POLLUTION IN MARINE COASTAL ENVIRONMENT:
A Consideration for Designing Sustainable Development of Marine Resources

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SUMMARY

Incompatibilities and conflicts among users of marine and coastal zone resources are consequences of increasing activities such as, in investments, exploitation of non-renewable resources, and disposal of human and industrial wastes. These are the result of Indonesia's policy to increase economic expansion through the industrial sector that has taken place during the previous Repelitas. All the activities, together with an ever-increasing population, are resulting in a rapid increase in the quantity of pollution in Indonesia marine and coastal waters. This may be leading, directly or indirectly, to severe conflict and degradation of marine resources (fisheries, coral reefs, seagrass, etc.) as a whole in the region. Degradation of the resources can be related to pollution that occur in marine and coastal environment. Pollutants (pesticides, heavy metals and PCB, etc.), as environmental contaminants, could have toxic effects on marine ecosystems. Ultimately, they diminish the number of survivors, influence metabolism and breeding efficiency, alter behavioral patterns, and affect structures and forms of the ecosystem. They can further degrade the quality of environment and influence the resources. Indonesia has been seriously focusing its national policies, strategies and action to environmental management in a context of sustainable development by establishing some Government Regulations. They are stressing and considering the point on marine environment including the impact of the all activities. The present paper tries to give some information on the environmental contaminants that may occur in the marine and coastal environment. It is addressed to planners and designer of marine environmental management to consider the degradation of the marine resources due primarily to the activities, including the exploitation of resources, which were not well managed.

Keyword: Pollution, coastal environment,

INTRODUCTION

Marine coastal waters are highly productive compared to maritime areas as a whole, and support resources providing the basis for world fisheries. Compared with other oceanic areas, the waters, as an ecosystem, is disproportionately productive. The ecosystem, including all components (coral reefs, mangroves, algae and seagrasses, etc.) plays an important role in maintaining the fisheries production, where it provides habitats for many species of commercial fish and fish that are commercially exploited in deeper waters at the later stages of their life.

Since Indonesia has focused its policy to increase the economic expansion through industrial sector that has taken place during the previous Repelitas (National Development Plan of Indonesia) (Anonymous 1996), investments and activities (in agriculture, industry, marine transport, disposal of human and industrial wastes), population pressure in coastal areas and long-established dependence on coastal zone for living space are significantly increasing. Besides these, there are also an increase in extraction of non-renewable natural resources and locations for heavy industry and recreation. Beside the consequences in incompatibilities and conflicts among uses of the coastal zone resources, all the activities have resulted in rapid increase in the quantity of pollution. As a result, this may be leading, directly or indirectly, to severe conflict and degradation of marine and coastal resources (fisheries, coral reefs and seagrass, etc.) as a whole in the region.

Regarding to the degradation of the marine and coastal resources, Indonesia has been seriously focusing its national policies, strategies and actions on environmental management in a context of sustainable development. This is exactly
true that Indonesian Government has been establishing some Regulations to control all development and exploitation of the resources. The exploitation, in their activities and targets, has to consider the sustainable development of the resources and minimize the impacts to the environment.

Our goal in this paper is to give some information on environmental contaminants (pollutants) that may occur in marine and coastal environments. It is addressed to planners and designer of marine environment management to consider, in order to develop the Indonesian sustainable marine resources, the degradation of the marine resources due primarily to those activities, especially exploitation of the resources, which were not well managed.

POLLUTION

It is now widely agreed that the term "pollution" be best interpreted in a broad sense as any substances or energy, directly or indirectly, introduced by man into the environment and which have deleterious consequences for living marine resources, be hazardous to human health, hinder marine activities, such as fishing navigation, and impair the quality of the sea and reduce amenities.

Rapid growth of urban centers, together with increasing investments in agriculture and industry, activities in non-renewable resource exploitation, and disposals of human and industrial wastes is resulting in rapid increase in the pollution and change in the types of pollutants present in the East Asian Seas Region, including Indonesia (Gomez et al. 1990). This may be leading to severe conflict with the harvest of marine fisheries and other resources in the region. An experience in Canada, dredging and relocation of sediments contaminated with metals and a variety of organic pollutants (e.g., chlorophenols, polychlorinated biphenyls [PCBs], polycyclic aromatic hydrocarbons [PAHs], and organochlorines) can lead to the degradation of coastal ecosystems (Waldichuk 1988 in MacDonald et al. 1992).

Serious marine pollution could occur from improper uses of marine and coastal areas for the disposal of anthropogenic wastes. More outbreaks of coastal water pollution are occurring all time. In some countries, waste disposal into marine and coastal areas may be leading to severe conflict with other appropriate activities involving the use of the areas. Historically, the sea has always been considered as a resource. Recently, the sea has been used as an easier and more accessible medium for disposals of various wastes. The conflicts over the use of the area, either as a resource or a waste disposal site, have been ongoing.

TYPES AND SOURCES OF THE PRINCIPAL POLLUTANTS

Thousands of substances enter the marine environment as a result of man's use of materials and production of energy. Some, like DDT, is alien to the sea, whereas others, such as mercury, lead and certain radionucleides are naturally present because of weathering of the earth's surface, but human being alters their concentrations and combinations and, thus, they become pollutants. They have toxic effects on marine organisms, diminish the number of survivors, influence the metabolism and breeding efficiency, alter behavioral patterns, and affect structures and forms of the ecosystem. They can further degrade the quality of the environment and influence the resources.

The sources of the principal pollutants of Southeast Asian Coastal Waters, their environmental impact and effect on living aquatic resources are summarized in Table 1. The main routes by which they enter the marine environment can be seen in Table 2.

THE IMPACT OF POLLUTANTS ON LIVING AQUATIC RESOURCES

Most elements listed in the Periodic Table are naturally present in seawater at least as an ion or a complex. Their introduction
through human activities does not necessarily constitute pollution. At the worst, they may regard as contaminants. Also, compared with freshwater, seawater has a high buffering capacity and is able to absorb some inorganic pollutants, such as acids, with a relatively little change. Bioaccumulation of heavy metals is a reversible process, and in many organisms, the increased levels of metallic pollutants that, for example, follow an acute exposure, decline once the source is removed (Ruddle 1982).

The effect of pollutants on marine environments depends on many complicated interactions among many factors or processes including: 1) the quantities and kinds of pollutant, 2) the chemical and physical properties of the pollutant, 3) the rates of discharge of the pollutant, 4) the interactions of the pollutant with seawater, 5) the toxicity of pollutants to organisms, and 6) the oceanic process in mixing and dispersing the pollutants (Shieh & Duedall 1992). Furthermore, the effect could be found in entire ecosystem that is indicated by changes in species compositions and population numbers (Connell & Miller 1985).

Typically, the following 8 ways have been established in which pollutants might affect the ecosystem and a given fish population (FAO/UNEP 1975 in Ruddle 1982; Lasut 1996):

1. Lethal effects or immediate death commonly follow an acute exposure to a pollutant.
2. Interference with the chemo-receptors of marine organisms may affect the behavioral patterns essential to the survival of population.
3. Long-term exposure to various levels of concentration of pollutants may make an organism more susceptible to disease. This has been theoretically asserted but there is a little supporting evidence.
4. Eggs and larval forms of many organisms are more sensitive to pollution than are adults, therefore additional stress on developing organisms might lead to failure of enough individuals to survive to maintain viable population.
5. Pollutants that interfere with various physiological processes without necessarily causing death may also threaten survival of populations.
6. Pollutants may interfere with nutrition of organisms by affecting ability to find prey, through adverse effects on digestion or assimilation of food, or by contamination of prey species rendering them unacceptable to the predator.
7. Many pollutants may produce genetic effects that have long-range implications for survival of a species, although there is still little supporting evidence.
8. Physical alteration or destruction of habitats may lead to death or migration of populations.

POLLUTANTS AND EFFECTS OF POLLUTION ON RENEWABLE MARINE RESOURCES

Long-term consequences of the depletion of marine resources for human beings are a matter of conjecture, as gradual and widespread effect of long-lasting sub-toxic levels of pollution are still only vaguely understood. But there are numerous examples of the impact of localized and major incidents of pollution that have immediate consequences.

The rearrangement of bottom topography, accelerated sedimentation and other effects of sea-mining or dredging operations, or acute toxicity from other sources have destroyed local fish population and caused distributional changes in fish stocks, mortality of the coral and degradation of other resources. The altered sea bottom topography, especially as a result of depositing mining tailings, digging pits, dumping boulders, reclaiming land or placing permanent structures may seriously restrict local use of the seines, long lines, set nets, lobster traps and other bottom gears, and impede the inshore navigation. Major oil spills could also cause a temporary economic disaster for entire communities or sectors
of local economy, as catch decline, when fish migrate to avoid the polluted area, or when fishermen cease fishing to avoid fouling their gear (Ruddle 1982).

Siltation

Siltation (silt of fine particulate matter [\(\varnothing<62\mu m]\)), the process of sedimentation, is of major concern in all coastal waters of Southeast Asia and its effects may widely be distributed by marine currents beyond the principal site far from the sources of the problem. Ecologically, deleterious agricultural practices and illegal timber operation in the mountains are responsible for excessive deposition of sediments. The coastal waters off Sumatra and Kalimantan are experiencing siltation problems as a consequence of deforestation as a large stretch of Malaysian coastal waters. In addition, some sediments derive from sea-based activities such as tin dredging, where tailings are deposited directly into the sea. For example, off southwest coast of Thailand and northwest Sumatra, 16 major dredges and up to 3,000 small illegal vessels are operating in coastal waters, mostly at ders, mostly at depths less than 50m (Cruickshank 1979 in IUCN/UNEP 1985).

Siltation results mainly from a combination of poor agricultural practices, deforestation, the dumping of mine tailings, and for a lesser and more localized extent, it is a consequence of urban development. The process may also constitute a significant stress on coral reef ecosystems. As an experience, some reefs along the north coast of Java have been buried activities and reclamation (Soegiarto & Polunin 1981 in Gomez 1990). In addition, sediment can arise from sources such as terrestrial runoff, dredging, and sewage. Suspended solids in receiving waters for sewage discharges originate from three sources: 1) particles contained in effluents, 2) particulate organic matter

Environmental pollution caused by residues of agricultural chemicals and other inorganic pollutants has received a great publicity in industrialized countries during the past quarter century. Several examples indicate that pollution by industrial effluents is on the increase. In Canada, for example, the discharges of wastes from mining activities on both the Pacific and Atlantic coasts have resulted in a contamination of a variety of estuaries and coastal ecosystems. The direct disposals of mine tailing into this waters may result in physical (e.g., smothering of benthic organisms), chemical (e.g., elevated levels of metals, PAHs, and other contaminants in water and sediment), and biological (e.g., acute toxicity, chronic toxicity) effects Waldichuk 1988 in MacDonald et al.

In Malaysia, the oyster beds of the Sungai Muar and Sungai Perka estuaries have been destroyed by unprocessed effluents from sawmills, boatyards and iron foundries. Thirty-one Philippine rivers were reportedly polluted by effluents from sugar refineries, textile factories, pulp and paper mills and food processing plants, and threaten the productivity of artisanal fisheries, fishponds and small-scale farms. The effluents from forestry and wood products industries were a common cause of pollution throughout the region (Ruddle 1982).

Heated effluents released by power plants, some desalination plants, and other installations are causing a serious stress in shallow tropical marine organisms. Corals are among the most sensitive species involved, being killed by heated effluents at greater distances from the outfall and restrain future spread of the practice if fish farming is found to be incompatible with the use of other renewable natural resources. Moreover, impounding lagoons and bulkheading mangrove swamps and other areas for fish ponds have same effects on free-swimming fish stocks as does urban construction and development of port facilities. If fish pond development
in coastal waters is too extensive or poorly planned, it could reduce mangrove areas to dangerously low levels, block the transport of freshwater and sediments and the associated input of marsh primary production into adjacent estuaries and lagoons. The result is a decline in primary production in the latter.

Aquaculture could also be incompatible with the use of other resources if the application of large quantities of lime, fertilizers, pesticides and supplementary foodstuff is detrimental to offshore fish stocks. A heavy application of lime is required to offset adverse conditions in fish ponds with acid sulphate soils. Such soils are particularly problematic in deeper ponds. Beside having outright toxic effects on fish, acid sulphates also fix phosphates, thereby render them useless as fertilizers, unless large quantities of lime are applied. This, however, pollutes other waters (Ruddle 1982).

Organic pollutants

Organic and biological pollutants are of great importance in the coastal waters of Southeast Asia, since most of the region’s untreated sewage from the world’s greatest concentration of population is allowed to enter the sea. Apart from removing screenable materials from large discharges, Hong Kong’s sewage, for example, is discharged raw into the sea. Based on available data, it is estimated that a BOD of 17 kg per caput per year of sewage is discharged into the coastal waters of Hong Kong; that is 70,720 MT per year, based on a population of, in 1971, 4,16 million. As a consequence, oysters in Deep Bay are heavily contaminated with faecal bacteria (Ruddle 1982).

The relationship between consumption of polluted fish and human health has become more firmly established. Filter-feeding molluscan shellfish concentrating bacteria and viruses such as hepatitis, typhoid, dysentery and cholera, present in untreated discharged of human sewage, along with other particulate materials. The consumption of contaminated shellfish may cause enteric infections, and transmission of infectious hepatitis through the consumption of raw contaminated shellfish by sewage is well documented. Dysentery is thought to have been transmitted by the consumption of cockles in Malaysia, and epidemic of typhoid and hepatitis are linked to the consumption of the contaminated shellfish by sewage in Vietnam. In addition, sewage contamination, through decomposition, which competes for oxygen with finfish larvae and shellfish, leads to economic losses by reducing the fish production. In Philippines, for example, the production of mussel and oyster beds in Manila Bay and brackish water fish pond north of Manila is thought to be reduced as a result of sewage discharge (Ruddle 1982).

**INDONESIAN SUSTAINABLE DEVELOPMENT**

Indonesia has realized that the exploitation on marine and coastal environments if it is not well managed with respect to marine environmental degradation, will result in a big problem. Regarding to these, Indonesia has been seriously focusing its policies, strategies and action on marine environmental management in a context of sustainable development by establishing some Government Legislation’s cited in the "National Strategies for Sustainable Development" (Agenda 21 Indonesia) and "Indonesia’s Marine Environment”. They are stressing and considering the point on marine environment including the impact of all activities within the areas.

In “Agenda 21”, Indonesia is offering some action programs to improve the quality of living environment for sustainable development in future of 21st century. (Sustainability has been defined based on determining: 1) the use rates of renewable resources which do not exceed regeneration rates; 2) the use rates of nonrenewable resources which do not exceed rates of development of renewable substitutes; and 3) the rates of pollution emission which do not exceed assimilative capacities of the environment. The current concept of sustainability further combines
three key elements, economic, social and environment (Anonymous 1996b)).

The recent regulations regarding pollution are, for example, Government Regulation (GR) No. 19, 1994, management of dangerous and toxic wastes; GR No. 51, 1993, revision of Environmental Impact Analysis (AMDAL); and Ministerial Decree Population and Environment No. 103, Quality Standard of Liquid Wastes (waste discharges from coastal developments). The point to be made is that in spite of increasing threat to the environment, Indonesia has been active in developing policy tools that reflect the government commitment to sustainable development.

CONCLUSION

Incompatibilities and conflicts have arisen because the development of coastal zones has proceeded haphazardly with little consideration or regard for their impact on the biological or physical environment. Undoubtedly, many incompatibilities arise from inadequate planning or from lack of environmental safeguard. However, when biological phenomena are involved in complex associations and interacting environments like the coastal zones, a large number of unalterable, uncertain or even unknown factors, such as oceanographic conditions, biological cycles or water chemistry, prevent thorough planning.

One principal incompatibility category that can arise in the use of coastal zone resources is a competition for coastal space itself and, as a result of the closely proximate location of the activities, environmental degradation by one activity adversely affecting the other. In addition, conflicts also frequently arise in coastal zone management owing to poorly defined intra-governmental responsibilities. Responsibilities invariably overlap because most government departments and agencies are organized on a functional basis and only few are horizontal linkages established among them.

Many factors can be sources of incompatibilities and conflicts, and both are not inevitable. Nor is intervention always required for prevention. And, most polluting activities could theoretically be re-designed to alter or reduce their deleterious consequences for the use of other resources.

There is no doubt that Indonesia will continue to expand its economic development by exploiting marine and coastal environments. Absolutely, designing and planning the environment should carry out an integrate management in order to manage the sustainable development and to avoid the incompatibilities among users.

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