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COASTAL MARINE POLLUTION AND TOXICOLOGY : OVERVIEW OF CURRENT RESEARCH AND FUTURE NEEDS

by

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Abstract

The problems of coastal pollution in Malaysia have been studied by various research institutions for more than two decades. However, reliable data is rather scarce. In addition, the available data may not be consolidated because inter-laboratory comparison exercises have only recently been practised. The studies that have been carried out were baseline in nature; very little work have been done on the behaviour and fate of the pollutants. The pollutants that have been studied include domestic and agro-industrial wastes, trace metals, faecal microbes as well as hydrocarbons and related chemicals. Very little work on pesticides and trace organics have been conducted. Levels of pollutants have been determined in seawater, sediments as well as plant and animal tissues.

Work on Marine Toxicology is lagging far behind marine pollution studies. A survey under the ASEAN-Canada programme on Marine Science revealed that the modest Marine Toxicology Laboratory at Universiti Sains Malaysia is one of the best equipped in the region. Organisms that have been used in toxity experiments include the blood cockle, Anadara granosa, the mussel, Perna viridis, various species of oysters, the clam, Donax faba, the seabass Lates calcarifer, the tiger shrimp, Peneaus monodon and the polycheate, Perineries sp. Although most of these studied were laboratory-oriented, a few field investigations have been carried out.

With rapid development and industrialization of the country, there is an urgent need to evaluate research activities in this areas in order that we would be able to remedy any negative impact of the development and industrial activities before it becomes irreparable. For laboratories that are involved in these studies, the emphasis now should be on quality assurance and quality control. For more efficient effort and less duplications, communication among the scientists is essential.

INTRODUCTION

Studies on marine pollution along the coastal areas of Malaysia have been carried out for more than two decades. Initially, the work involved were merely collection of baseline data for some of the common pollutants such as heavy metals, oil and grease, as well as determining levels of microbes such as faecal coliforms or. E. coli. Lately though, the research has become more sophisticated where pollution levels are correlated to such physical parameters as waves, tides, currents, temperature and salinity. At times, some form of mathematical modelling and simulation are also included in the studies. While the earlier research involved very small group of either biologists or chemists working independently of one another, presently marine pollution studies tend to be multidisciplinary in nature, involving biologists, chemists, oceanographers, as well as mathematicians.

Most of the work that have been carried out so far have been conducted by universities, including Universiti Sains Malaysia in Penang, Universiti Pertanian Malaysia, Universiti Kebangsaan Malaysia, Universiti Malaya, and to a lesser extent, Universiti Teknologi Malaysia. Apart from the universities, government agencies that have been actively involved with pollution studies are the Department of Environment in collaboration with the Chemistry Department of the Ministry of Science, Technology and Environment as well as the Fisheries Department, particularly the Fisheries Research Institute. Some of the earlier work include those of Lee and Low (1976), Chua et al (1977), Babji et al (1978), and Sivalingam et al (1979), while the later studies include those of Law and Singh (1988), Lim and Seng (1987), Department of Environment (1993). There are of course many other studies on marine pollution that have been carried out but a large majority of them were conducted under contract with certain agency/agencies or carried out by the private sector, and so the reports are either not available or not easily accessible. Thus if one

is just beginning to do research in marine pollution in Malaysia, one would be surprise to note that the available data is rather limited, although work in this field have been carried out for so many years.

MARINE POLLUTION AND TOXICOLOGY STUDIES AT UNIVERSITI SAINS MALAYSIA

Universiti Sains Malaysia has been involved with marine pollution studies almost ever since its formation in 1969. Most of the earlier work were conducted by researchers from the School of Biological Sciences and School of Chemical Sciences, working almost independently of one another. Lately, marine pollution studies at the university have become multi-disciplinary in nature, involving researchers not only from the earlier two School mentioned, but also researchers from the School of Physics, School of Housing, Building and Planning, and School of Mathematics. However, most of these inter-disciplinary studies have been and are contract work, particularly from the private sector.

Marine Pollution And Toxicology Facilities At USM

As was mentioned in the last section, marine pollution and toxicology work have been and are still being carried out by various Schools in the University; some are collaborative efforts while others are independent of one another. Realizing the importance of marine science studies at the University, and hoping to create a common platform for all the researchers in the field, the Centre for Marine and Coastal Studies (CEMACS) was established in 1991. The Centre now becomes the focus of inter-disciplinary coastal pollution studies at the University, although there are still those who rather work independently at their various Schools.

Pollution Studies is one of the three emphasis areas of the Centre. Under the Pollution Section, a Pollution Laboratory is located at the Centre's main building on the main campus, while the Toxicology Laboratory is located at the Muka Health Marine Station, about 30 km away on the northwestern tip of the island. The Pollution Laboratory is divided into 3 sections; the general purpose area, the Trace Metal Laboratory) and the Organic Laboratory. The Trace-Metal Laboratory is equipped with a class-100 clean room and an atomic absorption spectrophotometer with a granite furnace. The Organic Laboratory is presently being equipped with an HPLC and a gas chromatography. At present, the Organic Laboratory is being dedicated to the analysis of hydrocarbons and pesticides. For work with nutrients, the Mangrove Section of the Centre is equipped with an autoanalyzer. The Toxicology Laboratory is equipped with facilities to run both acute toxicity test as well as long-term sublethal tests. Some of the sublethal responses that have been measured are changes in feeding rate, respiration rate, excretion rate, and growth rate. Changes in early developmental stages of bivalves such as cockles, clams and oysters have also been monitored. At the Muka Head Marine Station is also located a Microbiology Laboratory where levels of bacteria contamination in water, sediment, and animal tissue can be analyses. For field sampling, the Centre has splendid collection of modern field instruments. Some of the major ones include a wave and tide recorder, a water quality analyzer, dredges and several current meters.

Apart from the facilities at the Centre for Marine and Coastal Studies, other major instruments available at the university that have been used and can be used for pollution studies and toxicology work include a GCMS at the School of Chemical Sciences and a scanning as well as a transmission electron microscope at the School of Biological Sciences.

Marine Pollution And Toxicology Projects At USM

Research on marine pollution and toxicology at Universiti Sains Malaysia have been supported by various agencies, from government bodies to private sectors, from local agencies to international organizations. Some of the major supports have been from the Government of Malaysia R & D grants under the IRPA programme, Exxon Corporation of USA, Sarawak Shell Berhad and Sabah Shell Petroleum Company, the Penang Development Corporation, the Penang Municipal Council, ESSO Production Malaysia, and the Canadian International Development Agency (CIDA), under the ASEAN-Canada Cooperative Programme in Marine Science.

Coastal Pollution Monitoring and Baseline Studies

This study, which is on-going, is primarily supported by CIDA. However, part of the work is funded under the Malaysian Government IRPA programme. For the past several years, the emphasis have been on the determination of levels of trace-metals in the coastal marine environment, in relation to other physico-chemical parameters. Levels of trace-metals in sediments and tissue of marine animals have been determined for a number of locations in the country. However, most of the stations were located on the west coast of Peninsular Malaysia mainly because of convenience. Levels of trace-metals have been reported absolute values as well as normalized with aluminium concentrations. Examples of such reports are Lim and Seng (1987), Din (1992), Din (1993), and Din and Jamaliah (in preparation). Reporting levels of trace metals in sediments normalized to aluminium enable us to get a rough estimated of input of the metals from human activities. Alarmingly, we found that for some metals (for example cadmium), the percent contribution of anthropogenic input into the marine sediments can be very close to 50%. Some of these values are shown in Table 1, from Din (1993). Based on the normalized data, we were able to identify

several locations along the Straits of Malacca where anthropogenic input of trace-metals have been found to be quite substantial (Figure 1). However, these results should be considered preliminary as only 24 stations along the Straits were sampled. More data is needed before any confirmatory conclusions can be made.

METAL	STATION	ANTHROPOGENIC INPUT (ppm)	% OF TOTAL CONCENTRATION
Cd	05	0.067	50.8
	15	0.144	47.7
	23	0.047	49.5
	24	0.154	48.7
As	01	11.23	32.4
	23	5.22	48.7
Cu	02	3.32	25.5
	04	3.66	19.3
	07	2.23	28.1
	07	1.48	20.6
	18	4.43	21.9
Zn	01	21.07	18.2
	10	25.16	20.6
	23	9.35	22.8
Pb	07	6.11	25.0
	07	5.41	22.8
	15	8.15	18.2
	15	9.32	19.4

Table 1 : Contributions of anthropogenic input of 5 trace-metals to the sediments of the coastal waters of the Straits of Malacca. (From Din, 1993).

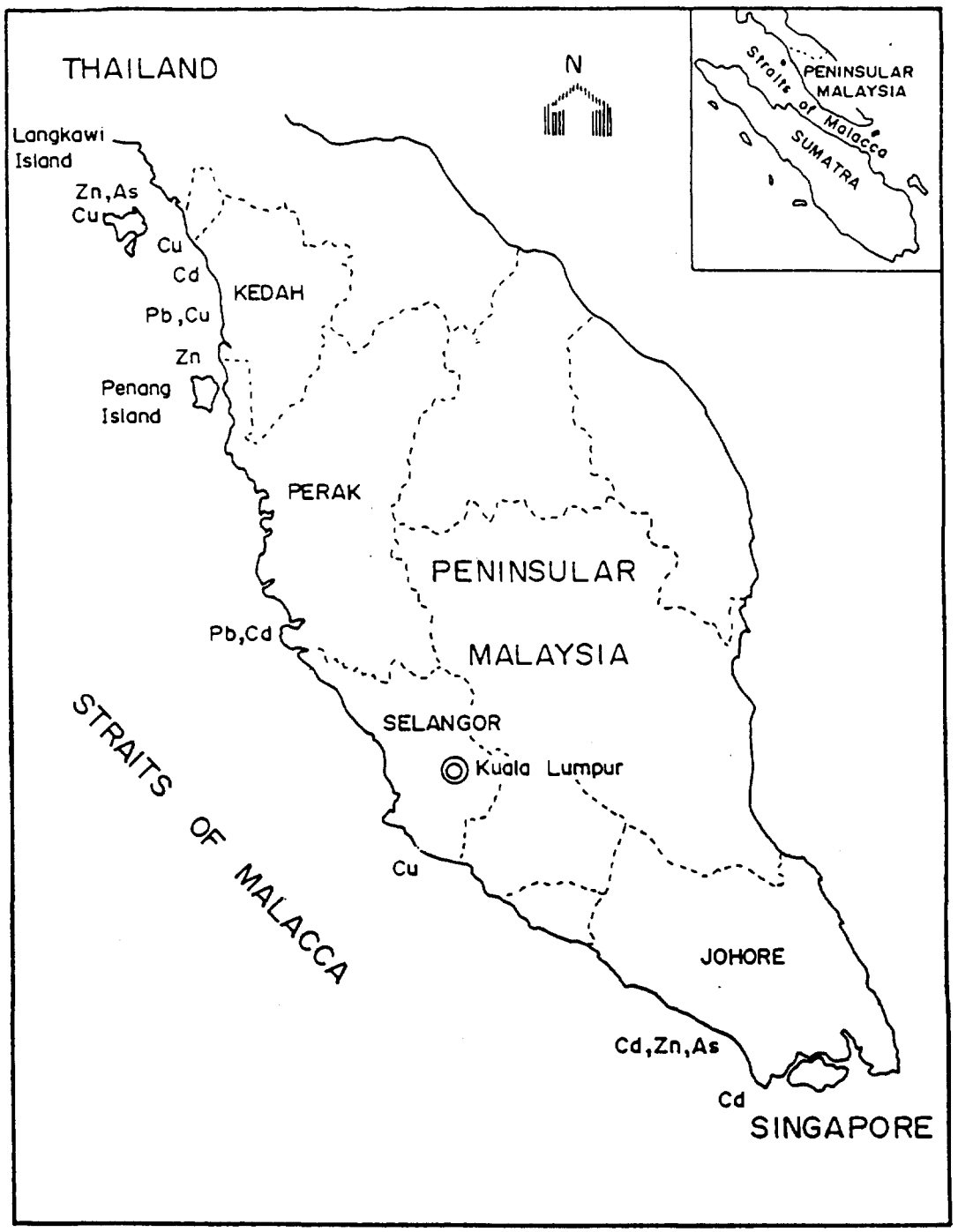

Figure 1: Locations along the west coast of Peninsula Malaysia where substantial amount of anthropogenic input of various trace-metals were found. (From Din, 1993).

Baseline study on levels of hydrocarbons and other organics in the coastal environment by the research team from Unviersiti Sains Malaysia has been very limited. Presently, under the ASEAN-Canada Programme on marine science, the USM team is making preparation to study levels of hydrocarbons (particularly the PAH's), pesticides, nutrients and microbial contamination, particularly those involving faecal coliform, in the coastal waters of Malaysia. Included in the preparation is an inter-laboratory comparison exercise among laboratories not only in Malaysia but also in other ASEAN countries, as well as development and upgrading of QA/QC programmes for these laboratories.

The coastal pollution survey founded by CIDA under the ASEAN-Canada Cooperative programme in Marine Science, although headed by USM through the Centre for Marine and Coastal Studies, will also involve group from Universiti Pertanian Malaysia in Trengganu and the Chemistry Department of Univesiti Kebangsaan Malaysia.

For the past several years, the pollution study team at USM was also made up of lecturers from the School of Mathematics who were responsible for constructing mathematical models and simulations using data generated from the study. Studies in which these mathematicians have been involved include a land reclamation impact assessment study at the Prai industrial area which was supported by the Penang Development Corporation, and the sewage dispersion study in the Western Channel, Penang, funded by the Penang Municipal Council.

Marine Toxicology : Laboratory Exposures

Toxicity test of various kinds of chemicals on marine organisms have been carried out at the Muka Health Marine Station. Chemicals that have been used include trace-

metals, effluent from crude oil terminals, trace organics and oil. Major fundings have been from Sarawak Shell Berhad and Sabah Shell Petroleum Company, the Government of Malaysia under the IRPA Programme, and CIDA, under the ASEAN-Canada marine science programme. Animals that have been used for these toxicity test include two species of diatoms, Skeletonema costatum and Cheatoceros sp., the polychaete Perineries sp., various species of bivalves including the clam Donax faba, the green-lipped mussel Perna viridies, the blood cockle Anadara granosa, juveniles of the seabass Lates calcarifer and the tiger prawn, Peneaus monodon. Toxicity tests using these organisms have also been compared with toxicity tests using the photoluminescent bacteria, Photobacterium phosphoreum. Din and Ahamad (1993) concluded that in general toxicity test using the bioluminescet bacteria is very handy in monitoring exercises because it is very easy to run and it takes only a few hours to complete. However, results from these tests should not be analysed in isolation as it will prove almost meaningless. From time to time, results from toxicity tests using the photoluminescent bacteria need to be 'calibrated' using a few other common organisms. Presently, under the ASEAN-Canada cooperative programme in marine science, a lot of effort is being put into running acute toxicity tests of various chemicals on the several species of marine organisms. The information is needed for the development of the ASEAN Marine Water Quality Criteria, which eventually can be used by the relevant enforcement agencies of the various ASEAN countries for the development of their respective Marine Water Quality Standards.

Although most of the toxicity work at our laboratory have been acute toxicity tests for the determination of specific LC50 values, some sublethal exposure studies have also been carried out. Response that have been monitored so far are those either related to growth or reproduction physiology. Examples fo such responses are, changes in rate of growth in diatoms which were measured through changes in

number of cell counts, indirectly through changes in chlorophyll-a concentration, as well as changes in ATP levels. Affects of chemical stress on the physiology of marine animals have been studied through changes in respiration rate of the seabass, as well as changes in feeding rate, respiration rate, excretion rate, and growth rate of several species of bivalves. Growth rate, apart from direct measurement of change in size of the organisms, has also been indirectly monitored by changes in the scope for growth of the animal. Scope for growth basically is a measure of the amount of energy that is available to the organism for growth and gamete production. A high value for this index suggests a potential for fast growth rate, while a lower value means a slower growth rate. A negative value suggests that the organism will experience negative growth, i.e., the amount of food (energy) taken in by the organism is not even enough to cater for its basic energy requirement such as for respiration and excretion. Figure 2 (from Din and Ahamad, 1992) shows an example of the kind of results that have been found. In this study, the clam Donax faba was exposed to various sublethal concentrations of effluent from the Sarawak Shell Berhad Crude Oil Terminal in Lutong. It is quite apparent from the figure that feeding rate (as represented by the clearance rate) and growth rate (shown as values for Scope for Growth) of the clams declined with concentration, while the contrary is true for respiration. Negative growth rates are suggested for animals that were exposed for concentrations of the effluent that were equivalent to their LC_{20} and LC_{40}.

Marine Toxicology : Field Studies

Field studies on effects of chemical stresses as well as changes in other related environmental factors on marine flora and fauna have also been investigated by our team. Since early 1980's the group from the School of Biological Sciences have been continuously contracted by Sarawak Shell Berhad, Sabah Shell Petroleum Company, and Brunei Shell to monitor the microbethic

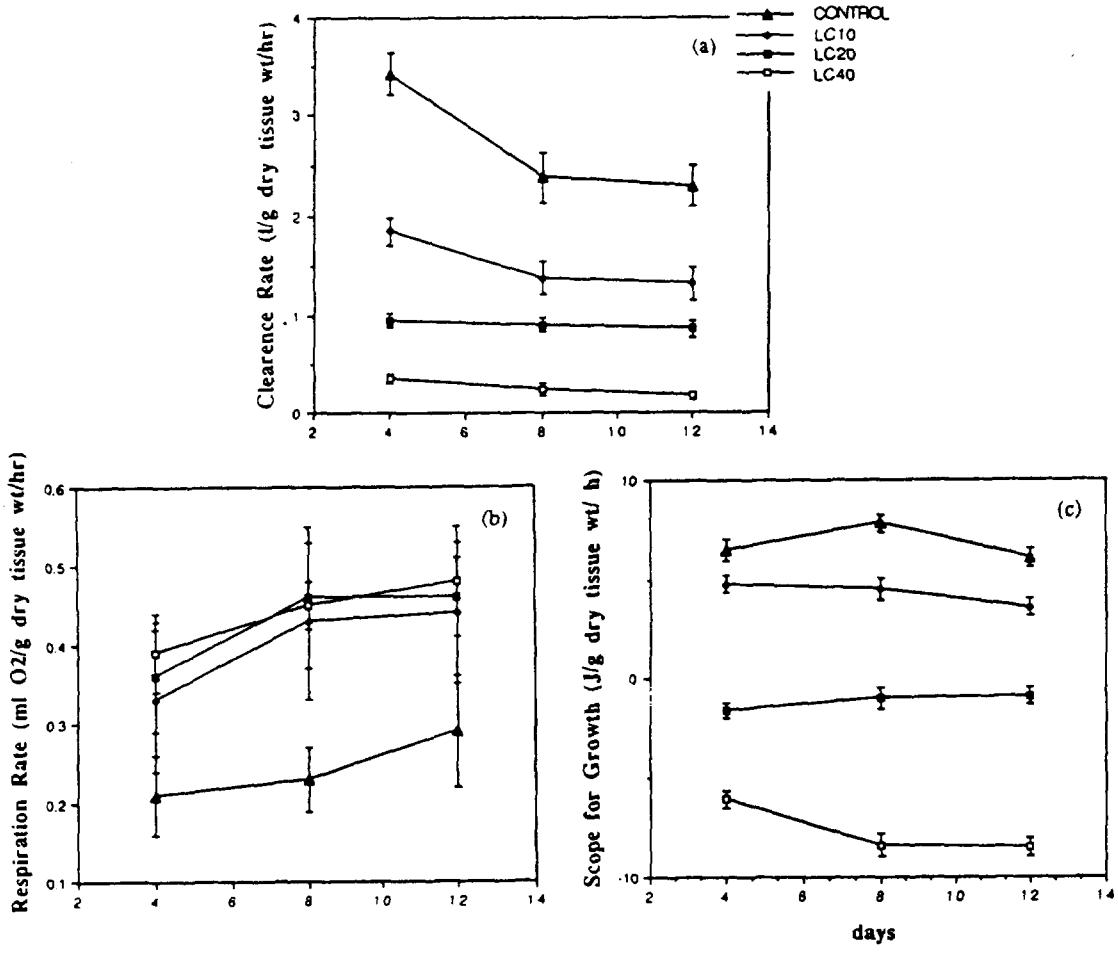

Figure 2: Effects of effluent from Sarawak Shell Berhad crude oil terminal at Lutong, Sarawak, on the clearence rate, respiration rate, and scope for growth of the clam *Donax faba*. (From Din and Ahamad, 1992).

communities in the vicinity of their operation areas in East Malaysia. Presently, apart from the Shell projects, the impact of coastal development on the benthic communities around Penang Island is being conducted by the group at CEMACS. This latter project is supported by CIDA under the ASEAN-Canada programme. Preliminary results indicate that areas which are regularly exposed to disturbances such as chemical stresses or sedimentation usually have low species diversity. There is usually an abundance of such opportunistic species as the polychaete Capitella capitata.

Effects of pollution gradient on the physiology of marine organisms have also been studied, using the blood cockle, ***Anadara granosa*** as the test animals. In this study, plastic cages containing the cockles were placed along a pollution gradient generated by effluent discharged from the Prai industrial area. With time, the animals were brought back to the laboratory and their feeding, respiration, and excretion rates measured. From these values, their scope for growth indices were estimated. These values were then correlated with the environmental stresses of the area, which were measured as levels of trace metals, oil and grease, biological oxygen demand (BOD), dissolved oxygen and pH. A startling conclusion that can be drawn from this study is that almost no organism can survive in the vicinity of the discharge point of the effluent. All the cockles that were placed at the discharge point were found dead after just a few days of exposure. And, relative to the other species of marine animals that we have used in our toxicity experiments, the cockles can be regarded as one of the least sensitive to externals tresses.

Impact of oil pollution on the marine environment have also been studied by the USM team. Two such studies are:

i. The fate and effects of oil in the mangrove environment.
ii. Biodegredation of crude oil in Sabah and Sarawak marine environment.

The first project, supported by Exxon Corporation, studied the fate and effects of oil in a simulated mangrove environment. Responses measured include oil uptake, changes in growth rate as well as rate of seeding germination. The second study, funded by Sarawak Shell Berhad and Sabah Shell Petroleum Company, was a joint project with University Kebangsaan Malaysia.

FUTURE NEEDS AND GOALS OF MARINE POLLUTION AND TOXICOLOGY STUDIES IN MALAYSIA

Although marine pollution and toxicological studies in Malaysia have been around for more than two decades the information that we have regarding these problems is very limited. Up till now, we barely scratch the surface of the problem; and we do not know what is waiting underneath.

One of the very obvious problem that requires urgent remediation is the lack of proper communication among the scientists involved in this field. Studies on marine pollution and toxicology in Malaysia have been carried out mainly by four universities in Malaysia, namely Universiti Sains Malaysia, Universiti Kebangsaan Malaysia, Universiti Pertanian Malaysia and Universiti Malaya. Yet one university has only very limited knowledge of the activities of the others. For whatever the reasons, this secretive attitude should not prevail any longer. Scientists in these fields should get together regularly to discuss their projects. At the least they should be in constant communication with one another regarding the work that they are doing. In this way, we would be able to reduce the amount of duplication, save a lot of money and eventually will be able to progress at a much greater speed. Presently, for example, under the ASEAN-Canada programme on marine science, this kind of collaborative effort is being practised.

At present, the baseline data available on marine pollutant levels in Malaysia generated by the various laboratories may not be consolidated. This is because there have been only limited number of laboratories in Malaysia that have been involved in inter-laboratory calibration exercises. Even less number of laboratories have proper QA/QC programmes. Thus there is an urgent need for these laboratories to upgrade their QA/QC programmes and also to be involved in various inter-laboratory comparison exercises. Only then can the marine pollution and toxicology studies in Malaysia become one huge project for the country.

In comparison with such advanced countries as the United States of America and Japan, most of the marine pollution and toxicology studies that have been conducted in Malaysia can still be regarded as basic. While we do have some information on the levels of some pollutants in the marine environment in Malaysia, we are still unclear as to the fate of these pollutants, especially with regards to their accumulation along the marine food-chain. We still have very little information as to what would be the effects of these pollutants along the food chain, and eventually to humans. Although there is substantial amount of informations on fate and effects of pollutants in the marine environment, most are on temperate species living in temperate situations.

Acute toxicity testing in the laboratory is important because it would enable us to determine the toxicity of certain chemicals relative to the toxicities of other common pollutants. However, the sublethal studies are regarded more important because from these studies we can draw conclusions as to the effects of the pollutant/s on the population or community. Presently, at the sublethal level of exposures, responses that have been monitored are mainly physiological in nature, especially those related to growth and reproduction. There is a need now to go deeper into the effects of the

pollutants, involving cellular and sub-cellular responses. Although in the United States, Britain and Japan, there have been many studies conducted on the biochemical and pathological effects of pollution, similar work in Malaysia is almost next to none.

So far most of the information regarding marine pollution and toxicology in Malaysia have ended up either as academic publications in some scientific journals or stuck in the shelves of libraries or some government and private agencies. Very little of these information is actually used in the overall development planning in the county. As the information in these areas is still very limited, whatever we have should be disseminated widely among the scientists as well as relevant government official and other interested group/s.

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