ACCUMULATION OF HEAVY METALS IN SEAGRASS (*Halodule pinifolia* AND *Halophila minor*) IN SETIU WETLAND, TERENGGANU

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MASTER OF SCIENCE
UNIVERSITI MALAYSIA TERENGGANU
MALAYSIA

2009

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Thesis Submitted in Fulfillment of the Requirement for the
Degree of Master of Science in the Institute of Oceanography
Universiti Malaysia Terengganu

February 2009

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Abstract of thesis presented to the Senate of University Malaysia Terengganu in fulfillment of the requirements for the Degree of Master of Science

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DECEMBER 2008

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In this study the metal uptake by two species of seagrasses, *Halodule pinfolia* and *Halophila minor*, from the Setiu lagoon was studied by carrying out a monitoring survey of the metal contents in the seagrasses in the lagoon and their bioaccumulation capacity and resultant toxicity investigated by carrying out laboratory sediment toxicity experiments. The aims of this study were: (i) To study the accumulation of metals in *Halodule pinfolia* and *Halophila minor*) towards selected metals (copper, zinc, lead and cadmium) in the Setiu lagoon., (ii) to determine the accumulation of heavy metals in the leaves and rhizomes – root system of the two seagrass species, (iii) To determine the accumulation of heavy metals in the sediments and seagrass tissues from artificially contaminated sediments.

In laboratory experiments, the seagrasses were grown in sediments spiked with four different concentrations of copper (56.44 µg/g, 112.87 µg/g, 225.74 µg/g and 451.49 µg/g), zinc (47.67 µg/g, 95.33 µg/g, 190.65 µg/g and 381.30 µg/g), cadmium (36.00

μg/g, 72.00 μg/g, 144.00 μg/g and 288.00 μg/g) or lead (21.88 μg/g, 43.75 μg/g, 87.50 μg/g and 175.00 μg/g). The exposure period to the spiked sediments was for 8 weeks during which plants were sampled weekly and the metal concentrations in leaves and root-rhizomes determined. In the field study, sediments from the seagrass beds and seagrasses in the Setiu lagoon were sampled for metal analyses for eleven months.

The heavy metal concentrations were measured by AAS after acid digestion of seagrass and sediment samples. Pearson Correlation was used to determine the relationships between the accumulation of heavy metals in root-rhizomes and leaves with sediment, pore water, oxygen produced, and plant size.

The root-rhizomes of *Halodule pinifolia* and *Halophila minor* accumulated higher concentration of Cu, Zn, Cd and Pb than in leaves in both the laboratory experiments and in the Setiu lagoon. The significant correlations were found between metal content of root-rhizome and leaves of *Halodule pinifolia* and *Halophila minor* with both sediment and pore water. Both species accumulated metals more from sediment than from pore water. However, the accumulation trend was different with the metal concerned. In laboratory experiments, the metal concentrations increased with duration of exposure. *Halodule pinifolia* died after 4 weeks exposure to Cu, Cd and Zn, when the concentration of test sediment Cu concentration was 112.87 μg/g and Cu concentrations in the respective tissues reached >93.98 μg/g (root-rhizomes) and >69.35 μg/g (leaves). Plant mortality occurred at test sediment Zn concentration of 95.33 μg/g and concentrations of the metal in tissues reached >85.06 μg/g (root-rhizomes) and >72.13 μg/g (leaves). For the Cd exposure experiment mortality occurred at sediment Cd concentration of 72.00

μg/g, and tissue Cd concentration reached >20.25 μg/g (root-rhizomes) and >30.00 μg/g (leaves). Seagrass mortality was found at Pb sediment concentration of 43.75 μg/g after 5 weeks exposure unlike the other metals where mortality occurred after 4 weeks exposure. Tissue Pb concentrations reached >31.63 μg/g (root-rhizomes) and >31.38 μg/g (leaves) in the surviving plants.

Halophila minor mortality was observed at sediment Cu concentration of 225.74 μg/g and the tissue concentrations of the metal in surviving plants reached >36.64 μg/g (root-rhizomes) and >23.79 μg/g (leaves). Mortality in the Zn experiment occurred at sediment Zn concentration of 95.33 μg/g and when tissue levels of the metal reached >65.89 μg/g (root-rhizomes) and >38.56 μg/g (leaves). Sediment Cd concentration of 72.00 μg/g resulted in seagrass mortality and tissue levels reached >21.13 μg/g (root-rhizomes) and >19.38 μg/g (leaves). Seagrass mortality occurred at sediment Pb concentration of 43.75 μg/g and tissue concentrations reached >30.13 μg/g (root-rhizomes) and >25.25 μg/g (leaves). At these sediment metal concentrations, the leaf color had changed (green to yellow for *Halodule pinifolia* and brown to transparent for *Halophila minor*) and resulted in a significant decrease in leaf size (growth) and of dissolved oxygen production during photosynthesis.

In the field study, the metal concentrations in *Halodule pinifolia* and *Halophila minor* increased every month from June onwards except for Pb uptake by *Halodule pinifolia* that did not show much variation throughout the 11 months of measurements while Cu increased by July onwards. The metal concentrations reached a peak in October or November 2004 for *Halodule pinifolia* and in the month of November 2004 for

Halophila minor except for Fe and Mn. The descending rank of metal concentration in seagrass and sediments were Fe > Mn > Cd > Cu > Pb > Cd and Fe > Mn > Zn > Pb > Cu > Cd respectively.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu sebagai memenuhi keperluan untuk ijazah Master Sains

AKUMULASI LOGAM BERAT DALAM RUMPUT LAUT (*Halodule pinifolia* DAN *Halophila minor*) DI MUARA SETIU, TERENGGANU

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Dalam kajian ini pengambilan logam oleh dua spesies rumput laut, *Halodule pinifolia* dan *Halophila minor*, dari Lagun Setiu dikaji melalui pengukuran kandungan logam dalam rumput laut di muara dan kapasiti akumulasi dan hasil ketoksikan dikaji melalui eksperiment ketoksikan sedimen yang dijalankan di makmal. Tujuan kajian ini adalah untuk: (i) mengkaji akumulasi logam dalam *Halodule pinfolia* dan *Halophila minor* terhadap kuprum, zink, plumbum, dan cadmium di Seitu lagun, (ii) mengenalpasti kandungan logam berat dalam daun dan sistem akar-rizom bagi kedua-dua spesies rumput laut, (iii) mengenalpasti akumulasi logam berat dalam sedimen dan tisu rumput laut dari sediment yang terkontaminasi.

Dalam eksperimen makmal, rumput laut ditanam dalam sedimen yang telah ditambahkan dengan empat kepekatan berlainan bagi logam kuprum (56.44 µg/g, 112.87 µg/g, 225.74 µg/g and 451.49 µg/g), zink (47.67 µg/g, 95.33 µg/g, 190.65 µg/g and 381.30 µg/g), kadmium (36.00 µg/g, 72.00 µg/g, 144.00 µg/g and 288.00 µg/g) atau plumbum (21.88

μg/g, 43.75 μg/g, 87.50 μg/g and 175.00 μg/g). Tempoh pendedahan kepada sedimen ini ialah selama lapan minggu, di mana pokok diambil untuk persampelan pada setiap minggu dan kepekatan logam dalam daun dan akar-rizom diukur. Dalam kajian lapangan, sampel rumput laut dan sedimen dari tapak yang ditumbuhi rumput laut di lagun Setiu diambil untuk analisis logam selama sebelas bulan.

Kepekatan logam berat diukur dengan menggunakan AAS selepas pencernaan asid sampel rumput laut dan sedimen. Korelasi Pearson digunakan untuk mengenalpasti hubungan di antara akumulasi logam berat dalam akar-rizom dan daun dengan sedimen, air liang sedimen, penghasilan oksigen dan saiz pokok.

Akar-rizom bagi *Halodule pinifolia* dan *Halophila minor* mengakumulasi lebih tinggi kepekatan Cu, Zn, Cd dan Pb berbanding dengan daun dalam kedua-dua eksperimen di makmal dan lagun Setiu. Korelasi yang signifikan diperolehi di antara kandungan logam dalam akar-rizom dan daun *Halodule pinifolia* dan *Halophila minor* dengan kedua-dua sedimen dan air liang. Kedua-dua spesis mengakumulasi logam lebih dari sedimen berbanding dengan air liang. Namun begitu, corak akumulasi berbeza dengan jenis logam. Dalam eksperimen makmal, kepekatan logam meningkat dengan tempoh pendedahan. *Halodule pinifolia* mati selepas empat minggu pendedahan kepada Cu, Cd dan Zn, apabila sedimen yang mengandungi kepekatan Cu sebanyak 112.87 μg/g dan kepekatan Cu dalam tisu mencapai >93.98 μg/g (akar- rizom) and >69.35 μg/g (daun). Kematian pokok berlaku pada kepekatan Zn dalam sedimen sebanyak 95.33 μg/g dan kepekatan logam dalam tisu ialah >85.06 μg/g (akar-rizom) dan >72.13 μg/g (daun). Bagi eksperimen pendedahan terhadap Cd, kematian berlaku pada kepekatan Cd dalam sedimen

sebanyak 72.00 μg/g dan kepekatan Cd dalam tisu mencapai >20.25 μg/g (akar-rizom) dan >30.00 μg/g (daun). Rumput laut didapati mati apabila sedimen mengandungi sebanyak 43.75 μg/g Pb selepas lima minggu pendedahan tidak seperti logam lain di mana kematian berlaku selepas empat minggu pendedahan. Kepekatan Pb dalam tisu mencapai >31.63 μg/g (akar-rizom) dan >31.38 μg/g (daun) dalam pokok yang masih hidup.

Kematian *Halophila minor* didapati berlaku dalam sedimen yang mengandungi kepekatan Cu sebanyak 225.74 μg/g dan kepekatan logam dalam tisu tumbuhan yang masih hidup mencapai >36.64 μg/g (akar-rizom) dan >23.79 μg/g (daun). Kematian dalam eksperimen Zn berlaku pada 95.33 μg/g kepekatan Zn dalam sedimen dan apabila logam dalam tisu mencapai >65.89 μg/g (akar-rizom) dan >38.56 μg/g (daun). Sedimen yang mengandungi 72.00 μg/g Cd telah menyebabkan kematian rumput laut dan tahap logam dalam tisu mencapai >21.13 μg/g (akar-rizom) dan >19.38 μg/g (daun). Kematian rumput laut berlaku pada sedimen yang mengandungi 43.75 μg/g Pb dan kepekatan dalam tisu mencapai >30.13 μg/g (akar rizom) dan >25.25 μg/g (daun). Pada kepekatan sedimen ini, warna daun berubah (hijau ke kuning bagi *Halodule pinifolia* dan perang ke lutsinar bagi *Halophila minor*) dan menunjukkan pengurangan signifikan bagi saiz daun (pertumbuhan) dan penghasilan oksigen semasa fotosintesis.

Dalam kajian lapangan, kepekatan logam dalam *Halodule pinifolia* dan *Halophila minor* meningkat pada setiap bulan dari Jun ke atas kecuali pengambilan Pb oleh *Halodule pinifolia* yang tidak menunjukkan banyak variasi sepanjang pengukuran selama 11 bulan manakala Cu meningkat dari Julai ke atas. Kepekatan logam mencapai kemuncak pada Oktober atau November 2004 bagi *Halodule pinifolia* dan November 2004 bagi

Halophila minor kecuali Fe dan Mn. Tertib penurunan kepekatan logam dalam rumput laut dan sedimen adalah Fe > Mn > Cd > Cu > Pb > Cd dan Fe > Mn > Zn > Pb > Cu > Cd masing-masingnya.