



#### REFERENCES

- Abdullah, M. I., L. G. Royle, and A. W. Morris, " Heavy Metal Concentration in Coastal Waters," Nature, 235, 158-160, 1972.
- Albert, J. J., D. R. Leyden, and T. A. Patterson, "Distribution of Total Al, Cd, Co, Cu, Ni and Zn in the Tongue of the Ocean and the Northwestern Atlantic Ocean," Mar. Chem., 4, 51-66, 1976.
- Anderson, M. A., F. M. M. Morel, and R. R. L. Gyillard, "Growth Limitation of Coastal Diatom by Low Zinc Ion Activity," Nature, 276, 70, 1978.
- Batley, G. E., and T. M. Florence, "Determination of the Chemical Forms of Dissolved Cadmium, Lead and Copper in Seawater," Mar. Chem., 4, 347-363, 1976.
- Brewer, P.G., " Minor Elements in Seawater," Chemical Oceanography (Riley, J.P., and Skirrow, eds.), vol. 1, pp. 415-496, Academic Press, London, 2nd ed., 1975.
- Buckley, P. J. M., and C. M. G. Van Den berg, "Copper Complexation Profiles in the Atlantic Ocean," Mar. Chem., 19, 281-286, 1986.
- Burton, J. D., "Basic Properties and Processes in Estuarine Chemistry," Estuarine Chemistry, (Burton, J. D., and Liss, P. S., eds.), pp.1-36, Academic Press, London, 1976.

- Chanpongsang, A., "The Distribution of Cadmium, Lead, Copper and Zinc from Chao Phraya Estuary to Si-Racha, " Proceedings of the Third Seminar on the Water Quality and the Quality of Living Resources in Thai Waters( Tamiyavanich, S.,ed.), pp. 352-367, Chulalongkorn University Publishing, 1984.
- Chester, R., and J.H. Stoner," The Distribution of Zinc, Nickel, Manganese, Cadmium, Copper, and Iron in Some Surface Water from the World Ocean,"Mar. Chem., 2, 17-32, 1974.
- \_\_\_\_\_, " Trace Elements in Total Particulate Material from Surface Sea Water,"Nature, 255, 50-51, 1975.
- Davis, J. A., and J. O. Leckie, "Effect of Adsorbed Complexing Ligands on Trace Metal Uptake by Hydrous Oxides," Envir. Sci. & Technol., 12 (12), 1309-1315, 1978.
- Duinker, J. C., R. F. Nolting, and H. A. Van Der Sloot, "The Determination of Suspended Metals in Coastal Waters by Different Sampling and Processing Techniques (Filtration, Centrifugation)," Netherlands J. of Sea Res., 13 (2), 282-297, 1979.
- Eaton, A., "Observations on the Geochemistry of Soluble Copper, Iron, Nickel, and Zinc in the San Francisco Bay Estuary," Envir. Sci. & Technol., 13 (4), 425-432, 1979.
- Elzerman, A. W., D. E. Armstrong, and A. W. Andren, "Particulate Zinc, Cadmium, Lead, and Copper in the Surface Microlayer of Southern Lake Michigan," Envir. Sci. & Technol., 13 (6), 720-725, 1979.
- Fabiano, M., F. Baffi, and R. Frache, "Seasonal and Depth Variations of Copper, Iron and Nickel in Ligurian Coastal Waters," Mar. Chem., 17, 165-175, 1985.

- Frache, R., P. Manfrinetti, M. Piccazzo, and S. Tucci, "Distribution and Transport of Particulate Fe and Cu in Suspended Matter of the Canyons of Genoa ( Northwestern Mediterranean )," Mar. Poll. Bull., 17 (3), 123-127, Great Britain, 1986.
- Kremling, K., "The Distribution of Cadmium, Copper, Nickel, Manganese and Aluminium in Surface Waters of the Open Atlantic and European Shelf Area," Deep Sea Res., 32, 531-555, 1985.
- Hasle, J. R., and M. I. Abdullah, "Analytical Fractionation of Dissolved Copper, Lead and Cadmium in Coastal Seawater," Mar. Chem., 10, 487-503, 1981.
- Hung, T. C., B. C. Han, and S. J. Wu, "Green Oyster: Species and Forms of Copper in the Charting Coastal Water", Acta Oceanographic Taiwanica, 23, 33-42, 1989.
- Hungspreugs, M., S. Dharmvanij and G. Wattayakorn, " Seasonal Variation in the Chemical Composition of the Bang Pakong River During Estuarine Mixing," Ratchadapisek Sompoch Research Report, 114 pp., 1985.
- Hungspreugs, M., and S. Siriruttanachai, "Accumulation of Cadmium, Copper, Lead and Zinc in the Oysters in the Gulf of Thailand, " Proceedings of the Second Seminar on the Water Quality and the Quality of Living Resources in Thai Waters ( Tamiyavanich, S.,ed.), pp. 165 - 179 , Chulalongkorn University Publishing, 1981.
- Hungspreugs, M., " Baseline Levels of Cadmium, Chromium, Copper, Lead and Zinc in Seawater from the Gulf of Thailand," J. Sci. Soc. Thailand, 8, 193-204, 1982.

- Hungspreugs, M., W. Utoomprurkporn, S. Dharmvanij, and P. Sompongchaiyakul, "The Present Status of the Aquatic Environment of Thailand," Mar. Poll. Bull., 20 (7), 327-332, 1989.
- Idthikasem, A., R. Bamrungrajhiran, W. Kaewpakdee, and K. Chingchit, "Analyses of Some Trace Metals in Seawaters and Marine Sediments," Proceedings of the Second Seminar on the Water Quality and the Quality of Living Resources in Thai Waters (Tamiyavanich, S., ed.), pp.165-179, Chulalongkorn University Publishing, 1981.
- IOC, "Inorganic Handbook for River Transport Workshop," GEMSI, 29 pp., 1986.
- Ishimori, S. N., K. Harada, and S. Tsunugai, "Removal of Trace Metals from Seawater During a Phytoplankton Bloom as Studied with Sediment Traps in Funka Bay, Japan," Mar. Chem., 17, 75-89, 1985.
- Mantoura, R. F. C., A. Dickson, and J. P. Riley, "The Complexation of Metals with Humic Materials in Natural Water," Estuar. and Coast. Mar. Sci., 6, 387-408, 1978.
- Mantoura, R.F.C., "Organo-Metallic Interactions in Natural Waters," Marine Organic Chemistry, (Duursma, E.K., and R. Dawson, eds.), pp. 179-223, Elsevier Scientific Publishing Company, New York, 1981.
- Newell, A.D., and J.G. Sanders, "Relative Copper Binding Capacities of Dissolved Organic Compounds in a Coastal Plain Estuary," Envir. Sci. & Technol., 20, 817-821, 1986.
- Open University, "Oceanography : Chemical Processes," S.334, Unit 7 & 8, The Open University, Great Britain, 1978.

Paulson, A. J., R. A. Feeley, H. C. Curl, and J. F. Gendron, "Behavior of Fe, Mn, Cu, and Cd in the Duwamish River Estuary," Water Res., 19 (4), 633-641, 1984.

Petpiroon, P., "The Distribution of Pb, Zn, and Cu in Marine Environment in the Coastal Areas of Rayong, Chanthaburi and Trat," Technical Paper No.2, Eastern Marine Fisheries Development Center, Marine Fisheries Division, Department of Fisheries, Ministry of Agriculture and Cooperatives, 1988.

\_\_\_\_\_, " Heavy Metals in the Food Chain of Squid and Carnivorous Fish from the Coastal Areas of Rayong, Chanthaburi and Trat Province," Master of Science Thesis, Department of Marine Science, Graduate School, Chulalongkorn University, 1988.

\_\_\_\_\_, "The Concentration of Some Heavy Metals in Rayong Bay," Technical Paper No.15, Eastern Marine Fisheries Development Center, Marine Fisheries Division, Department of Fisheries, Ministry of Agriculture and Cooperatives, 1989.

Petpiroon, S., S. Yoo-sook-swat, and J. Sanguansin, "Fisheries Status and Marine Environment in the Vicinity of Ship Scrapping Activities at Ban Nongfab, Rayong Province," Technical Paper No. 3/2529, Eastern Marine Fisheries Development Center, Marine Fisheries Division, Department of Fisheries, Ministry of Agriculture and Cooperatives, 1986.

Sukasem, W., "Improvement of Solvent Extraction Method for Trace Metals in Seawater," Master of Science, Department of Marine Science, Graduate School, Chulalongkorn University, 1989.

United Nations Environment Programme, "The Health of the Oceans,"  
UNEP Regional Seas Reports and Studies No. 16, 103 pp.,  
1982.

United Nations Environment Programme, "GESAMP: Cadmium, Lead and Tin  
in the Marine Environment," UNEP Regional Seas Reports and  
Studies No. 56, 82 pp., 1985.

Utoomprurkporn, W., M. Hungspreugs, S. Dharmvanij and C. Yuangthong.  
"Improvement of the Processes for the Determination of Trace  
Elements in Sea Water and River Water," Proceedings of the  
Fourth Seminar on the Water Quality and the Quality of  
Living Resources in Thai Waters (Sunthirata, S. ed.),  
pp.165-179, National Research Council of Thailand, 1987.

Van Crean, M. J., E. A. Denoyer, D. F. S. Natusch, and F. Adams,  
"Surface Enrichment of Trace Elements in Electric Steel  
Furnace Dust," Envir. Sci. & Technol., 17, 435-439, 1983.

Vashrangsi, C., *et al.*, "Pollutants Discharged to the East Coast of  
the Gulf of Thailand," Proceedings of the Second Seminar on  
the Water Quality and the Quality of Living Resources in  
Thai Waters(Tamiyavanich, S. ed.), pp.101-114, Chulalongkorn  
University Publishing, 1981.

Wallace, G. T., Jr., G. L. Hoffman, and R. A. Duce, "The Influence  
of Organic Matter and Atmospheric Deposition on the  
Particulate Trace Metal Concentration of Northwest Atlantic  
Surface Seawater," Mar. Chem., 5, 143-170, 1977.

Wallace, G. T., Jr., and R. A. Duce, "Transport of Particulate  
Organic Matter by Bubbles in Marine Waters," Limnol.  
Oceanogr., 23, 1155-1167, 1978.

Wallace, G. T., Jr., "The Association of Copper, Mercury and Lead with Surface-Active Organic Matter in Coastal Seawater," Mar. Chem., 11, 379-394, 1982.

Wangersky, P. J., "Biological Control of Trace Metal Residence Time and Speciation : A Review and Synthesis," Mar. Chem., 18, 269-297, 1986.

Wong, M. H., K. Y. Chan, S. H. Kwan and C. F. Mo, "Metal Contents of the Two Marine Algae Found on Iron Ore Tailings," Mar. Poll. Bull., 9, 56-59, Great Britain, 1979.

Yeats, P. A., J. M. Bowers, and A. Walton, "Sensitivity of Coastal Waters to Anthropogenic Trace Metal Emissions," Mar. Poll. Bull., 9, 264-268, Great Britain, 1978.

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย



APPENDIX

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย



## APPENDIX A

### PREPARATION OF REAGENTS

#### Nitric Acid (HNO<sub>3</sub>) Conc.

AR grade nitric acid ( HNO<sub>3</sub> ) was purified by sub-boiling distillation in a teflon distillation apparatus and it was stored in a precleaned polyethylene bottle.

This purified nitric acid was used to prepare 4N nitric acid by diluting 250 ml of purified nitric acid to 1000 ml by double distilled water. This 4N nitric acid was used in the analysis of heavy metals in sea water.

10 % nitric acid was used for cleaning all apparatus used in this study.

#### Ammonium Pyrrolidine Dithiocarbamate (APDC) Solution.

2% (w/v) aqueous solution of APDC was prepared by dissolving 2 g. of APDC in 100 ml of double distilled water. This solution was purified by shaking with methyl isobutyl ketone (MIBK) prior to use in order to make it free of metal impurities. Purification was made by extracting each solution 3 times with MIBK. At the first extraction, APDC solution was extracted with MIBK in a ratio 10:1 and 20:1 at the second and third extractions. Each extraction was performed by shaking for 5 minute in a separatory funnel and allowing for each phase to fully separate and then the lower layer was withdrawn. Discard the upper layer with was MIBK. The

APDC solution was freshly prepared each time prior use for solvent extraction.

Methyl Isobutyle Ketone (MIBK).

The MIBK was purified by redistillation at 115-116 °C in all glass apparatus.

Ammonium Hydroxide Solution (NH<sub>4</sub>OH).

NH<sub>4</sub>OH was purified by placing two 250 ml teflon beakers in which the first beaker contained concentrated ammonium hydroxide solution (AR grade) and another beaker contained double distilled water to about half of full in a vacuum desiccator. The pressure inside the desiccator was reduced by a vacuum pump and let stand for at least 24 hour. The purified ammonium hydroxide solution was obtained from the beaker originally contained double distilled water. This purified solution was a dilution of ammonium hydroxide solution.

Stock Standard Solution of Copper, Lead, Iron and Zinc.

The stock standard solutions (1000 ppm) of Cu, Pb, Fe and Zn were commercially available and were used to prepare a primary standard solution (100 ppm)

1. Primary Standard Solution (100 ppm).

Primary standard solution was prepared by diluting 500 µl of stock standard solution to 5 ml with 4N HNO<sub>3</sub>, and then stored in the precleaned polyethylene vials and kept in a refrigerator.

2. Secondary Standard Solution (10 ppm).

Secondary standard solution was prepared by diluting 500  $\mu\text{l}$  of primary standard solution to 5 ml with 4N  $\text{HNO}_3$ , and then stored in the precleaned polyethylene vials and kept in a refrigerator.

3. Third Standard Solution (1000  $\mu\text{g/l}$ ).

Third standard solution was prepared by diluting 500  $\mu\text{l}$  of secondary standard solution to 5 ml with 4N  $\text{HNO}_3$ , and then stored in the precleaned polyethylene vials and kept in a refrigerator.

4. Working Standards Solution (Cu, Pb, Fe and Zn).

4.1 Copper.

The copper working standard solutions were 0, 1, 5, 10, 20 and 40  $\mu\text{g/l}$  which were prepared by diluting 0, 10, 50, 100, 200 and 400  $\mu\text{l}$  of third standard solution to 10 ml with 4N  $\text{HNO}_3$ .

4.2 Lead.

The lead working standard solutions were 0, 1, 3, 5, 10, 15 and 20  $\mu\text{g/l}$  which were prepared by diluting 0, 10, 30, 50, 100, 150 and 200  $\mu\text{l}$  of third standard solution to 10 ml with 4N  $\text{HNO}_3$ .

4.3 Iron.

The iron working standard solutions were 0, 100, 500, 1000, 2000, 4000 and 8000  $\mu\text{g/l}$  which were prepared by diluting

of 0, 100, 500, 1000, 2000, 4000 and 8000  $\mu$ l of secondary standard solution to 10 ml with 4N  $\text{HNO}_3$ .

#### 4.4 Zinc.

The zinc working standard solutions were 0, 50, 100, 200, 400, 1000 and 1500  $\mu$ g/l which were prepared by diluting of 0, 50, 100, 200, 400, 1000 and 1500  $\mu$ l of secondary standard solution to 10 ml with 4N  $\text{HNO}_3$ .

#### TOC Standard Solution Preparation.

0.85 g of potassium hydrogen phthalate was dissolved in distilled water and diluted to 1000 ml. The standard solution was equivalent to 0.4 mgC/ml = 400 ppmC.

#### IC Standard Solution Preparation.

1.40 g of sodium hydrogen carbonate and 1.77 g of sodium carbonate (dried at 500-600 ° C for 30 min and then allowed to cooled in a desiccator) was dissolved in distilled water and diluted to 1000 ml. The standard solution was equivalent to 0.4 mgC/ml = 400 ppmC.

#### Calibration Curves Preparation of TOC and IC.

The working standard solution of 0, 10, 20, 30 and 40 ppm standard solution were dilutions of 0, 2.5, 5.0, 7.5 and 10.0 ml of TOC and IC standard solution stock (400 ppmC) to 100 ml with distilled water.

APPENDIX B

STATISTICS ANALYSIS

Table B-1 Analysis of Variance, Completely Randomized (CRD)

Source of Variation	Sum of Squares	Degree of Freedom	Mean Square	Variance Ratio
Among group	$SS_{\text{among}} = \sum_{j=1}^k n_j (X_{.j} - X_{..})^2$ $= \sum_{j=1}^k \frac{T_{.j}^2}{n_j} - \frac{T_{..}^2}{N}$	$k - 1$	$MS_{\text{among}} = \frac{SS_{\text{among}}}{(k-1)}$	$V.R. = \frac{MS_{\text{among}}}{MS_{\text{within}}}$
Within group	$SS_{\text{within}} = \sum_{j=1}^k \sum_{i=1}^{n_j} (X_{ij} - X_{.j})^2$ $= \sum_{j=1}^k \sum_{i=1}^{n_j} x_{ij}^2 - \sum_{j=1}^k \frac{(T_{.j})^2}{n_j}$	$N - k$	$MS_{\text{within}} = \frac{SS_{\text{within}}}{(N - k)}$	
Total	$SS_{\text{total}} = \sum_{j=1}^k \sum_{i=1}^{n_j} (X_{ij} - X_{..})^2$ $= \sum_{j=1}^k \sum_{i=1}^{n_j} x_{ij}^2 - \frac{T_{..}^2}{N}$	$N - 1$		

When  $x_{ij}$  = Observed data  
 $i$  = 1, 2, 3, ..., n  
 $j$  = 1, 2, 3, ..., k  
 $T_{.j} = \sum_{i=1}^{n_j} x_{ij}$  = sum of column j  
 $X_{.j} = \frac{T_{.j}}{n_j}$  = mean of column j

$$\begin{aligned}
 T_{..} &= \sum_{j=1}^k T_{.j} \\
 &= \sum_{j=1}^k \sum_{i=1}^{n_j} x_{ij} = \text{sum of total} \\
 \bar{X} &= \frac{T_{..}}{N}, \quad N = \sum_{j=1}^k n_j
 \end{aligned}$$

where,

- $SS_{\text{among}}$  = the among groups sum of squares  
 $SS_{\text{within}}$  = the within groups sum of squares  
 $SS_{\text{total}}$  = the total sum of squares  
 $MS_{\text{among}}$  = among group mean square  
 $MS_{\text{within}}$  = within group mean square  
 $V.R.$  = the variance ratio

#### Decision

The variance ratio (V.R.) value was compared with the critical value  $F$  listed in a percentile of  $F$ -distributions table at degrees of freedom  $(k-1)$  and  $(N-k)$ . If the V.R. was greater than  $F$ -value, the null hypothesis  $H_0$  was then rejected and could be concluded that the mean of samples were significantly different. If the V.R. was smaller than  $F$ -value, the null hypothesis  $H_0$  was accepted and could be concluded that the mean of samples were not significantly different.

APPENDIX C



Oil in the fuel tank and engine room is transferred to storage tank for sale.



Remaining oil which cannot be removed is eliminated by burning.



Pieces of steel directly falls into the sea and weathering.



Some parts of the vessel presented on the sand beach.





## BIOGRAPHY

Mr. Supawat Kan-atireklap ( Lim ) was born on 16th August 1961 in Samutprakarn Province. He graduated with a B.Sc. degree in Marine Science from Chulalongkorn University in 1984. After graduation during May 1985 - May 1987, he worked as a research assistant at the Faculty of Agriculture and Food Engineering, Asian Institute of Technology, Pathum Thani Province.

In July 1987 he was admitted at Chulalongkorn University and worked toward a Master Degree in Marine Science.

During July 1988 - November 1989, he worked as an environmental scientist in the Water Quality Sub-division, Environmental Quality Standard Division, Office of the National Environment Board.

Science December 1989, he has been working as a marine fisheries biologist at the Eastern Marine Fisheries Development Center, Marine Fisheries Division, Department of Fisheries, Ministry of Agriculture and Co-operatives.

### Publication

Sompongchaiyakul, P., M. Hungspreugs and S. Lim, " Baseline Values of Petroleum Hydrocarbon in the Upper Gulf of Thailand and in the Eastern Seaboard," Paper presented at the Third Seminar on Marine Science arranged by the National Research Council of Thailand.