Jap. J. Phycol. (Sôrui) 29: 81-84. June 20, 1981

Pollutant levels in the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL

P. M. SIVALINGAM

School of Biological Sciences, University of Sciences Malaysia, Minden, Penang, Malaysia.

SIVALINGAM P. M. 1981. Pollutant levels in the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL. Jap J. Phycol. 29: 81-84.

Investigations on the seasonal variation of the following trace metal pollutants, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb and Zn, in the abundantly found Malaysian sea lettuce, *Ulva reticulata* Forsskal, indicated the presence of amounts below detectable levels of Cd, Co, Cr and Cu the year through while Fe, Hg, Mn, Ni, Pb and Zn had three peaks between the months of January-March, May-July and September-December. These fluctuations correspond well to the peak productivity periods of the alga.

Contaminants of persistent pesticide residues of pp'DDE, α-, β-, γ- BHC and aldrin in this algal species fluctuated between 9.6 ± 0.05, 0.089 ± 0.012, 1.03 ± 0.015, 0.48 ± 0.04 and 606.8 ± 0.53 ppbs, respectively. PCBs (KC-400), on the other hand, ranged between 16.6 ± 0.015 ppb.

From the viewpoint of environmental contaminants this algal species appears to be within the safety levels for human consumption.

Key Index Words: *environmental pollution*; *PCBs*; *persistent pesticides*; *trace metals*; Ulva.

Marine pollution studies, in the Malaysian context, are very scarce (SIVALINGAM *et al.* 1978, 1979a, 1980a). Trace metals pollutant levels in some marketed shellfish have been reported by LEE and LOW (1976), while PCBs and persistent pesticide residues in cultured cockles, *Anadara granosa*, were studied by SIVALINGAM *et al.* (1980b). Related studies on solid and liquid shrimp paste have also been conducted (SIVALINGAM *et al.* 1980c). Elaborate laboratory studies on the modes of bioaccumulation of trace metals in the local green mussel, *Perna viridis* L., and the rock oyster, *Saccostrea cucullata* BORN, have also been carried out (SIVALINGAM and BHASKARAN 1980; SIVALINGAM 1979b). The Consumers Association of PENANG (1976) reported extensive pollution of the Juru River and its detrimental effects on the adjacent fishing communities A study on the Hg content of human hair in fishing communities in the State of Penang verified these findings (SIVALINGAM and AZURA bt. SANI 1980).

Studies (SIVALINGAM 1977, 1978a) on marine algae and their succession patterns had indicated the existence of 3 species of Cyanophyta, 21 species of Rhodophyta, 8 species of Phaeophyta and 12 species of Chlorophyta along the shores of Penang Island. Analyses of biodeposited trace metals and minerals in Penang Island marine algae have also been reported (SIVALINGAM 1978b, 1979b). At this location the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL, is the dominent species and its biochemical evaluation as a potential human food source (SIVALINGAM 1979c) and the effects of high concentration stresses

Abbreviations: γ-BHC, γ-benzene hexachloride; pp'DDE, pp'l, 1-di-chloro-2, 2-bis (p-chlorophenyl) ethylene; PCB, polychlorinated biphenyls.

of trace metals on the mode of biodeposition have been reported (SIVALINGAM 1978c).

Following this line of investigation the author has endeavoured to make a detailed study on the seasonal fluctuation of trace metals, PCBs and persistent pesticide residues content in *Ulva reticulata* FORSSKÅL prior to utilization of it as a significant food source.

Materials and Methods

Ulva reticulata FORSSKÅL was harvested during low tides periodically between January 1977-December 1978 at the Marine Depot, Penang. The fronds were cleaned of epiphytes and other contaminants by washing with filtered sea water and then with distilled water. The clean thalli were dried at 90°C for about 72 hr and pulverized using a pestle and mortar before processing for analysis.

The presence of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn were determined by predigesting 500 mg of dried sea lettuce overnight in 10 ml of a mixture of hypochloric and nitric acid (1 : 2) before digestion on an electrothermal heater in a Kjeldahl flask. The digest was filtered and diluted to 100 ml before analysis using a Varian Techtron AA 120 atomic absorption spectrophotometer.

The total Hg content of the dried thalli was determined using a Coleman Mercury Analyzer MAS-50 according to the method of STANLEY *et al.* (1971).

PCBs and persistent pesticide residues were extracted from 5 gm of powdered thalli with n-hexane. The extract was dehydrated in Na_2SO_4 column, adsorbed on a silica gel column and eluted with 100 ml of n-hexane and 15% ether in n-hexane as eluates 1 and 2 for PCBs and DDE and other pesticide residues, respectively. The two eluates were then concentrated separately in a Kuderna-Danish concentrator and subjected to gas chromatographic analysis. GC-analysis was performed under the following conditions; column packing-OV 17/1.5% chromosorb W, detector and column temperature-210 and 190°C, respectively, N_2 flow-30 ml/min., chart speed-10 mm/min., range-$10^2 \times 8$ and an electron capture detector of ^{63}Ni. Identification and quantification of the PCBs and pesticide residues were done through comparison with gas chromatograms of authentic samples.

Results and Discussion

Table 1 shows the seasonal variation in trace metal contents of *Ulva reticulata* FORSSKÅL. It is obvious that the trace metals Fe, Hg, Mn, Ni, Pb and Zn are fairly low in content as compared with amounts reported for other algal species of Penang Island (SIVALINGAM 1978b) or the seaweeds of Goa, India, Öresund Area, Sweden and Vostok Bay, Sea of Japan (AGADI *et al.* 1978; HAGEHALL 1973; SAENKO *et al.* 1976). The quantity of these trace metals however, appears to vary corresponding with the three maximal productivity periods which fall between the months of January-March, May-July and September-December (SIVALINGAM 1979c).

Table 1. Seasonal variations in trace metal content in the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL.

Month	Concentrations (ppm g^{-1} dry wt.) Fe	Hg	Mn	Ni	Pb	Zn
Jan.	810	0.0625	29	94	BDL+	46
Feb.	1,980	0.0632	138	60	128	60
Mar.	1,470	0.0619	66	46	100	133
Apr.	960	0.0628	62	11	113	357
May.	2,660	0.0615	130	34	BDL	128
Jun.	1,570	0.0625	154	11	56	77
Jul.	2,960	0.0598	63	24	95	47
Aug.	1,290	0.0628	62	BDL	56	36
Sep.	1,560	0.0640	67	12	BDL	40
Oct.	1,060	0.0604	173	BDL	53	50
Nov.	1,000	0.0624	32	268	BDL	89
Dec.	400	0.0654	29	20	91	91

+ BDL: below detectable levels. Also take note that the contents of Cd, Co, Cr and Cu were undetectable the whole year through except for Cu which had a value of 34 ppm in November.

Table 2. Mean PCBs and persistent pesticide residues content in *Ulva reticulata* FORSSKÅL.

Contaminant	Concentration (ppb g^{-1} dry wt.)
PCB (KC 400)	16.6±0.15
DDE	9.6±0.05
α-BHC	0.089±0.012
β-BHC	1.03±0.015
γ-BHC	0.48±0.04
Aldrin	606.8±0.53

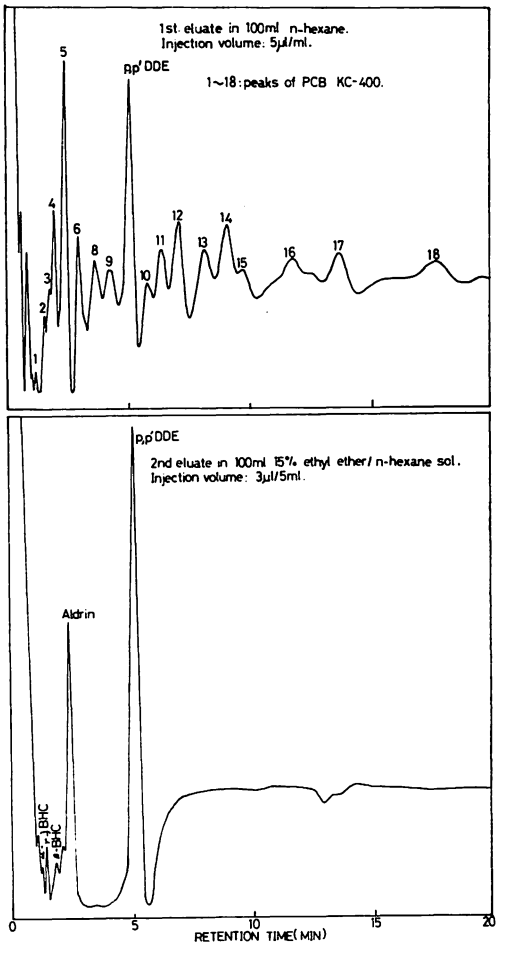

Fig. 1. Gas chromatograms of PCBs and persistent pesticides of 1st and 2nd eluates.

Table 2 shows the mean contents of PCBs and persistent pesticide residues in the fronds of *U. reticulata*, while Figure 1 is the gas chromatogram of eluates 1 and 2 obtained from silica gel. As compared to the levels found in a liter of sea water around the Island of Penang (1980a) these are lower by exponential 3731 times for DDE, 449-1798 times for α-BHC, exponential-1749 times for β-BHC, 318-2849 times for γ-BHC and 3.2-30 times for aldrin. However, although no amounts of PCBs were detectable in 1 liter sea water samples from Penang Island, a contaminant amount is detectable at 16.6 ppb g^{-1} dried thalli. This quantity does not seem detrimental to human health and is comparable to those reported by AMICO *et al.* (1979) for seaweeds of the East Coast of Sicily.

Based on the present data, it is concluded that the Malaysian sea lettuce, *Ulva reticulata* FORSSKÅL, is safe to be considered as a possible human food source from the viewpoint of environmental contaminants.

Acknowledgements

The author wishes to express his gratitude to the School of Biological Sciences, University of Sciences Malaysia, Malaysia, for all the aid rendered during the course of this study.

References

AGADI, V.V., BHOSLE, N.B. and UNTAWALE. A.G. 1978. Metal concentration in some seaweeds of Goa (India). Bot. Mar. 21: 247-250.

AMICO, V., IMPELLIZZERI, G., ORIENTE, G., PIATELLI, M., SCINTO, S. and TRINGALI, C. 1979. Levels of chlorinated hydrocarbons in marine animals from Central Mediterranean. Mar. Poll. Bull., 10: 282-285.

CONSUMER'S ASSOCIATION of PENANG. 1976. Pollution: Kuala Juru's battle for survival. pp. 1-73.

HAGERHALL, B. 1973. Marine botanical-hydrographical trace element studies in the Oresund Area. Bot. Mor. 16: 53-64.

LEE, K.H. and LOW, T.P. 1976. Heavy metals in Malaysian finfish and shellfish. Seminar on Protecting our Enviroment. March 11-13, 1976 in Kuala Lumpur. Preprint No. 11.

SAENDO, G.N., KORYAKOVA, M.D., MAKIENKO,

V. F. and DOBROSMYSLOVA, I. G. 1976. Concentration of polyvalent metals by seaweeds in Vostok Bay Sea of Japan. Mar. Biol. 34: 169-176.

SIVALINGAM, P. M. 1977. Marine algal distribution in Penang Island. Bull. Jap. Soc. Phycol., 25(12): 202-209.

SIVALINGAM, P. M. 1978a. Algal succession patterns on the rocky shores of Batu Ferringhi in Penang Island. Jap. J. Phycol., 26: 161-164.

SIVALINGAM, P. M. 1978b. Biodeposited trace metals and mineral content studies of some common tropical marine algae. Bot. Mar. 21: 327-330.

SIVALINGAM, P. M. 1978c. Effects of high concentration stress of trace metals on their biodeposition in *Ulva reticulata* FORSSKAL. Jap. J. Phycol., 26: 157-160.

SIVALINGAM, P. M. 1979a. Bioaccumulation mechanisms of trace metals by the Malaysian rock oyster, *Saccostrea cucullata*, under high concentration stresses. 2nd Symposium on Our Environment, 14-16 Nov., 1979, Singapore. Session IV. Pollution and its control (Part 3), Paper 2.

SIVALINGAM, P. M. 1979b. Mercury contamination in tropical algal species of the Island of Penang, Malaysia. Mar. Poll. Bull., 11: 106-108.

SIVALINGAM, P. M. 1979c. Biochemical evaluation of the Malaysian sea lettuce, *Ulva reticulata* FORSSKAL, as a potential food source. Proc. MIFT Symp. 'Protein Rich Foods in Asean', Kuala Lumpur, 12-13th July, 1979, Session 3: New Protein Sources. Paper 14, pp. 118-125.

SIVALINGAM, P. M. and AZURA bt. SANI. 1980. Mercury content in hair from fishing communities of the State of Penang, Malaysia. Mar. Poll. Bull., 11: 188-191.

SIVALINGAM, P. M. and BHASKARAN, B. 1980. Experimental insight of trace metal environmental pollution problems of mussel farming. Aquaculture, 20: 291-303 (Special Issue).

SIVALINGAM, P. M., ALLAPITCHAY, I., KOJIMA, H. and YOSHIDA, T. 1980a. PCBs and persistent pesticides pollution of coastal waters of Penang Island, Malaysia. J. Singa. Nat. Aca. Sci. (in press).

SIVALINGAM, P. M., ALLAPITCHAY, I., KOJIMA, H. and YOSHIDA, T. 1980b. PCBs and pesticides content in cultured cockles from the State of Penang, Malaysia. Proc. MBAI Symp. on Coastal Aquaculture. Jan. 11-18, 1980, Cochin, India. Preprint No. 298 (in press).

SIVALINGAM, P. M., ALLAPITCHAY, I., KOJIMA, H. and YOSHIDA, T. 1980c. Nutritive evaluation, trace metals as well as persistent pesticides content in shrimp paste produced in the State of Penang, Malaysia. Proc. MBAI Symp. on Coastal Aquaculture. Jan. 11-18, 1980, Cochin, India. Preprint No. 299 (in press).

SIVALINGAM, P. M., YOSHIDA, T., KOJIMA, H. and ALLAPITCHAY, I. 1979. Trace metals biodeposition and its extent of pollution in molluscs, sediments and water samples from Penang waters, Malaysia. Proc. 4th CSK Symp. Feb. 14-18, 1979, Tokyo, Japan. pp. 532-544.

SIVALINGAM, P. M., SAW, C. G., CHIN, N. F. and WUAN, T. O. 1978. Aquatic pollution effects of discharges from a sugar refinery in Malaysia. Proc. Intern. Conf. Wat. Poll. Control in Developing Countries, Bangkok, 2: 203-216.

STANLEY, J. M., WILLIS, S. A. and MOREY S. W. 1971. Determination of mercury by flameless atomic absorption. Marine Research Laboratory, Div. of Mar. Resources, Florida Department of Natural Resources, St. Petersburg, Florida. Leaflet Series. Vol. VI-Chemistry Part 2 (Organic) No. 5.

P. M. シバリンガム: マレーシア産 *Ulva reticulata* FORSSKÅL における環境汚染物質量

多量に見出されるマレーシア産の *Ulva reticulata* 中の Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn などの環境汚染微量金属の季節的変動を調査した。その結果, Cd, Co, Cr, Cu は年間を通してもその存在量は検知能以下であったが, Fe, Hg, Mn, Ni, Pb, Zn は一年の間の1～3月, 5～7月, および9～12月の3回に増加のピークがみられた。この変動はこの藻の最大現存量とよく一致する。

この藻体中の持続性農薬残溜物である pp' DDE は 9.6±0.05 ppb, α-BHC は 0.089±0.012 ppb, β-BHC は 1.03±0.015 ppb, γ-BHC は 0.48±0.04 ppb, そしてアルドリンは 606.8±0.53 ppb の変動を示した。PCBs (KC-400) は 16.6±0.015 ppb の変動幅であった。

環境汚染物質の点からみれば, *U. reticulata* は人間の利用消費にも安全な範囲にあると思われる。