UNIVERSITI PUTRA MALAYSIA

Concentrations Of Heavy Metals In Sediment And Selected Organisms In Lukut River, Malaysia, And Their Toxicological Effects On *Penaeus Monodon* (Fabricius) Juveniles.

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By

ALIREZA SAFAHIEH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

April 2007

DEDICATION

To:

my mother,
my wife,
and my children

Abstract of thesis presented to the Sanate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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April 2007

Chairman: **Associate Professor Ahmad bin Ismail, PhD**

Faculty: **Science**

The status of heavy metals contamination in Lukut River, Negeri Sembilan, Malaysia was studied in September 2003. In general, except for Pb in the water, the level of heavy metals in the water and sediment of Lukut River were found to be within the range of other Malaysian Rivers. The metals concentrations in *T. telescopium* and the prawns *P. monodon* and *P. merguiensis* was within the range of heavy metal measured in other gastropods or prawn species previously studied in Malaysia indicating no serious metal pollution exists in the study area. Heavy metal concentration in the muscle tissues of the prawns was found to be lower than maximum permissible levels recommended for human consumption.

High level of Pb was found in the water of Lukut River (390.10 µg/l) which was found to be relatively higher than some Malaysian rivers. The pattern of Pb concentration in water samples and low Pb level in the sediment suggested that dissolved Pb was originated from the sea–based inputs.

The sublethal toxicity of the metals on growth, moulting and Ca content in exoskeleton of *P. monodon* juveniles were also investigated in 21 days period.

Results indicated that after 21 days the juveniles exposed to Cu concentration of 1000 µg/l, Zn concentration of 1000 µg/l, Cd concentration of 160 µg/l and Pb concentration of 316 µg/l or above grew slower than controls ($P<0.05$).

Among the metals studied, Cu and Zn were found to have an inhibition effect on exoskeleton calcification. The lowest concentration caused reduction in exoskeleton calcification was 100 µg/l and 1000 µg/l for Cu and Zn respectively.

Metals exposure was also affected the moulting of *P. monodon*. The period of molt cycle was increased significantly in the prawns exposed to 3160 µg/l Cu, 1000 µg/l Zn, 160 µg/l Cd and 316 µg/l Pb. However, low Cu and Zn concentrations were found in Lukut River do not affect the calcification of the prawn's exoskeleton or their molting.

Penaeus monodon does not regulate the level of metals in the body. It was found to accumulate heavy metals (Cu, Zn, Cd and Pb) in proportion of external metal concentrations. Meanwhile the metals accumulation in muscle, exoskeleton and remainder were found to perform in different rates. The highest accumulation rate for Zn and Cd was found in exoskeleton while the highest accumulation rate of Cu and Pb was found in remainder. In addition, the lowest accumulation rates for all of the studied metals were found in the muscle tissue. Among the metals studied Cu and Pb were accumulated faster than Cd and Zn.

Heavy metals depuration from muscle, exoskeleton and remainder of tissues were studied during one week duration. The fastest depuration of Zn, Cd and Pb was

found in exoskeleton, while Cu was mainly depurated from the remainder of tissues. Furthermore among the metals studied Cu and Pb depurated faster than Zn and Cd.

Moulting was found to cause no significant reduction in the Cu, Zn and Cd concentration in the moulted prawns. On the other hand it caused significant reduction of Pb content in the prawn's body. Comparison between exoskeleton of the exposed intermolts and the exuviae of the newly moulted prawns (post moults) indicated that Pb concentration in the moults was significantly higher than exoskeleton which indicates that molting could be a effective way to eliminate the accumulated Pb from the body.

In general, based on the results from field study (analysis of water, sediment and biological samples) it is concluded that Lukut River is not polluted by heavy metals. Except for Pb, the level of metals in the water of Lukut River is not high enough to cause any impact either on aquacultured or on wild prawns.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

Kepekatan Logam Berat Di Dalam Sedemen Dan Organisma Terpilih Di Sungai Lukut, Malaysia Dan Kesan Toksikologi Mereka Ke Atas Juvenal PENAEUS MONODON (FABRICIUS)

Oleh

ALIREZA SAFAHIEH

April 2007

Pengerusi: **Profesor Madya Ahmad bin Ismail, PhD**

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Status pencemaran logam berat dalam Sungai Lukut, Negari Sembilan, Malaysia dikaji pada bulan September, 2003. Secara keseluruhan, semua logam berat kecuali Pb dalam air, didapati air dan sediment dari Sungai Lukut adalah dalam tahap taburan sungai Malaysia. Kepekatan logam dalam *T. telescopium* dan udang bagi *P. monodon* dan *P. merguiensis* adalah dalam taburan logam berat yang diukur dalam gastropod lain atau spesis udang yang dikaji dulu di Malaysia menunjukkan tiada pencemaran logam berat yang serius dalam kawasan kajian. Kepekatan logam berat dalam tisu otot udang didapati lebih rendah daripada cadangan tahap kebenaran maksimum bagi pemakananan manusia.

Kepekatan logam Pb didapati tinggi dalam air di Sungai Lukut (390.10 µg/l) yang mana lebih tinggi berbanding dengan sungai lain yang dikaji di Malaysia. Corak kepekatan Pb dalam sampel air dan tahap rendah Pb dalam sediment mencadangkan bahawa larutan Pb berasal dari kemasukan berasaskan laut.

Toksiksiti separa akut logam berat pada pertumbuhan, penyalinan kulit dan kandungan Ca dalam eksoskeleton juvenil *P. monodon* dikaji dalam tempoh 21 hari. Keputusan menunjukkan bahawa juvenil yang didedah selepas 21 hari kepada kepekatan Cu pada 1000 µg/l, Zn pada 1000 µg/l, Cd pada 160 µg/l dan Pb pada 316 µg/l atau lebih tinggi menunjukkan pertumbuhan yang lebih perlahan daripada kawalan ($P<0.05$).

Di kalangan logam berat yang dikaji, Cu dan Zn didapati mempunyai kesan rencatan pada kalsifikasi eksoskeleton. Kepekatan paling rendah pada 100 µg/l dan 1000 µg/l bagi Cu dan Zn masing-masing mengakibatkan pengurangan kalsifikasi eksoskeleton. Pendedahan kepada logam berat juga memberi kesan kepada penyalinan kulit *P. monodon*. Tempoh kitaran meningkat secara signifikan pada udang yang terdedah kepada 3160 µg/l Cu, 1000 µg/l Zn, 160 µg/l Cd dan 316 µg/l Pb. Akan tetapi, kepekatan Cu dan Zn yang rendah yang didapati dalam Sungai Lukut tidak memberi kesan kepada kalsifikasi ekoskeleton atau penyalinan kulit udang.

Penaus monodon tidak regulasi bagi tahap logam dalam badan. Ia didapati mengakumulasi logam berat (Cu, Zn, Cd dan Pb) dalam sebahagian kepekatan logam dari luaran. Selain itu, akumulasi logam dalam tisu otot, ekoskeleton dan sisa dijumpai mengakumulasi pada kadar yang berlainan. Kadar akumulasi yang tertinggi bagi logam Zn dan Cd adalah pada sisa. Tambahan pula, kadar akumulasi yang terendah bagi kesemua logam yang dikaji adalah pada tisu otot. Di antara logam berat yang dikaji, Cu dan Pb berakumulasi pada kadar yang lebih cepat daripada Cd dan Zn.

Depurasi logam berat daripada tisu otot, eksoskeleton dan remainder dikaji. Selepaas 1 minggu, kadar depurasi yang tertinggi bagi Zn, Cd and Pb didapati pada eksoskeleton manakala Cu hanya didepurasi daripada tisu remainder. Tambahan pula, di kalangan logam berat yang dikaji,kadar depurasi bagi Cu dan Pb adalah lebih cepat berbanding Zn dan Cd.

Penyalinan kulit didapati mengakibatkan tiada signifikasi dalam pengurangan kepekatan Cu, Zn dan Cd dalam udang yang telah menyalin kulit. Akan tetapi, penyalinan kulit mengakibatkan signifikasi pengurangan kandaungan Pb dalam badan udang. Perbandingan antara eksoskeleton bagi intermolt udang yang terdedah dan ‘exuviae’ udang yang baru salin kulit (‘post molt’) mennunjukkan kepekatan Pb dalam kulit yang disalin (‘molt’) adalah signifikan lebih tinggi daripada ekoskeleton yang membuktikan penyalinan kulit adalah cara yang terbaik dalam menyingkirkan Pb daripada badan.

Secara keseluruhannya, keputusan yang didapati daripada kajian lapangan (analisis air, sedimen dan sampel biologi) menyimpulkan bahawa Sungai Lukut tidak tercerma oleh logam berat. Logam berat dalam kajian kecuali Pb dalam air Sungai Lukut adalah tidak tinggi untuk mengakibatkan kesan pada udang akuakultur atau udang liar.

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follow:

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DECLARATION

I hereby declare that the thesis is based on my original work except for the quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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ALIREZA SAFAHIEH

Date: 10 May 2007

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