DISTRIBUTION OF DDT AND LINDANE IN A MODEL MUDFLAT ECOSYSTEM

By

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A DISSERTATION SUBMITTED FOR THE DEGREE OF MASTER OF SCIENCE IN THE DEPARTMENT OF CHEMISTRY, FACULTY OF SCIENCE, UNIVERSITY OF MALAYA, KUALA LUMPUR.

JULY 1997.

To My Late Parents,
in Affection and Gratitude.

Acknowledgement

I would like to express my deepest gratitude to my supervisor **Associate Professor Dr. Abdul Rani Abdullah**. He has given me the confidence to undertake this work and has carefully guided me in research work throughout the years I have known him. My thank are especially due to the University of Malaya for granting of a fellowship and annual F-votes, **Professor Hamid Hadi** Head of Department for his support.

I would also like to thank **Associate Professor Dr. Noorhayati Mohd Tahir, Associate Professor Dr. Abdul Halim Sulaiman, En Azizi Yusop** from University of Malaya and **Dr. Juzu Hayati** from Unversiti Pertanian Malaysia for their invaluable help throughout this study.

I am as ever grateful to my former teacher **Mr. Murugeson** and my brothers **Mr. Ramachendran** and **Mr. Manisegaran** for all their unfailing support, patience and love they given me along the way.

I would also like to take the opportunity to thank all my colleagues, friends and staffs of the Chemistry Department and Institute of Postgraduate Studies and Research, University of Malaya.

Last but not least, I thank my wife **Sukunah** for her invaluable moral support and constant encouragement throughout my study.

Abstract

The fate and distribution of the organochlorine insecticides DDT and lindane were investigated in a model mudflat ecosystem comprising of estuarine water, sediment and cockles *(Anadara granosa)*. The distribution [^{14}C]DDT in the mudflat ecosystem was monitored for a period of 21 days. [^{14}C]activity in water reduced from 96.9% of the applied activity immediately following introduction of the insecticide to 0.4% of the applied activity at the end of 48 hours. Only the parent compound was detected in water throughout the first 3 days. In the sediment [^{14}C]activity expressed in concentration terms ranged between 0.02 to 0.05μg/g in the first seven days of the study, thereafter increasing to a maximum of 0.10μg/g at the end of 21 days. DDE ranging from 0.003 - 0.008 μg/g was the major metabolite, first detected at the end of 24 hours. DDD (0.002 μg/g) was first observed at the end of 3 weeks. DDT ranging from 0.004 - 0.020 μg/g was present throughout the study. Both bound and extractable residues in the sediment increased with time. The level of [^{14}C]activity in the cockles was found to be constant over the whole study period ranging from 20-22% of the applied activity. DDE ranging from 0.001 - 0.002 μg/g was first detected at the end of 7 days. DDD (0.001μg/g) was first detected at the end of 3 weeks. DDT ranging from 0.001 - 0.009 μg/g was present in

the cockle tissue throughout the study. DDMU was not detected in water, sediment and cockles throughout the study period.

The distribution of lindane in the model ecosystem was investigated at concentration of 5 and 15 μg/L of the insecticide under semistatic condition, for a period of 30 days. A gradual increase in lindane concentration was observed in both sediment and cockles. Concentration of lindane in water ranged between <0.01 - 0.73 μg/L at the end of 24 hour exposures. The half life of lindane in estuarine water was found to be 21.9 hours under aerated conditions and 43.0 hours without aeration.

In order to further elucidate the processes involved in the dissipation of lindane from the mudflat environment the volatilization, adsorption and biodegradation of lindane were examined. Using a manifold assembly volatile parent compound as well as other organic degradation products were trapped in a polyurethane plug. Volatile organic material amounted to 6.74% of the applied activity was observed at the end of 7 days increasing to 13.62% at the end of 21 days. Biodegradation of lindane was demonstrated by the release of $^{14}CO_2$ from mudflat soils treated with [^{14}C]lindane. Maximum production of $^{14}CO_2$ amounting to 0.2% of the applied activity was observed at the end of 21 days. [^{14}C]activity in water decreased from 0.05% at the end of 7 days to 0.03% at the end of 21 days, whereas [^{14}C]activity in the soil increased from 51.05% at the end of 7 days

to 66.37% at the end of 21 days. The ratio of pesticide volatilized to pesticide metabolized were found to be 332 at the end of 7 days, decreasing to 68 at the end of 21 days. The adsorption of lindane in the mudfalt soils were also examined. The pesticide adsorption capacity ($LogK_{OM}$) of soils were highest in the mudflat soil (1.20) compared to agricultural soils (1.00 and 1.17).

The biodegradation of lindane in the mudflat soil was demonstrated by comparing the persistence of the chemical in sterilized and nonsterilized soils. Less than 7% of the applied chemical was detected at the end of a 60-day incubation period in nonsterilized soils compared to 65% remaining in sterilized soils. The microbial biomass content of mudflat soils determined as the increase in CO_2 evolution caused by fumigation with $CHCl_3$ was found to be 3.84 mgC/g of mudflat soil while the initial respiration rate was estimated as 0.27 CO_2-C evolved mg/g soil.

Abstrak

Agihan racun serangga DDT dan lindan telah dikaji dengan menggunakan ekosistem persekitaran lumpur (mudflat) model yang mengandungi air, sedimen dan kerang. Taburan [^{14}C]DDT di dalam ekosistem model telah diperhatikan selama 21 hari. Aktiviti [^{14}C] di dalam air telah menurun daripada 96.9% pada permulaan penambahan racun serangga kepada 0.4% pada akhir 48 jam. Hanya sebatian induk DDT telah dikesan di dalam air selama 3 hari. Di dalam sedimen aktiviti [^{14}C] dalam unit kepekatan adalah antara 0.02 dan 0.05 μg/g pada 7 hari permulaan. Selepas itu ia bertambah kepada kepekatan maksimum sebanyak 0.10 μg/g pada penghujung hari yang ke 21. Kepekatan DDE adalah diantara 0.003 dan 0.008μg/g dan merupakan metabolit yang paling banyak dikesan . DDD (0.002μg/g) kali pertama dikesan pada minggu ketiga. Kepekatan DDT adalah antara 0.004 - 0.020 μg/g dan hadir pada keseluruhan tempoh kajian. Aktiviti [^{14}C] di dalam kerang didapati tidak banyak berubah sepanjang tempoh kajian dengan kepekatan berjumlah antara 20 - 22% daripada jumlah aktiviti yang didedahkan.

Agihan racun serangga lindan didalam ekosistem persekitaran lumpur (mudflat) telah dikaji pada kepekatan 5 dan 15μg/L dalam keadaan separa statik selama 30 hari. Bermula dari hari pertama penambahan

kepekatan lindan telah dikesan dalam sedimen dan kerang sehinggalah tamat tempoh kajian. Kepekatan didalam air adalah antara <0.01 - 0.73 μg/L pada akhir pendedahan selama 24 jam. Tempoh separuh hayat lindan dalam air muara adalah 21.9 jam dalam keadaan pengudaraan dan 43.0 jam tanpa pengudaraan.

Sebagai langkah untuk mengkaji secara lebih mendalam proses yang terlibat dalam kehilangan lindan daripada ekosistem persekitaran lumpur (mudflat). Proses-proses pengewapan, penyerapan dan biodegradasi lindan telah dikaji. Dengan menggunakan alatkaca yang direkabentuk untuk mengkaji proses pengewapan bahan organik meruap termasuk bahan induk dan hasil-hasil degradasi dapat diasingkan dengan perangkap poliuretan. Sebanyak 6.74% daripada jumlah aktiviti lindan berlabel ^{14}C yang ditambah, merupakan bahan organik meruap pada hari yang ke 7. Nilai ini meningkat kepada 13.62% pada hari yang ke 21. Pengeluaran maksimum $^{14}CO_2$, iaitu sebanyak 0.2% daripada jumlah aktiviti, telah dikesan pada hari yang ke 21. Aktiviti [^{14}C] dalam air menurun dari 0.05% pada penghujung hari ke 7 dan ke 0.03% pada penghujung hari ke 21. Manakala aktiviti [^{14}C] dalam sedimen mengalami peningkatan dari 51.05% pada penghujung hari ke 7 dan ke 66.37% pada penghujung hari ke 21. Nisbah pestisid meruap dan pestisid yang mengalami metabolisme dianggarkan sebanyak 332 pada penghujung hari ke 7. Nilai ini telah menurun ke 68 pada penghujung hari ke 21. Penyerapan lindan dalam lumpur juga telah dikaji

bersama dua tanah pertanian. Muatan penyerapan pestisid (Log K_{OM}), didapati paling tinggi untuk lumpur (1.20) berbanding tanah pertanian (1.00 dan 1.17).

Biodegradasi lindan didalam tanah lumpur telah dikaji dengan perbandingan ketahanan antara tanah yang telah disterilkan dan yang tidak disterilkan. Kurang daripada 7% dikesan pada penghujung hari yang ke 60 dalam tanah tak disterilkan manakala sebanyak 65% masih dapat dikesan dalam tanah yang disterilkan. Kandungan biojisim mikrob dalam lumpur yang ditentukan sebagai peningkatan pembebasan CO_2 ekoran daripada pewasapan dengan $CHCl_3$ didapati sebanyak 3.84mgC/g lumpur manakala kadar awal respirasi dianggarkan sebanyak 0.27 CO_2-C terbebas mg/g tanah lumpur.

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<	less than
>	greater than
C	degree Centigrade
eV	electron volt
g	gram
GC/MS	gas chromatograph-mass spectrometer
i.d.	internal diameter
kg	kilogram
L	liter
m-	meta
mg	milligram
mL	milliliter
mm	millimeter
MS	mass spectrometer
m/z	mass to charge ratio
ng	nanogram
nm	nanometer
o-	ortho
p-	para
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
SD	standard deviation
µg	microgram
µCi	microcurie
v/v	volume per volume