station (0.2 psu). The salinity at Sam Pran station was in the range of standard brackish water while the salinity of Song Pee Nong station was in the standard of freshwater. The turbidity at Sam Pran station and Song Pee Nong station were 13.1 and 11.7 NTU, respectively. Nong. The BOD at Sam Pran station (9.15 mg/L) was higher than Song Pee Nong (1.15 mg/L). The COD at Sam Pran station (45.3 mg/L) was higher than Song Pee Nong station (16.0 mg/L). The TDS at Sam Pran station (610.0 mg/L) was significantly higher than Song Pee Nong station (226.7 mg/L). The TSS at Sam Pran station (75.0 mg/L) was significantly higher than Song Pee Nong station (8.7 mg/L).

Table 4.1 Water quality in Tha Chin River at Song Pee Nong station and Sam Pran station

Parameter	Station		Water quality standards for surface waters of Thailand[a]
	Song Pee Nong	Sam Pran	
1. pH	6.4	6.8	pH 5-9
2. Temp Water (°C)	33.4	29.8	Not determined
3. Dissolve Oxygen (mg/L)	3.3	3.3	Water source type 3: 2-4 Water source type 4: <2
4. Electric Conductivity (µg/cm)	574	1508	Not determined
5. Salinity (psu)	0.2	0.6	Fresh water <0.5 psu Brackish water 0.5-30 psu
6. Turbid (NTU)	11.7	13.1	Not determined
7. Biochemical Oxygen Demand, BOD (mg/L)	1.15	9.15	Water source type 3: 1.5-2 Water source type 4: 2-4
8. Chemical Oxygen Demand, COD (mg/L)	16	45.3	Not determined
9. Total Dissolve Solid, TDS (mg/L)	226.7	610	Not determined
10. Total Suspended Solid, TSS (mg/L)	8.7	75	Not determined
11. Copper (Cu) (mg/L)	0.0041	0.0041	Not over 0.1
12. Cadmium (Cd) (mg/L)	0.0121	0.0142	Not over 0.05
13. Lead (Pb) (mg/L)	0.0396	0.0249	Not over 0.05
14. Nickel (Ni) (mg/L)	0.0027	0.0092	Not over 0.1
15. Zinc (Zn) (mg/L)	0.1032	0.1018	Not over 1.0

a: Pollution Control Department of Thailand

4.2 Heavy metals in Tha Chin River

The concentration of Cu, Cd, Pb, Zn and Ni in the Tha Chin River were determined and shown in Figure 4.1. In this study, the results indicated that the concentration of Zn is the highest both in Song Pee Nong station (0.1032 mg/L) and Sam Pran station (0.1018 mg/L). The levels of Ni were lowest in both Song Pee Nong (0.0092 mg/L) and Sam Pran station (0.0027 mg/L). However, the amount of all heavy metals in both stations were in the range of the water quality standards for surface water of Thailand. The analysis of water quality in the Tha Chin River is likely the same as the Weeyaporn et al. report (2015) measured in May 2014 because measured in dry season. In this study, the water was sampled in April. It was the dry season of Thailand. Therefore, the surface runoff or soil leaching by rain was considered as low that affected the dissolution of heavy metals into the river.

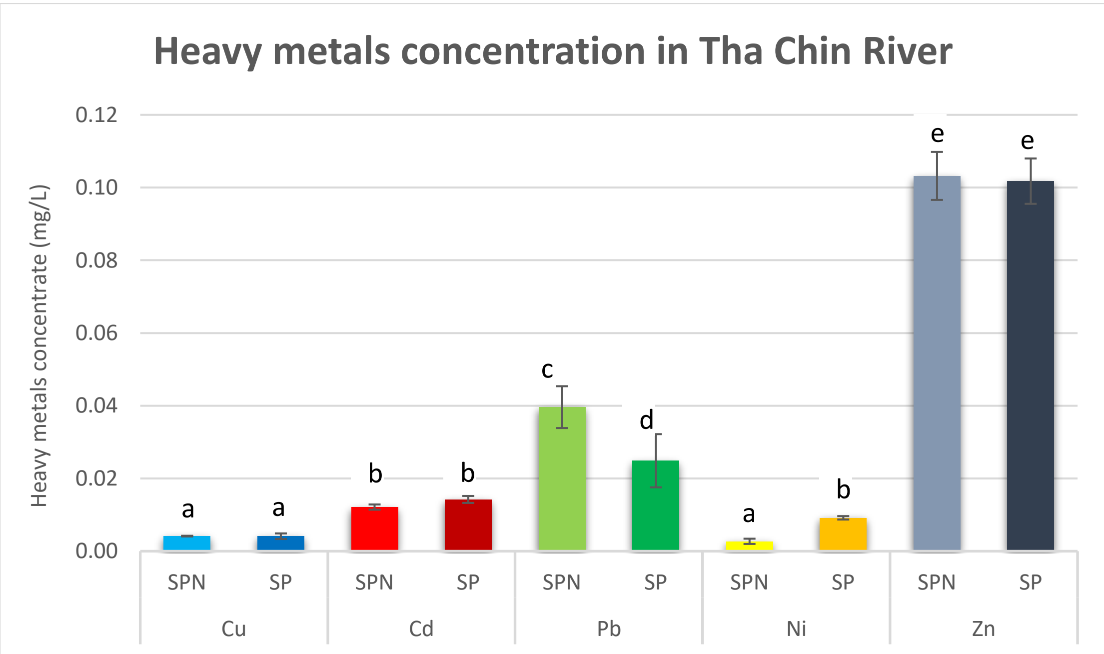

Figure.4.1 Heavy metals concentration in Tha Chin River

4.3 Heavy metals accumulation in water mimosa

The heavy metals accumulation in water mimosa (whole plant) was shown in Figure 4.2. The results revealed that the highest accumulation in water mimosa was Zn while the lowest was Ni. However, Cd was not detected in the tissue of water mimosa. At Song Pee Nong station, the accumulation level of Zn, Pb, Cu, and Ni was 135.02±10.21, 128.98±13.70, 106.12±6.64, and 8.15±1.04 mg/kg, dry weight respectively. At Sam Pran station, the accumulation level of Zn, Pb, Cu, and Ni is 452±3.15, 106.48±7.06, 45.98±1.94, and 17.28±0.64 mg/kg, respectively. As a result of the direction of the water mimosa stems that lay along the water surface resulting in its heavy metal absorption that can occur at both roots and stems.

The study in ryegrass indicated that the translocation of heavy metal in plant was ranged in order: Zn>Cd>Ni. The translocation of Pb in ryegrass was lowest. (Antoniadis et al, 2008).

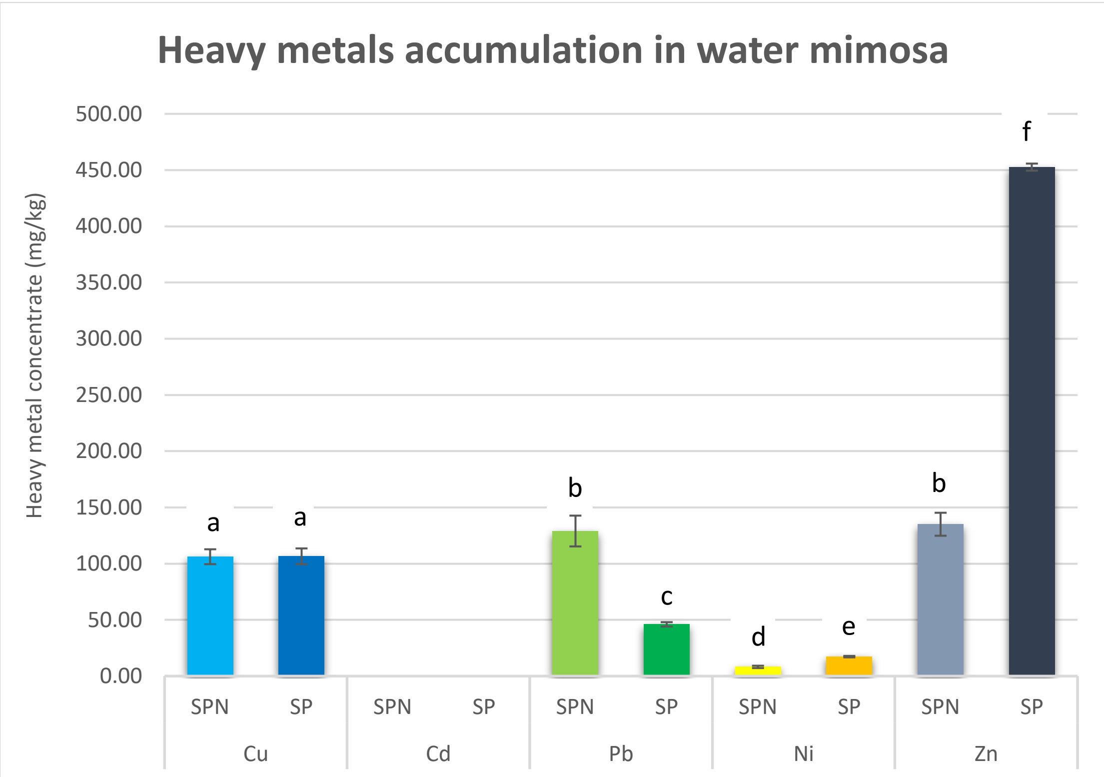

Figure.4.2 Heavy metals accumulation in water mimosa

4.3.1 Cu accumulation in water mimosa

The Cu accumulation in water mimosa was shown in figure 4.3. At Song Pee Nong station, water mimosa accumulated Cu at the stems> roots> leaves respectively. At the Sam Pran station, Cu accumulation was as follow: roots> stems>leaves. However, the total accumulation of Cu in plants at Song Pee Nong station and Sam Pran station was not significantly difference (P<0.05). At low concentrations of water, the accumulation of Cu in floating fern occurred mainly in the roots while the metal content in shoots increased at high concentrations according to time (Asit K. and Nitya G., 1989). The total accumulation of Cu in water mimosa was related to the concentration of Cu in water at two study stations.

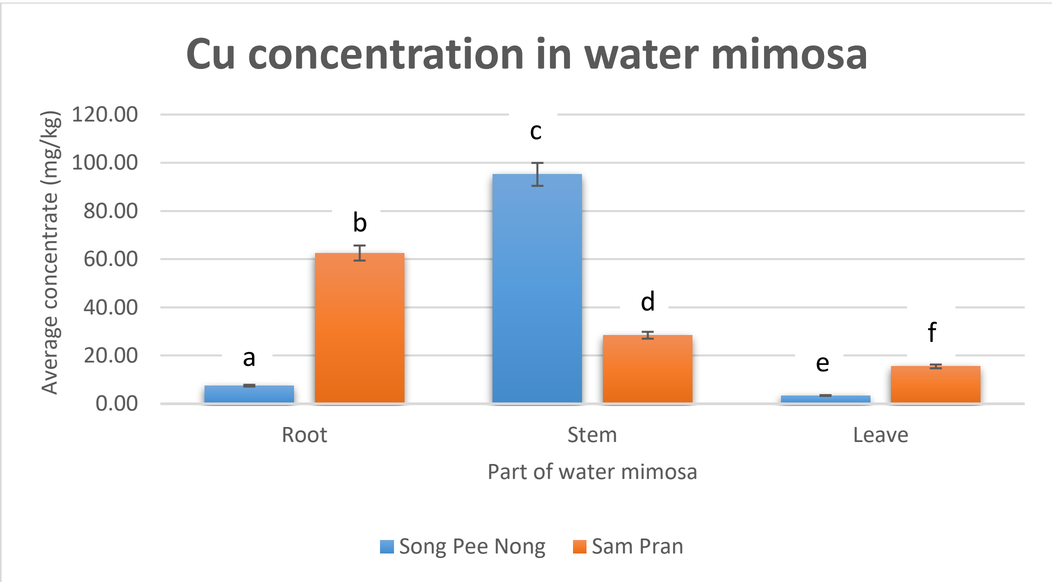

Figure.4.3 Cu accumulation in water mimosa

4.3.2 Cd accumulation in water mimosa

In this study, the Cd accumulation in water mimosa in both sampling sites were not detectable.

4.3.3 Pb accumulation in water mimosa

The Pb accumulation in water mimosa was shown in figure 4.4. At Song Pee Nong station, water mimosa accumulated Pb in the stems> roots>leaves. At Sam Pran station, the concentration of Pb in water mimosa was as follow:

roots> stems> leaves. The total accumulation of Pb in water mimosa grown at Song Pee Nong was significantly greater than in Sam Pran station ($P<0.05$). The concentration of Pb in water depends on the pH. At low pH, there is a high concentration of Pb (Onodera, 1985). At Song Pee Nong station was more acidic than Sam Pran station and surrounding area that is agriculture use fertilizer, household chemicals and pesticides to increase productivity which contains Pb component. Pb has the most difficult ability to move affect to accumulate at stems show high accumulation and low accumulation at leaves at Song Pee Nong station. Sam Pran station has accumulated in accordance with ability of uptake Pb. At Sam Pran station, the accumulation of Pb is consistent with the uptake of Pb.

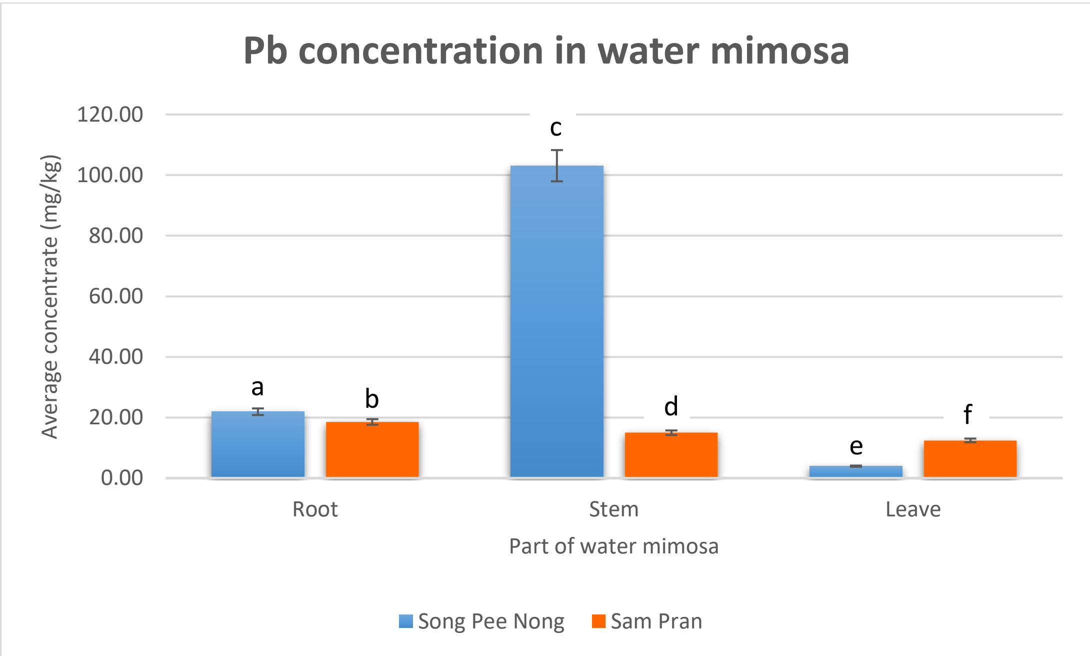

Figure.4.4 Pb accumulation in water mimosa

4.3.4 Ni accumulation in water mimosa

The Ni accumulation in water mimosa was shown in figure 4.5. At Song Pee Nong station and Sam Pran station, water mimosa accumulated Ni in the roots> stems>leaves. The total concentration of Ni in water mimosa at Sam Pran station was significantly higher than in Song Pee Nong station ($P<0.05$).

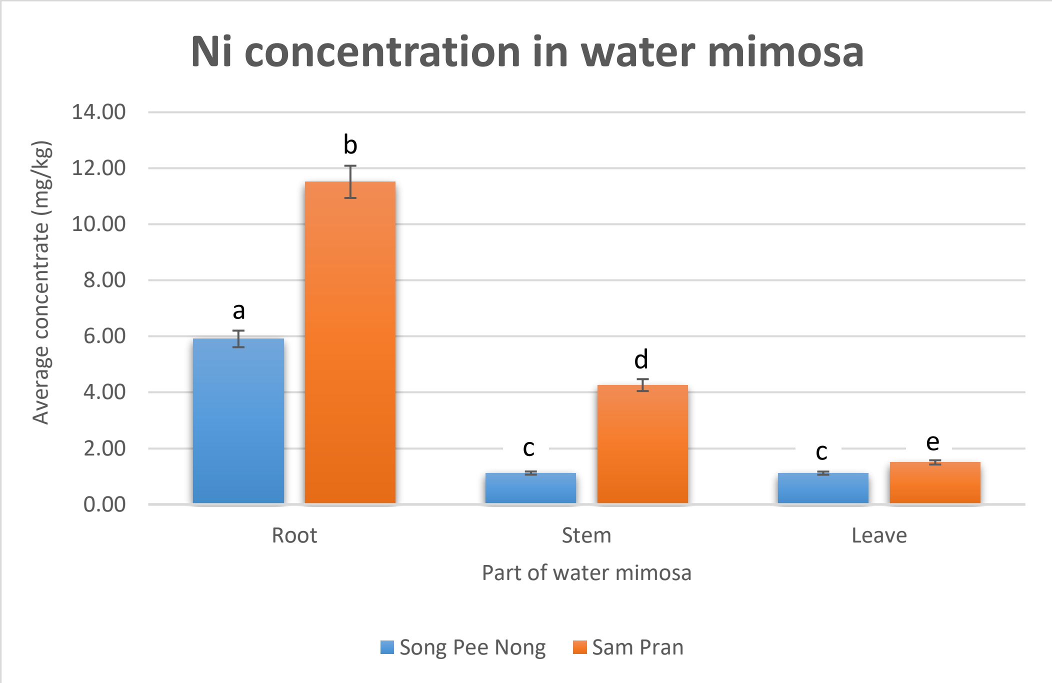

Figure.4.5 Ni accumulation in water mimosa

4.3.5 Zn accumulation in water mimosa

The Zn accumulation in water mimosa was shown in figure.4.6. The concentration of Zn in Sam Pran station was found in roots>stems>leaves. The concentration of Zn in Song Pee Nong station was found in stems>roots>leaves. Zn soluble in water in formed ZnO affect to 2 stations were the highest concentration of Zn in this study. Zn from metal coating, drug, fungicide or untreated industrial wastewater under control value of PCD of Thailand affect to high concentration of Zn at 2 station and high accumulation of Zn at root in water mimosa at Sam Pran station because this station gather a lot of heavy metal residue and accord with the water quality index shows Sam Pran stations is the worst in the Tha Chin River. The accumulation in each parts of water mimosa due to the ion exchange or transpiration.

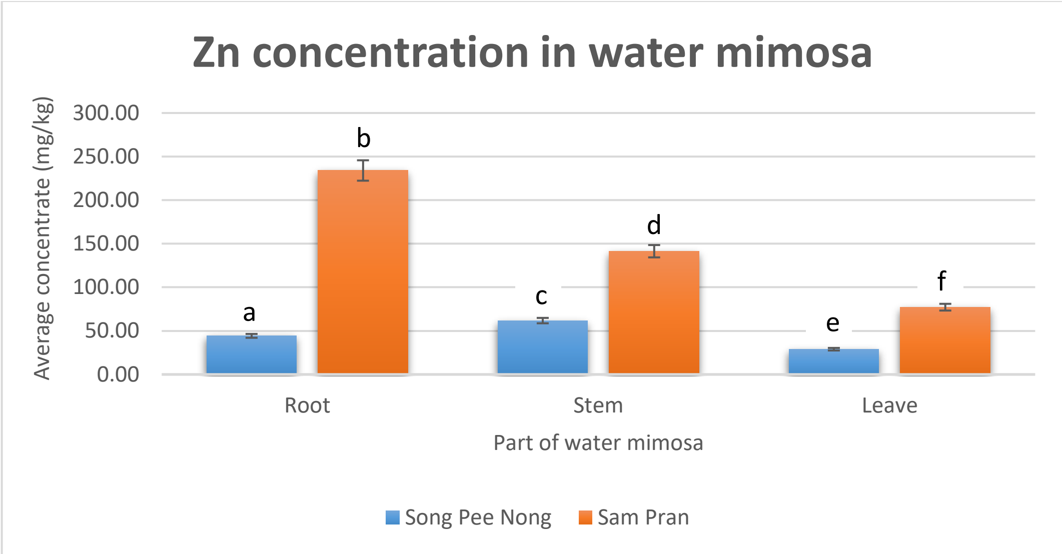

Figure.4.6 Zn accumulation in water mimosa

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

5.1 Water Quality in Tha Chin River

The water quality in the Tha Chin River including pH, temperature, DO, EC, TDS, TSS, BOD, COD, and salinity were analyzed. All of parameters was in the ranged of the water quality standards for surface waters of Thailand except BOD at Sam Pran station.

5.2 Heavy metals in Tha Chin River

The concentration of Zn is the highest both in Song Pee Nong station and Sam Pran station. The levels of Ni were lowest in both Song Pee Nong and Sam Pran station. However, the amount of all heavy metals in both stations were in the range of the water quality standards for surface water of Thailand.

5.3 Heavy metals accumulation in water mimosa

The heavy metals accumulation in the water mimosa were in order as follow: Zn>Pb>Cu>Ni both at Song Pee Nong station and Sam Pran station. Nevertheless, Cd was not detected in the tissue of water mimosa. The concentration of heavy metals in roots and stems were higher than leaves.

Recommendations

1. In this study, the high concentration of heavy metals was found in the stems of water mimosa which was the consumable parts for human. Therefore, it should be a guideline to protect the consumers from the contaminated plants.

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