UNIVERSITI PUTRA MALAYSIA

COPPER IN MANGROVE ENVIRONMENT: CURRENT STATUS IN SOIL, WATER AND PLANT AT SEPANG-LUKUT MANGROVE FOREST, MALAYSIA

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By

MAHMOOD HOSSAIN

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Science and Environmental Studies Universiti Putra Malaysia

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Abstract of the thesis presented to the Senate of the Universiti Putra Malaysia in fulfilment for the degree of Master of Science

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Chairman: **Associate Professor Saberi Othman, Ph.D.**

Faculty: **Science and Environmental Studies**

This study presents copper concentrations and distributions in Sepang-Lukut mangrove forest, Malaysia. This mangrove ecosystem is mainly polluted from different sources like waste from pig farms, oil palm industries and house hold waste. Untreated waste discharge from pig farms may be responsible for copper pollution in this forest area as copper sulphate has been used in the farms in the diet of pigs for protection from pathogenic disease. Untreated wastes are discharged directly into the Sepang Besar river which is situated in the Sepang-Lukut mangrove forest ecosystem.

Six stations were chosen for the study starting from the discharge point at every 2 km interval towards sea. Total and available copper in soil and copper content in infiltration water were measured for each station. Copper content was

also measured in river water adjacent to each station. Copper absorption and it's distribution in leaf, stem and root of *Rhizophora mucronata* seedlings were measured at the last three stations towards the sea.

Soil is the main reservoir of total and available copper content in the mangrove forest. Highest total and available copper concentration in soil was found in the stations nearest to the discharge point and decreased towards the stations near to the sea. The means of total and available soil copper content were 145 μg/g (ranged from 1.20 to 703.90 μg/g) and 36 μg/g (ranged from 0.74 to 103.21 μg/g) respectively. Available soil copper found to positively correlate with total soil copper, soil organic matter content and CEC. Total soil copper also found to positively correlate with soil organic matter content, soil CEC, total dissolved solids and *in situ* pH.

On the other hand, the mean concentration of copper in river and infiltration water were 0.07 mg/l and 0.04 mg/l respectively. Infiltration water copper content found to positively correlate with river water copper content. River water copper concentration found to positively correlate with redox potential and negatively correlate with dissolved oxygen and salinity.

Highest copper concentration in *Rhizophora mucronata* seedling parts were detected at Station 4 and roots attained the highest (9.24 μg/g) followed by stem (3.12 μg/g and leaves (3.10 μg/g). Copper concentration in seedling parts at Station 5 showed same trend like Station 4, where roots contained highest (2.84 μg/g) followed by leaves (2.39 μg/g) and stem (1.82 μg/g). But leaves contained the highest (2.25 μg/g) followed by stem (1.64 μg/g) and roots (1.54 μg/g) at Station 6.

Total copper in each seedling was 49.54 μg and its distribution in leaves, stem and roots were 16.96, 6.99 and 25.59 μg respectively at Station 4 where the total and available copper in soil were 3.72 and 1.36 g/m^2 (to a depth of 10 cm). At Stations 5 and 6 the total copper in seedling were 24.90 and 19.79 μg. Total and available copper in soil at this two station were 1.84, 0.88 and 0.29, 0.14 g/m^2 (to a depth of 10 cm).

Total and available soil copper concentration was very high at the study area which was 145 and 46 time higher than the accepted level allowed by the Department of Environment, Malaysia. Copper concentration in seedling parts found to increase with the increased copper level in soil. Copper concentration in soil, water and seedling parts found to decrease with increasing distance from pollutant discharge point. High copper concentration was observed in different parts of seedling in respect to the normal requirement for growth and development. For normal growth and development copper is required by plant only 0.01 μg/g. It seems that soil enriched with high copper concentration may be the contribution of river water copper content.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

UNSUR KUPRUM DALAM PERSEKITARAN KAWASAN PAYA: STATUS SEMASA DI DALAM TANAH, AIR DAN TUMBUHAN DI HUTAN PAYA SEPANG-LUKUT, MALAYSIA

Oleh

MAHMOOD HOSSAIN

Jun 1998

Pengerusi: Profesor Madya Saberi Othman, Ph.D.

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Kajian ini memberikan kepekatan dan taburan kuprum di hutan paya bakau Sepang-Lukut, Malaysia. Ekosistem ini kebanyakannya dicemari oleh sumber-sumber seperti sisa buangan dari ladang penternakan khinzir, industri kelapa sawit dan buangan domestik. Sisa buangan dari ladang khinzir yang tidak dirawat mugkin menyebabkan pencemaran kuprum di hutan paya bakau ini. Kuprum sulfat telah ditambahkan kepada diet khinzir untuk melindungi mereka daripada penyakit patogenik. Sisa buangan yang tidak dirawat sering dibuang terus ke dalam sungai Sepang Besar yang mengalir melalui hutan paya bakau Sepang-Lukut.

Enam stesen telah dipilih bagi kajian ini, bermula dari titik punca buangan dan di setiap selang jarak 2 km mengarah ke laut. Jumlah dan kandungan unsur kuprum dalam tanah dan air yang tidak ditapis diukur dan direkod pada setiap stesen. Kadar serapan dan taburan kuprum dalam daun, batang dan akar bagi anak benih *Rhizophora mucronata* diukur pada tiga stesen terakhir menuju laut.

Tanah merupakan 'reservoir' utama jumlah dan kandungan kuprum di hutan paya bakau. Jumlah dan kandungan kuprum di dalam tanah didapati tertinggi di stesen terdekat dengan titik punca buangan dan jumlah ini menurun apabila menuju ke stesen berdekatan laut. Purata bagi jumlah dan kandungan kuprum tanah adalah 145 μg/g (julat 1.2-703.9 μg/g) dan 36 μg/g (julat 0.74-103.21 μg/g) masing-masing. Kandungan kuprum didapati mempunyai kolerasi positif dengan kandungan kuprum di dalam tanah organik tanah dan CEC tanah. Kandungan kuprum di dalam tanah didapati berkolerasi positif dengan kandungan bahan organik di dalam tanah, CEC tanah, jumlah bahan terlarut dan 'insitu' pH.

Sebaliknya, nilai min kandungan kuprum di dalam sungai dan air tidak ditapis ialah 0.07mg/l dan 0.04 mg/l masing-masing. Kandungan kuprum di dalam air tidak tertapis adalah berkolerasi positif dengan kandungan kuprum di dalam air sungai. Kandungan kuprum di dalam air sungai didapati mempunyai kolerasi positif dengan keupayaan 'redox' dan kolerasi negetif dengan oksigen terlarut dan salinity.

Kandungan kuprum pada bahagian-bahagian benih *Rhizopora mucronata* adalah tertinggi dikesan pada stesyen 4 di mana akar mempunyai nilai tertinggi (9.24 μg/g) dan dikuti oleh batang (3.12 μg/g) serta daun (3.10

μg/g). Kandungan kuprum pada bahagian-bahagian benih pada stesyen 5 menunjukkan tren yang sama seperti stesyen 4, di mana akar adalah tertinggi (2.84 μg/g) dan dikuti oleh daun (2.39 μg/g) dan batang (1.82 μg/g). Akan tetapi, daun adalah tertinggi (2.25 μg/g) dan dikuti oleh batang (1.64 μg/g) serta akar (1.54 μg/g) pada stesyen 6.

Jumlah kuprum di dalam setiap benih ialah 49.54 μg dan taburan di dalam daun, batang dan akar ialah 16.96, 6.99 dan 25.59 μg masing-masing pada stesyen 4 di mana jumlah dan kandungan kuprum di dalam tanah ialah 3.72 dan 1.36 g/m^2 (pada kedalaman 10cm). Pada stesyen 5 dan 6 kandungan nya ialah 24.90 dan 19.79 μg. Jumlah dan kandungan kuprum pada dua stesyen ini ialah 1.84, 0.88 dan 0.29, 0.14 g/m^2 (pada kedalaman 10 cm).

Jumlah dan kandungan kepekatan kuprun adalah sangat tinggi di kawasan kajian iaitu 145 dan 46 kali lebih tinggi daripada paras yang dibenarkan oleh Jabatan Alam Sekitar, Malaysia. Kandungan kuprum pada bahagian-bahagian benih didapati bertambah dengan peningkatan paras kuprum di dalam tanah. Kandungan kuprum di dalam tanah, air dan bahagian-bahagian benih didapati berkurangan dengan pertambahan jarak dari titik punca buangan. Kandungan kuprum pada bahagian-bahagian berlainan pada benih diperhatikan adalah tinggi berbanding dengan keperluan dan perkembangan normalnya. Kandungan kuprum yang diperlukan oleh tumbuhan untuk keperluan dan perkembangan normalnya cuma 0.01 μg/g. Ini mungkin kerana kandungan tanah telah diperkayakan sehingga menjadi tinggi datangnya dari kandungan kuprum air sungai.

CHAPTER I

INTRODUCTION

Mangrove ecosystem is very complex and diversified in nature. Mangrove forest formations occur in the inter-tidal zones along the sea coasts in most tropical and subtropical countries and are among the most productive ecosystems (Aksornkoae, 1993).

Mangrove forests serve as a link between marine and terrestrial ecosystems. These communities are clearly important to the stability and maintenance of various adjoining ecosystems, such as seagrass, coral reef and marine ecosystems. Mangrove represents a unique ecological niche and habitat for a variety of marine and terrestrial animals. The amount of organic matter produced by mangrove communities supports not only the mangrove ecosystem itself but also other related ecosystems. Moreover, mangroves help to stabilize shorelines in coastal streams and estuaries by protecting them against tidal bores and soil erosion. Mangrove also serve as a wind breaker against storms, especially in countries which are frequently attacked by strong winds, such as Philippines, Vietnam, Bangladesh and Australia (Aksornkoae, 1993).

It is believed that if the mangrove communities along the banks of estuaries and coastlines were disturbed, or destroyed, there would be no habitat or food to support the organisms in these areas. Furthermore, the loss of mangroves related ecosystems (seagrass, coral reef and marine ecosystems) would disturb the natural ecological systems over a considerable area and result in large scale economic loss and socio-cultural change in coastal communities (Aksornkoae, 1993).

Heavy metals pollution to the terrestrial environment is not a recent occurrence. It has appeared as pollutant from the beginning of the human civilization but its intensity and impact has become alarming with the increasing industrialization. Some heavy metals are ubiquitous in trace concentrations in soil and vegetation, in fact some of them are required by plants as micronutrients. Some 15 elements which are present in the rocks and soils, normally in very small amounts, are essential for plant nutrition. However, larger concentrations of these trace elements/ metals could be toxic to the plants. These potentially toxic elements include arsenic, boron, cadmium, copper, fluorine, lead, mercury, molybdenum, nickel, selenium and zinc. The range of problems of these metals to the plants depends on their total concentration in soils, chemical forms, mobility and availability (Fergusson, 1990).

Of the heavy metals, copper is one of the most extensively used by men. In nature, copper is usually found as sulphides, sulfates, thiosulphates, carbonates and other compounds and also occurs as the native metals. The use of native copper has been started by man since 8000 B. C. and it's first alloy was bronze which become popular from about 4000 B. C. (Tiller and Merry, 1981). The total world production of copper from ancient time to 1980, estimated to be about 170 X 10^6 tonnes (Tiller and Merry, 1981).

Effect of metal pollution to the mangrove plants and mangrove ecosystem is a very recent field of interest. Heavy metals are usually enriched in mangrove forest areas due to industrial and farm waste discharge to the mangrove rivers. Nowadays it is becoming common to the recently industrializing developing countries in the tropical and sub-tropical regions.

Increased use of fertilizers and insecticides may add pesticides and fertilizer residues to the waterways from field runoff. Harmful chemicals could also be accumulated in the soils leading to hindrance of microbial processes and mineralization, thereby impeding tree growth, or may be directly taken by the plants in toxic quantities. Mangrove plants are generally considered as filters of many pollutants, particularly sewage discharge. But such material, once accumulated in their tissues, can be passed along the food chain, ultimately with a potential of attaining unacceptably high levels in species consumed by humans (Karim, 1994).

Mangrove sediment has certain characteristics that favor metal accumulation. Stream water containing fine particles enriched with metals, high organic and sulphide content which help to fix metals. On the other hand high sedimentation rates contribute to a permanent burial of locally formed metal sulfides and refractory metal organic complexes (Aragon, 1986; Harbinson, 1981; Lacerda and Abrao, 1984).

Moreover, it is found that heavy metals in mangrove soil can reach high concentrations but mangrove plants seem to be unaffected by them (Lacerda *et al.*, 1991). Mangrove sediment accumulates 98% of the total metals in the mangrove forest, and rest of the small amount of the metals accumulates in the plant biomass, therefore with very slow cycling (Silva *et al.*, 1990).

The source of copper pollution at the study area is untreated waste discharge from pig farms into the Sepang-Besar River. The Sepang-Lukut mangrove forest is situated on both sides of this river. Farms are situated near to the river banks, about 10 km away from the sea. The farmers usually add copper sulphate to the diet of pig for protection against pathogenic disease (Ong *et al.*, 1991). Organic waste of pig farms mainly contain N, K and Cu (Weigand, 1991). Of these elements copper is reported more toxic to the plant (Dalgarno and Miller, 1975). Moreover, high copper concentration about 500 μg/g in the sediment of this mangrove forest was reported by Saberi (1997). So, it seems that Sepang-Lukut mangrove forest is becoming environmentally stressed due to pollution. If the mangrove communities are destroyed or disturbed the existence of some closely linked ecosystems like seagrass, coral reef and coastal ecosystems, could also be destroyed. The stocking as well as the existence of a natural mangrove forest depends mainly on the status of natural regeneration. There are many factors affecting the natural regeneration of the forest and high levels of heavy metals in the soil could be one of the important factors.

Objectives

1. To determine the accumulation of Cu in different parts of *Rhizophora mucronata* seedlings.
2. Determine the total and available copper in the mangrove soil.
3. Determine the copper content in water environment.
4. To identify the polluted mangrove areas based on copper accumulation in *Rhizophora mucronata* seedlings at the four leaf stage.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

In Peninsular Malaysia, the total extent of mangrove forests is about 107,720 ha. Of which about 92,350 ha (85.7%) are gazetted as reserve forests and the rest of about 15,370 ha (14.3%) are stateland mangroves. Most of these forests are found along the sheltered west coast which borders the Straits of Malacca in the states of Kedah, Perak, Selongor and Johor. Selangor alone accounts for about 24.12% of the total mangrove forest in Peninsular Malaysia (Ibrahim and Chan, 1995).

Location of the Study Area

This study was conducted at Sepang Lukut mangrove forest in Negeri Sembilan, Malaysia. Sepang-Lukut mangrove reserve is situated both sides of Sepang-Besar River bank and extended to some areas along the sea at the west coast of Malaysia. This mangrove forest is located in between latitudes 2^0 36' - 2^0 41' N and longitudes 101^0 42' - 101^0 46' E (Figure 1).

Timing of Survey

Field work was conducted on two occasions, 13th November and 24th December in 1997 respectively. Systematic sampling procedure was employed for sample collection. For the study 6 (six) stations were selected along the river at every 2 km interval.

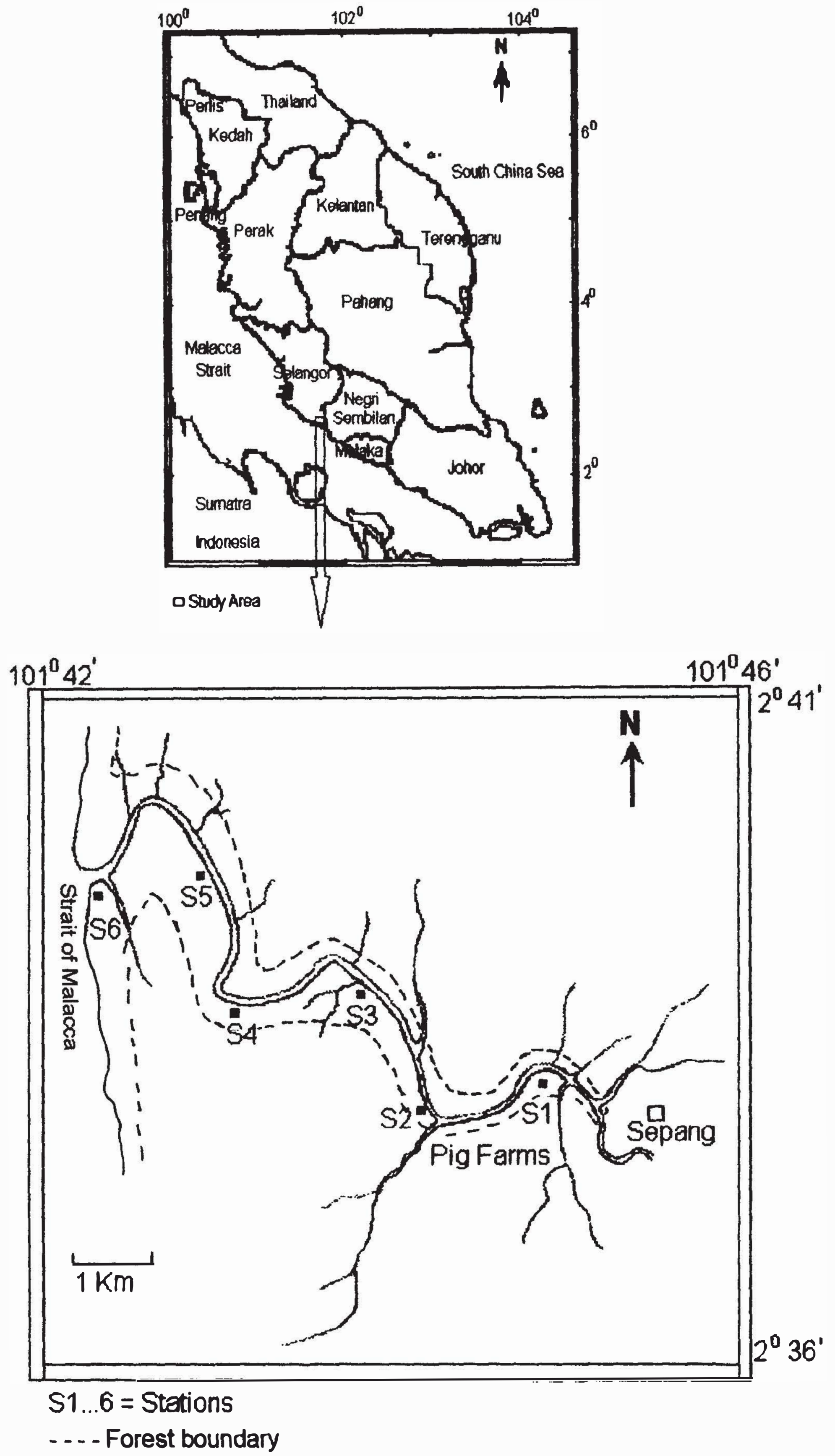

Figure 1: Map of the Sepang-Lukut Mangrove Forest Area Showing the Location of Sepang Besar River with Sample Stations

Two plots were chosen from each station. Each plot was further subdivided into 3 sub-plots. Soil, infiltration water and plant samples were collected from 3 sub-plots in each main plot. River surface water samples were also collected from the middle part of the river adjacent to each station at the study area. The size of the main sample plot was 3 m X 3 m and each sub-plot was 3 m X 1 m.

Description of the Forest Area

Forest Structure

Sepang-Lukut mangrove forest appears as a strip. The width of the strip is only 5 (five) meter at the upstream of Sepang-Besar River. But it increases towards the sea, where it is found to vary from 100 to 200 m in width. The canopy is continuous at about 15 meters, occasionally broken by emergents which can reach 26 meters (Saberi, 1993). General view of Sepang-Lukut mangrove forest area is shown in Plate 1 and forest boundary is shown in Figure 1.

Species Composition

There are very few plant species in this forest, of which *Rizophora mucronata*, *Rhizophora apiculata*, *Avicennia alba*, *Sonneratia alba*, *Bruguiera gymnorrhiz, Ceriops tagal* and *Xylocarpus granatum* are important. Of these species *Rhizophora mucronata* is the dominant and frequent in distribution at this forest and also the highest in density of about 350 trees per ha (Saberi, 1993). *Rizophora mucronata*, *Rhizophora apiculata* and *Avicennia alba* are found at