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OVERVIEW OF IMPACT OF SEWAGE ON THE MARINE ENVIRONMENT OF EAST ASIA: SOCIAL AND ECONOMIC OPPORTUNITIES

UNEP

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PREFACE

The Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-based Activities was adopted by 109 governments on 3 November 1995 in Washington, USA. These 109 governments also designated the United Nations Environment Programme (UNEP) as Secretariat of the GPA, with the task of promoting and facilitating its implementation at the national, regional and global level.

The GPA aims at preventing the degradation of the marine environment from land-based activities by facilitating the realisation of the duty of States to preserve and protect the marine environment. It is designed to assist States to take actions individually or jointly within their respective policies, priorities and resources, which lead to the prevention, reduction and control and/or elimination of the degradation of the marine environment, as well as to its recovery from the impacts of land-based activities. Achievement of the GPA will contribute to maintaining and, where appropriate, restoring the productive capacity and biodiversity of the marine environment, ensuring the protection of human health, as well as promoting the conservation and sustainable use of aquatic living resources.

In the Washington Declaration, governments expressed their commitment to protect and preserve the marine environment from the impacts of land-based activities by, among others, "cooperating on a regional basis to coordinate efforts for maximum efficiency and to facilitate action at the national level, including, where necessary, becoming parties to and strengthening regional cooperative arrangements and creating new arrangements when necessary".

To facilitate implementation of the GPA, UNEP, as Secretariat, organised in cooperation with relevant regional organisations, a series of regional technical workshops as a means of strengthening national capabilities for protection of the aquatic environment from land-based activities, and to promote regional and sub-regional cooperation. It was at these workshops that participating experts from the countries of the Region identified wastewater as a major source of marine and coastal pollution.

This report comprises a consultant's report on the socio-economic effects and opportunities of sewage and its effects on the marine environment. Existing relevant data, published material, reports, books and interviews with regional, national and local authorities were used to prepare this report.

The report is only as good as the data and information available for it, and it was soon identified that the social effects of not treating or disposing sewage adequately were not well documented. The economic costs of major treatment plants may be prohibitively high in some countries and alternatives are discussed in this report. The report will be used to assist endorsement by member countries for the "Recommendations for Decision Making on Municipal Wastewater" at the forthcoming GPA Intergovernmental Review meeting.

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OVERVIEW OF IMPACT OF SEWAGE ON THE MARINE ENVIRONMENT OF EAST ASIA: SOCIAL AND ECONOMIC OPPORTUNITIES

EXECUTIVE SUMMARY

1) This report provides an overview of economic and social development in the East Asian Seas affecting the coastal, marine and associated freshwater environment. Particular attention is given to the problem of sewage and especially urban domestic sewage from large urban centres.

2) This study covers ten East Asian countries/regions, seven in the Southeast Asian sub-region (Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam), China and South Korea (henceforth referred to as Korea) in East Asia proper and tropical Australia.

3) Sixty percent of the nearly 1.8 billion people inhabiting the East Asian Seas region are concentrated in coastal areas. In the past several decades, the region experienced high economic growth and rapidly increasing urbanisation. Problems of sanitation are most acute in urban areas and especially large cities. The rate of urbanisation varies from a high of 80 per cent for Australia to a low of 12 per cent in Cambodia. Singapore is entirely urbanised. Many of the 44 cities with populations over one million are located on the coast or near mouths of large rivers. Some megacities such as Jakarta and Manila are experiencing rates of urbanisation of around 4 per cent per annum.

4) East Asian countries surveyed experienced high rates of economic growth although large variations of per capita income continue to exist. All countries in the region suffered to varying degrees from the financial crisis that began in mid 1997. This has affected the ability of many countries to deal with the need to provide for proper sanitation for their cities.

5) Available data show that the region`s population has good to moderately good access to safe water and sanitation and the conditions over the last two decades have improved. However, there are indications that the real situation, in for example Malaysia, is far less than satisfactory.

6) In 1995, international tourist expenditures came to $52.4 billion in the East Asian region under review (not including Cambodia and Viet Nam) and the industry generates substantial employment. The total number of tourist arrivals in the three Northeast Asian countries and Australia doubled over the period, 1990-1999, while it increased by 40 per cent in the Southeast Asian countries included in the review. Many hotels and holiday resorts are located along the coast and on the shores of water bodies. Proper sanitation facilities are essential as tourists are sensitive to and will flee from polluted and degraded coasts and related water bodies. Within the region, many coastal resort areas do not have proper sewerage and sewage treatment facilities although some have installed centralised sewerage systems and wastewater treatment plants.

7) The review then gives an account of the nature of sewage and notes that it poses a serious threat in semi-enclosed bays, estuaries and shallow water environments that experience little flushing action. Where the water from freshwater bodies, including rivers, is used for human consumption, it is imperative that proper sanitation is undertaken to avoid people from being infected by waterborne diseases. Attention is also drawn to the problem of sewage contamination as a result of natural disasters.

8) The review also gives an account of the effects on humans of pathogens contained in sewage. Details of the bacteriological aspects of wastewater and night soil and a discussion on the methods employed in the treatment of sewage and sludge are given.

9) As the review is concerned with the impact of sewage pollution on the marine environment, a brief account of the value of marine and coastal resources is provided. The region's waters contain one-fourth of the world's most productive mangrove forests and nearly one-third of the world's coral reefs. Around 30 per cent of the world's coral reefs, one-third of the world's mangroves, as well as many other important critical habitats are found in the region. An estimated value of the coral reefs in Southeast Asia amounts to $112.5 billion annually. The region comprises the world's richest marine biodiversity and produces about 41 per cent of the total fish catch in the world. Not surprisingly, the coastal communities derive most of their protein requirements from fish and depend on marine resources either directly or indirectly for employment and a source of income. This includes burgeoning marine tourism that needs clean water and beaches, a rich marine life and attractive seascapes. Within the Straits of Malacca the net revenue from fisheries and aquaculture was valued at $ 681.7 million in 1995.

10) Pollution by sewage from domestic, industrial and commercial sources is of more concern than that from agricultural sources. A list of rivers with pollution problems is given. Many of the uses of river water require water of a high standard; pollution by sewage would therefore result in the need to find alternative sources.

11) Damage done by untreated sewage depends on the value of the resources damaged and the extent of the damage. Its effects may be contamination of fisheries and aquaculture, the formation of red tides that kill fish and enhancement epiphytes and phytoplankton blooms, which smother underwater plants. The presence of untreated sewage and its impact on coastal and marine resources varies greatly and is complicated by numerous other factors.

12) Water-borne diseases also result from sewage contamination of surface water and food in many cities they have become endemic. Infection by viruses, bacteria, protozoa and parasitic worms (helminths) in excreta is discussed. This is followed by a discussion on the fate of pathogens in sewage treatment and the effects on sewage pollution on the coastal ecosystem. In some cities, the discharge of untreated sewage into water courses and seepages have seriously contaminated groundwater, which is drawn for domestic use.

13) The incidence, size and duration of red tides or harmful algal bloom (HAB) outbreaks have increased since several decades ago. Severe red tide episodes have been reported in China. However, reports show strong positive action by the Chinese government to deal with the problem of water pollution including building sewage treatment plants in many large cities at considerable cost. Likewise, many severe outbreaks of red tides in the Philippines and Malaysia have been reported.

14) Within Asia, some 90 per cent of sewage is untreated and is discharged directly into freshwater bodies and the sea. There are many problems encountered in the

implementation of sewage management including inadequate waste management legislation and regulations, ineffective enforcement of regulations, insufficient or inadequate waste management facilities and services, and lack of skilled human resources and equipment in the public and private sectors.

15) The fundamental requirements of an effective sewage management programme are a comprehensive set of legislation and well-endowed environmental institutions empowered by law. In general, there is no separate legal provision for dealing with sewage in all of the countries reviewed. The control of sewage pollution is covered under the overall environmental law or legislation governing water pollution.

16) The 1972 Stockholm Conference on the Human Environment and the UN Conference on Environment and Development (UNCED) in 1992 had a signal effect on the countries in the region under review.

17) Most countries reviewed have expressed concern with the problem of sewage because of the impact on human health and quality of life more than as a concern for environmental degradation and resource damage. Application of the "polluter-pays" principle and the adoption of environmental impact assessments are directed at business enterprises.

18) A review of the use of Environmental Impact Assessment (EIA) requirement as a means to address the control of sewage pollution in the countries surveyed is given. EIAs are mandated in seven of the countries reviewed in this report. In the cases of Cambodia and Singapore, EIAs are required on an *ad hoc* basis. Details of the application of EIAs in Malaysia where they have become an accepted practice are presented notwithstanding shortcomings and difficulties.

19) Most cities in the East Asian region have master land-use plans for residential, commercial and industrial and other uses. With few exceptions, there is a general lack of physical planning and adequate financial and technical resources to implement modern large-scale sewerage and wastewater treatment plants.

20) The provision of sewerage systems and sewage treatment plants in the region is reviewed. Most large and small cities in the region are without modern sanitation and the cost of providing such systems are beyond the reach of city administrations in the foreseeable future.

21) An account of the sewerage systems and sewage treatment facilities in Metro Manila, Philippines followed by those in Bangkok, Thailand, are presented. These two cases illustrates a fairly general situation in most large cities in the East Asian region and provide lessons on pitfalls that should be avoided.

22) The considerations and criteria for the selection of appropriate sewerage systems are dealt with and details on the different types of sewage treatment plants and onsite systems given.

23) Several countries in the region have chosen to pass on the provision of sanitation services to private operators. From the experience of Malaysia, it should be noted that while there are cogent arguments for adopting this approach, there are many practical difficulties in the implementation of privatisation.

24) Sewage (and animal wastes) may be regarded as a resource that can be converted into biogas, fertiliser, fill material and are used in a variety of other ways. Wastewater can be used for industrial use, as in Singapore, irrigation purposes and recharging groundwater.

25) Adequate financing for the construction of sanitation facilities and operation and management of the systems are essential.

26) The report discusses opportunities arising from the provision of proper sanitation in the prevention and minimisation of health hazards that constitute very high costs to the economy and confers many benefits to the country concerned. Options for adopting medium and small-scale sanitation systems should be considered while privatisation should be adopted only after careful study and that the conditions for its implementation are assured. The construction of Bangkok`s Samut Prakan wastewater treatment system gives useful experience on potential political and social implications.

27) Political will, possibly due to greater social awareness and enhanced environmental education in Malaysia, Thailand and China, has led them to invest in expensive and much need sewerage facilities and sewage treatment plants.

28) The region is a long way from the European Union`s programme of setting common standards for sanitation and empowerment for monitoring and enforcing regulations. There remains many opportunities for regional co-operation among East Asian countries.

OVERVIEW OF IMPACT OF SEWAGE ON THE MARINE ENVIRONMENT OF EAST ASIA: SOCIAL AND ECONOMIC OPPORTUNITIES

1. BACKGROUND

The impact of sewage on the marine environment is recognised and widely regarded as a serious threat to human health, economic activities, and recreational and tourism opportunities in many parts of the world. This situation certainly applies to large urban centres in the East Asian region where there is a serious inadequacy of sanitation with resulting pollution from the discharge of untreated sewage into the groundwater, water courses and coastal waters. Within the urban environment, there is a wide range of activities that come under the categories of domestic, industrial, and commercial sources of wastewater. Most domestic wastewater is generated in small quantities from numerous point sources. When these sources are widely dispersed, natural processes are able to break down this waste; however, the heavy concentration of people in urban centres results in the generation of waste in quantities far above the absorptive capacity of the aquatic environment. Unless legislation or social norms prescribe limits to the uncontrolled disposal of sewage, it is then discharged into the nearest available watercourse or coastal waters. As a result, the problem becomes a particularly difficult one to deal with because of the wide area covered, high frequency and regularity of production and, in urbanised areas, large volumes involved. Attention is focused in this report on the marine, or more appropriately coastal, environment and associated water bodies. This includes rivers, estuaries, lakes and lagoons around which the wastewater is discharged and accumulated before it is eventually discharged into the sea through river mouths and deltas.

The concern is directed at the impact of untreated sewage on human health and activities covering both social and economic aspects. However, the report is constrained by the little information available in the national reports of seven countries covered under the Transboundary Diagnostic Analysis (TDA) of the South China Sea Project (henceforth referred to as the TDA) overview report by Talaue-McManus (2000) and the Overview of Land-based Sources of Pollution prepared under the global Plan of Action (GPA) (Chia and Kirkman, 2000). Efforts, however, are made to gather additional information from reports and published literature to strengthen this report.

1.1 Aims of the Study

This report is intended to provide an overview of potential economic and social development in the region of the East Asian Seas, affecting the coastal, marine and associated freshwater environment and the status of these developments. Particular attention is given to the problem of sewage and especially urban domestic sewage.

The overview draws information from earlier studies, in particular, seven national reports and the overview report for the project on transboundary diagnostic analysis for the South China Sea (Talaue-McManus, 2000). Separate national reports (case studies) are produced for each of the ten countries/regions under review. The report provides an account of the type, quantity and point and non-point sources of sewage, especially from urban centres affecting the coastal, marine and associated freshwater environment. A general description of the demographic, economic status of the study area is provided in the report. An analysis of the sewage sources contributing to the degradation of the marine and coastal environment is also included. Where data permits, estimates of the environmental impacts on the marine environment of these sources are given. The study seeks to identify various measures adopted to manage sewage including legislation, particularly environmental impact assessment (EIA) requirements and privatization of the provision, operation and maintenance of sanitation facilities and services.

The terms of reference requires "an analysis of the actual and potential social and economic costs of pollution by sewage expressed in monetary terms; indirect impacts due to loss or depreciation of natural resources, or due to effects in human health. An analysis of the costs and benefits from measures that have been introduced to control pollution by sewage in coastal areas. An analysis of costs and benefits of additional measures (legal, administrative, economic, fiscal, technological, institutional), which would have to be introduced in order to protect marine and coastal areas and to ensure their sustainable development and use. An evaluation of costs and benefits in non-monetary terms related to sustainable development and the quality of life of populations, including those largely outside the monetary economy." The absence of information and the brevity of the study period prevented this effort. However, wherever data permitted, a qualitative assessment of the economic benefit of these uses and the benefits of appropriate measures is attempted. Special effort is made to bring together information on existing organisational framework and legal measures adopted in each of the countries. Albeit, the study reveals important gaps in our understanding of the social and economic impacts and the cost and benefits of measures that have been made and can be made to deal with the problem of sewage pollution.

1.2 Scope of the Study

This study covers ten East Asian countries including seven in the Southeast Asian sub-region (Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam), China and South Korea (henceforth referred to as Korea), plus Tropical Australia (see overview on land-based pollution for the region in Chia and Kirkman, 2000) (Fig. 1). In the case of China, the focus will be on southern China, while only the tropical coastal area of northern Australia is considered. As the TDA overview and national reports of China, Indonesia, Malaysia, Philippines, and Thailand deal with only coastal provinces in the South China Sea (areas defined in Chia and Kirkman, 2000), more details from other parts of these countries will be included in the present study. Figure 2 shows the seven South China Sea countries and the shaded portions indicate the coastal and river basin areas covered in the TDA study.

While the study covers both the marine environment and associated water bodies in terms of the level of pollution arising from sewage, attention on the impact is focused primarily on marine resources and activities on the coast and in the sea. It is worth noting here that land-based pollution accounts for 70–80 per cent of the pollutants that enter into the marine environment. A companion set of reports together with an overview is devoted to a review of the broader problem of land-based pollution of the same ten East Asian countries (Chia and Kirkman, 2000). The present report is more narrowly focused on the problem of sewage primarily from urban settlements and especially on large urban centres. It is also not the intention of this report to reproduce in any detail the characteristics of neither the marine environment nor the marine resources that have been dealt with in the companion study. Here, the direct and indirect impacts of sewage from industrial, domestic, and commercial sources on the marine environment and its consequences on human health, marine life, and economic opportunities will be examined. In some places, the problem of solid waste is included especially for countries where its collection and disposal pose a problem. In these cases, the problem becomes very much one of sewage as solid waste enters the freshwater bodies and marine environment in a liquid form.

2. POPULATION GROWTH AND URBANISATION

The basic demographic parameters of countries covered in this review is given in Table 1. The East Asian Seas region is the most populous region in the world. It is home to almost 1.8 billion people, 60 per cent of whom are concentrated in coastal areas. In the past several decades, the region has been the center of considerable economic growth bringing about increased urbanization in the region. The Peoples' Republic of China, at 1.28 billion is the most populous country in the world while, Singapore, has a population of only 4.2 million. The largest country in Southeast Asia is Indonesia with a population size of 212 million. By the year 2025, it is estimated that China will have a population of just under 1.5 billion, Indonesia 272 million while two countries, the Philippines and Viet Nam, will have each a population exceeding 100 million while Thailand would have grown to 73 million and Korea 53 million. While most countries have fairly modest population growth rates, several are experiencing annual growth rates exceeding 2 per cent per annum with Cambodia at 2.4 per cent per annum. The city-state of Singapore has the highest growth rate of 3.5 %/annum due mainly to immigration.

Table 1 Demographic Parameters for Selected East Asian Countries

	Population (millions) 1997	Average annual population growth rate (%) 1990–1997	Land area ('000 km^2) 1997	Population density (persons per km^2) 1997	Gross GNP (bil. US$) 1997	GNP per capita (US$) 1997	Life expectancy at birth (years) 1996		Adult illiteracy rate (% of people 15 and above) 1995	
							male	female	male	female
Australia	19	1.2	7,682	2	380.0	20,540	75	81	-	-
Cambodia	11	2.7	177	57	3.2	300	52	55	*20*	*47*
China	1,227	1.1	9,326	129	1,055.4	860	68	71	10	27
Hong Kong, China	7	1.9	1	6,218	164.4	25,280	76	81	4	12
Indonesia	200	1.7	1,812	107	221.9	1,110	63	67	10	22
Korea, Republic	46	1.0	99	456	485.2	10,550	69	76	1	3
Malaysia	21	2.3	329	61	98.2	4,680	70	74	11	22
Philippines	73	2.3	298	236	89.3	1,220	64	68	5	6
Singapore	3	1.9	1	4,896	101.8	32,940	74	79	4	14
Thailand	61	1.2	511	116	169.6	2,800	67	72	4	8
Viet Nam	77	2.1	325	227	24.5	320	66	70	4	9

Note: Figures in italics are for years other than those specified.
Source: World Bank (1999), World Development Report 1998/99, Oxford: New York.

Of particular interest in the demographics is the infant mortality rate that varies from a low of around 5-6 per 1000 population for Singapore and Australia to as high as 79 for Cambodia and moderately rates of 44 per 1000 in the case of Indonesia, 30 for China and 35 for Viet Nam. Equally of interest is the life expectancy at birth with several countries/ territories in excess of 80 years (Hong Kong, Macao, Singapore and Australia while others have estimated life expectancies as low as 61 years (Cambodia), 68 years (Indonesia) and 71-73 years (China, Philippines, Viet Nam). The level of economic development and therefore health and sanitation conditions are more than likely to be major factors in determining both of these parameters.

Figure 1 East Asian Sub-region and Southern China Covered in the Study.

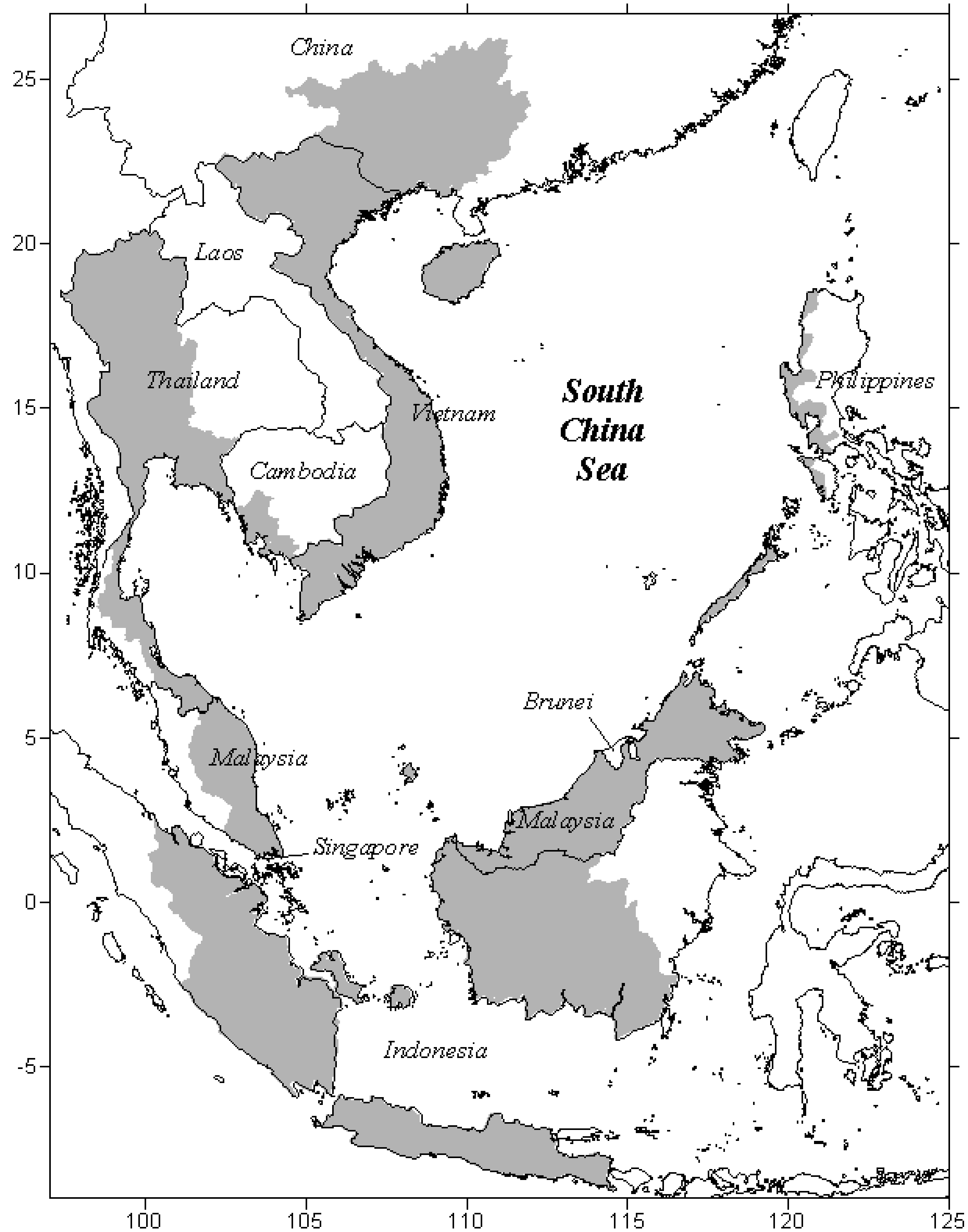

Figure 2 Countries in the Southeast Asian Sub-region and Southern China Showing Catchment Areas into the South China Sea.

Problems of sanitation are most acute in urban areas and especially large cities. Hence, attention should be paid toward the percentage of urban population in the countries under review. Estimates for the year 2000 show 100 per cent urbanised countries/territories for Singapore, Hong Kong and Macau. Korea and Australia have over 80 per cent of their population living in urban areas. China as a whole and countries in Southeast Asia, except for Singapore, have moderate levels of urbanisation, the highest being the Philippines (59 %) and Malaysia (57 %). The least urbanised countries are Cambodia (16 %), Viet Nam (24 %), Thailand (31 %) and China (32 %) (Table 1).

On the whole, Southeast Asian countries are experiencing a higher rate of urbanisation (3.5 %) than Northeast Asian states (2.0 %). Cambodia the least urbanised country has the highest rate of growth (4.4 %) of urban population. This is followed by Indonesia (3.9 %), and Viet Nam (3.5 %). Urbanisation trends determine the size of the task for governments and municipal authorities to provide adequate sewerage services and sewage treatment facilities. A current low rate of urbanisation can be seen as an advantage and an opportunity in that the absolute costs of providing these facilities and services are still relatively low. Also, if urban planning is undertaken effectively, this can be translated into lower costs of providing sanitation for the expected increase in urban population.

For countries covered in the present review, Table 2 lists 44 cities with populations over one million. Among the top ten cities, China alone accounts for six (Shanghai, Beijing, Tianjin, Sheyang, Guangzhou and Wuhan), while Seoul in Korea is the largest of all cities listed. There are two among the top ten cities in Southeast Asia (Jakarta and Bangkok). Many of these megacities are located along the coast (shown in bold letters in the table) and near the mouths of large rivers including Seoul, Shanghai, Guangzhou, Hong Kong, Ho Chi Minh, Bangkok, Jakarta, Surabaya, Manila and Cebu. Some very large cities, although well inland from the sea, are located along rivers. Many countries possess narrow coastal lowlands where population is densely settled. As a consequence, there are numerous medium-sized and small cities and innumerable coastal villages that depend heavily on coastal and marine resources for economic gain and a source of food.

The value of marine-dependent economic activities has only begun to be assessed but has gained considerable attention on the part of the respective governments. The threat of ship-source pollution, particularly from oil spills, has received much greater attention and publicity than land-based sources of marine pollution. The impact of untreated sewage in coastal and the marine environment is focussed primarily on human health, through direct contact contagion from the associated pathogens but also indirectly through ingesting fish and other products contaminated by it. Attention has also been drawn on the impact of sewage on coastal tourism and recreation, which have become increasingly important as contributors of employment and revenue for countries in the region.

Table 2 Cities with Over One Million Population, East Asian Countries Covered in this Study

Rank	City	Population (mil.)	Country
1	**SEOUL**	10.02	Korea
2	**Jakarta**	9.98	Indonesia
3	Shanghai	8.90	China
4	Beijing	6.58	China
5	Tianjin	6.37	China
6	Bangkok	5.95	Thailand
7	Shenyang	4.66	China
8	Guangzhou	4.01	China
9	Wuhan	3.82	China
10	**Pusan**	3.81	Korea
11	Harbin	3.60	China
12	**Singapore**	3.55	Singapore
13	Chengdu	3.48	China
14	Ho Chi Minh	3.35	Vietnam
15	Chongqing	3.12	China
16	Jinan	2.89	China
17	**Surabaya**	2.87	Indonesia
18	**Inchon**	2.80	Korea
19	Taegu	2.63	Korea
20	Quezon City	2.30	Philippines
21	Medan	2.09	Indonesia
22	Zhengzhou	1.98	China
23	**Kowloon**	1.98	China
24	Taiyuan	1.90	China
25	**Manila**	1.76	Philippines
26	**Hong Kong**	1.62	China
27	Palembang	1.53	Indonesia
28	Hanoi	1.50	Vietnam
29	Fushun	1.50	China
30	**Taejon (Tae Chon)**	1.47	Korea
31	**Semarang**	1.45	Indonesia
32	Kuala Lumpur	1.43	Malaysia
33	Lanzhou	1.42	China
34	Baotou	1.39	China
35	Kwangju	1.39	Korea
36	**Fuzhou**	1.35	China
37	**Caloocan**	1.26	Philippines
38	Shijiazhuang	1.23	China
39	**Ujung Pandang**	1.20	Indonesia
40	Nanning	1.17	China
41	**Davao**	1.14	Philippines
42	Guiyang	1.13	China
43	Phnom Pénh	1.08	Cambodia
44	Syngnam	1.04	Korea

Note: Coastal cities are shown in bold letters.
Figures are for latest available years.
Sources. Global Population Project; One World–Nations Online. http://www.nationsonline.org/oneworld.

In China alone, the number of cities has grown from 324 to 467, an increase of 143 cities in the five-year interval from 1985 to 1990 while in the same period the number of statutory towns grew from by 4,573 to a total of 12,084 (UNCHS, http://www.unchs.org/unchs/english/urbanpl/asian/Box%20D). Many cities in Asia are growing very fast as indicated in Table 3. In general, the more advanced countries do not experience high urban growth, in part because they are already highly urbanised and there is little or no rural poverty as in the case of Korea. China's cities are not growing as fast as Manila or Jakarta due to the country's policy to restrict population movement from rural areas to the city. In the case of China, its system of restricting people to the country side began to unravel from the early 1980s with the opening up of coastal cities and the country to foreign investments. The government is currently considering removing restrictions to allow more rural people to move to urban areas. This is intended to provide a continuing pool of cheap labour to meet the high rate of industrial growth centered in cities. China has also opened up and promoted inland cities for foreign investments. This will inevitably raise the growth rate of urban populations in all Chinese cities and put immense pressure on the urban environment and the associated waterbodies.

Table 3 Growth Rates of Selected Cities in East Asian Countries

City, Country	Population (million)	Av. Annual growth rate 1990-1995 (%)
Shanghai, China	15.1	2.29
Beijing, China	12.4	2.57
Seoul, Korea	11.6	1.95
Jakarta, Indonesia	11.5	4.35
Tianjin, China	10.7	2.88
Metro Manila, Philippines	9.9	3.80

Source. United Nations, Population Division, World Urbanization Prospect, 1994.Revision.

In the case of less developed countries (LDCs) such as the Philippines and Indonesia, the capital cities are a gigantic magnet that attracts rural migrants from near and far. As a result squatter colonies, many along river banks, are spawned and most of them find employment as itinerant informal sector traders, artisans, and operate food stalls. There is a barest minimum of sanitation facilities or services and human waste and garbage are discharged directly into the streams and canals. In some areas, floods occur frequently and the incidents of waterborne diseases arising from contamination of surface water becomes a serious problem. Some of these squatter colonies develop around municipal rubbish dumps such as the one in Payatas and earlier in what is known as 'smokey mountain' in Manila. The incidence of the collapse of the several-stories high garbage killing 137 people (Trididad and Balana, 2000) called attention to the problem. Clearly, the problem becomes not merely one of sewage management but the entire question of urban governance. In order to emphasize the problem, one study predicted that 60 per cent of the urban population of Asia would be living in slums and squatter settlements by the year 2000 unless drastic reforms were undertaken (ESCAP, 1994). The challenge of municipal and central governments in the region is indeed a daunting one.

3. ECONOMIC AND SOCIAL DEVELOPMENT

Over the last three decade, East Asia experienced strong economic growth led first by Japan, then the Newly Industrialising Economies (NIEs) of Korea, Taiwan, Hong Kong and Singapore, and followed by the high performance economies of Southeast Asia, namely, Indonesia, Malaysia and Thailand. Since its policy of liberalisation in 1979, China opened up its coastal cities for foreign investments and easier economic exchanges with foreign countries, the country entered a long period of sustained high growth. Its development is fueled not just by foreign investments but also internally generated investments that have, as earlier mentioned, resulted in a fast rate of industrialisation and a massive influx of population, first into coastal cities and more recently cities elsewhere in the country. The less developed countries in Southeast Asia too, including Viet Nam and Cambodia, became members of the Association of South East Asian Nations (ASEAN) in 1996 and 1999, respectively. They too began to attract foreign investments and, Viet Nam in particular, developed strongly in the 1990s decade as shown in Table 4. With the exception of Cambodia, the other countries have sizeable gross national products (GNP) and gross domestic product (GDP) although per capita GNP still vary widely from a low of $260 (Cambodia), $370 (Viet Nam) through $580 (Indonesia) and $780 (China) to high levels of affluence of the city economies of Hong Kong ($23,520) and Singapore ($29,610) as well as Korea (US$8,490) and Australia ($20,090) (all 1999 figures)(World Bank, 2000). Many of the countries in the region under review have become industrial states with manufacturing accounting for between 25-35 per cent of GDP (in value added terms) in the 1990s decade. Hong Kong's manufacturing sector declined from 18 per cent to only 6 per cent as a result of the mass migration of manufacturing industries into nearby mainland China in search of lower costs of land and labour, mainly in the Guandong province (especially in Guangzhou city and the Pearl River Delta area) and nearby coastal cities.

Table 4 Economic Indicators for East Asian Countries

	Gross National Product (GNP)		GNP/cap	Gross Domestic Product $mil		Manufacturing as % of DGP	
	$ billions (1999)	Av ann. Growth rate 1989/99	$	1980	1999	1990	1999
Northeast Asia							
China	980.2	7.2	780	354.6	991.2	33	24
Hong Kong, China	161.7	2.9	23,520	74.8	158.6	18	6
Korea	397.9	11.0	8,490	252.6	406.9	29	32
Southeast Asia							
Cambodia	3.0	4.5	260	1.1	3.1	5	6
Indonesia	119.5	1.9	580	114.4	141.0	21	25
Malaysia	77.3	4.3	3,400	42.8	74.6	26	35
Philippines	78.0	3.6	1,020	44.3	75.4	25	21
Singapore	95.4	5.6	29,610	36.6	85.0	27	26
Thailand	121.0	4.9	1,960	85.4	123.9	27	32
Viet Nam	28.2	4.2	370	6.5	28.6	19	n.a.
Australia	380.8	3.8	20,050	297.2	389.7	15	n.a.

Source. World Bank (2000), Table 1, pp. 274-5; Table 12, pp. 296-7.

From the above review of economic conditions of the countries in the East Asian region and Australia, it is evident that, with some exception, the region as a whole has the capacity to do more to improve their sanitation conditions and environment generally.

3.1 Impact of the Financial Crisis

The Asian financial crisis that began in mid 1997 in Thailand and soon spread to most other countries in the region dealt a shattering blow to the development of their economies. The worst affected countries as shown by the fall of their GDPs in 1998 were Korea (-5.8 %), Hong Kong (-5.1 %), Indonesia (-13.7 %), Malaysia (-7.1 %), and Thailand (-8.0 %) (APEC, 1999, pp. 5-6). The crisis drastically reduced the financial capability of governments that curtailed many essential infrastructure projects including sewerage and waste treatment plants. In some cases, existing plants closed down for lack of funds and public cleansing services were stopped. There is little comfort to be gained from the closure of many factories – thereby reducing industrial pollution – and foreign investments in manufacturing plants fell to very low levels. Massive unemployment seriously affected the ability of many households to pay utility charges including sewerage and water services. Most of the countries adversely affected by the financial crisis have recovered and positive GDP growth is registered in all of these countries. However, the damage to the economies remain and there will be little funds available to undertake sanitation projects to meet the demands of existing and growing urban populations in some of the worst affected countries.

3.2 Access to Safe Water and Sanitation

Table 5 shows the level of access to safe water (improved water source) and sanitation in the East Asian countries under review. In general, access to safe water and sanitation for the region have improved between the early 1980s and the second part of 1990. For Northeast Asia, access to sanitation for all of China, is still only 21 per cent in 1998 while access for urban population is better at 58 per cent, but still highly inadequate. For Korea, the data needs further examination but show 83 per cent access to safe water but 100 per cent for sanitation and. In the case of Southeast Asia, Cambodia, representing the poorest among the countries in the region, does not have available information except for a mere 13 per cent of the population having access to safe water. Viet Nam shows better access to safe water and sanitation, but the levels are still unacceptably low. While Indonesia, a country that has experienced strong economic growth from the 1970s, shows significant improvement in access to both safe water and sanitation. It is also in need of upgrading basic health services in the country including urban areas where access to sanitation is still only at 73 per cent of the urban population. Among the other more developed Southeast Asian countries, Philippines is still lagging especially in terms of access to sanitation. There is some evidence that suggests that the figures for most countries are lower than indicated. The Malaysian National TDA study (Mohd Nizam and Tan, 1998) using information provided by the Department of Sewerage Services, Ministry of Science and Technology reports only 8.6 per cent of the urban population Kuala Terengganu (KT) in Terenggan state, 24.0 per cent in Kuantan, Pahang state, have access to sanitation facilities while none in Kota Bharu in the state of Kelantan has it (see Table 6.3 in the Malaysian country report on sewage). Details on the provision of sanitation facilities for Metro Manila (see Section 9.4.2) and several other cities in the Philippines also indicate that the level of access of proper sanitation is lower than the 77 per cent (1998 figures) given in the table below. The level of access given for China at 58 per cent for urban populations and 21 per cent for country as a whole is probably closer the truth.

Table 5 Access to Water and Sanitation for Urban Populations and Country as a Whole in Selected East Asia Countries

	Access to sanitation in urban areas (% urb pop with access, 1990-96*)	Access to improved water source (% of pop. with access)		Access to sanitation (% pop. with access)	
		1982-85	1990-96	1980	1998
Northeast Asia					
China	58	--	90	--	21
Hong Kong, China	--	==	--	--	--
Korea	100	83	83	100	100
Southeast Asia					
Cambodia	--	--	13	--	--
Indonesia	73	39	62	30	51
Malaysia	100	71	89	75	94
Philippines	88	65	83	57	77
Singapore	100	100	100	85	100
Thailand	98	66	89	47	96
Viet Nam	43	--	36	--	21
Australia	n.a.	99	99	99	86

Source. World Bank (2000), Table 2, pp. 277-8; Table 7, pp. 286-7.

Information on the provision of the collection, treatment and disposal of wastewater from domestic, industrial, commercial and other sources of the cities in the countries under review is sketchy.

3.3 Tourism Development

The tourist industry brings much financial benefit through its spending on hotels, shopping and other services. Table 6 shows the number of tourist arrivals in the countries of the region. Tourist earnings will depend on the average number of days they spend in the country. There is also substantial benefits from employment generation and indirectly many other spinoffs from the industry. Both domestic and foreign tourists are relevant to the present study because:

(1) Many hotels and holiday resorts are located along the coast and on the shores of water bodies. Unless there are adequate sanitation facilities to treat and dispose of wastewater, they will contribute substantially to marine pollution and increase the pollution loads of rivers and lakes, and

(2) Tourists are sensitive to and will flee from polluted and degraded coasts and related water bodies or when it becomes known that there is high pollution levels such as coliform counts, discoloured water and foul smells arising from sewage and other pollution sources. Thus, any reduction in tourists as a consequence of water pollution and the fear of contaminated food will result in lost revenue and employment opportunities as well as other downstream economic activities.

Wong (1995) identified major coastal and marine tourist areas in Southeast Asia including established ones Phuket, Pattaya, Hua Hin, Rayong and Ko Samui in Thailand, Penang, Langkawi, Kuantan and Pulau Tioman in Peninsular Malaysia and Kota Kinabalu in Sabah, Nias (off the west coast of Sumatra), Bali, Lombok, and a number of less developed areas in Indonesia; and Cebu and a dozen or so other areas in the Philippines. Singapore has developed Sentosa Island into a tourist and leisure facility catering to both tourists and local people for recreation. Viet Nam has a number of potentially highly attractive coastal and marine tourist areas such as Ha Long Bay, Cat Ba Island, and a number of coastal townships along the east coast. Also, near the coast, is a complex of ancient Khmer Buddhist religious sites of great cultural interest. The coastal town of Hoi An is designated a World Heritage site for its historic value. In China, the better known tourism areas are in Xiamen and the adjacent Gulang Island and Qingdao city in Shandung province. In tropical Australia, Darwin and Cairns and the Great barrier Reef islands are already well known tourist destinations. There is considerable potential for many more coastal and marine tourism development in all of the countries under review. Also, ecotourism is providing a new attraction for tourists giving the region still further opportunities for developing its marine and coastal tourism.

Table 6 International Tourist Arrivals in Selected East Asian Countries, 1990, 1998, and 1999

(in thousands)

Country	1990	1998	1999	1999/1990
Northeast Asia	17,605	35,344	35,658	2.03
China	2,218	12,602	4,098	1.85
Hong Kong, China	5,032	7,083	7,210	1.43
Korea	3,559	5,890	5,623	1.58
Southeast Asia	14,473	20,414	n.d.	1.41*
Cambodia	n.d.	166	190	--
Indonesia	2,105	4,045	n.d.	1.92*
Malaysia	1,667	2,456	2,822	1.69
Philippines	1,306	2,413	2,534	1.94
Singapore	4,937	5,162	5,788	1.17
Thailand	4,326	5,934	7,000	1.62
Viet Nam	85	86	n.d.	1.01*
Australia	2,215	4,157	4,459	2.01

*Note. * indicates ratio for 1998/1990.*
Source. World Tourism Organisation (2000), pp. 20 and 25

Table 6 shows that the region is experiencing very high rates of growth of the tourism industry (WTO, 2000). Over the period 1990-1999, the numbers of international tourists travelling to Northeast Asia has doubled, while it increased by 40per cent in Southeast Asia from 1990-1998. There is every possibility that this fast rate of growth will be maintained for the foreseeable future. The data on China appears to be inaccurate, but a five-fold increase over the same period is credible. A UNESCO report says that China will attract 137 mil. visitors by the year 2020 from the 63.5 mil. overseas visitors, in 1999, travelling to the country.[1] The report also warns of immense pressure on water and marine resources and a potential devastating impact on the environment and the local population which will increasingly be deprived of access to clean water and other resources (Groth, 2000). The

[1] Note the much lower numbers given in Table 6 above. The discrepancy is, in part, due to not counting the very large number of people travelling between Hong Kong and mainland China.

same report mentions that there will be 100 million Chinese who will make international trips by the year 2020. In addition, the data here do not show domestic tourists, but growing affluence of the countries in the region will translate into enormous flows of domestic tourists within the respective countries with similar effects on the environment and resources.

Many of the coastal and marine tourist areas do not have adequate sewerage and sewage treatment facilities. In the case of Phuket, the most developed Patong Beach suffers from inadequate freshwater supply and wastewater is not treated adequately (Bunapong and Ausavajitanond 1991 quoted in Wong 1995). In Batu Feringgi, Penang, Malaysia, hotels were built along the beach and each operated a septic tank that discharges without treatment into the sea. The Malaysian authorities eventually built a 10.3 million Ringgit centralised sewage treatment plant at the northern end of the resort area.

While some coastal tourist areas such as Sanur and Nusa Dua in Bali were properly designed and had comprehensive integrated development plans, others suffer from unplanned development. Nusa Dua, reputed to be the first integrated resort is provided with proper water supply, and a centralised sewerage and sewage treatment plant. The well-known resort, Pattaya, suffered initially from uncontrolled tourist development and eventually the number of visitors declined. An existing 8,000 tonnes/day treatment plant was the first to be built for a beach resort in Thailand. It's capacity was expanded to 22,500 tonnes/day to service Central Pattaya, while North Pattaya was to be provided with a centralised wastewater treatment plant of 50,000 tonne/day capacity and a new 20,000 tonne/day plant would be built for South Pattaya (Wong, 1995). In the case of Boracay Island, north of Iloilo in the Philippines, the highly successful resort attracted some 70,000 tourists. The area suffered from water shortages and contamination of water sources from sewage and garbage. The majority of resort facilities had no septic tanks and sewage flows directly into the sea (Smith, 1992 quoted in Wong 1995).

Table 7 shows the tourist expenditures for countries in the East Asian region under review for 1995. The total expenditure by tourists for the region as a whole, without Cambodia and Viet Nam (no data) came to $52.4 billion. Assuming a multiplier effect of 2, the benefits in terms of direct and indirect revenue generated by tourists would be of the order of $100 billion for 1995 rising as the number of tourist arrivals increases over time.

Table 7 Tourist Expenditures in Selected East Asian Countries, 1995 and 1996

Country	1995
Northeast Asia	
China	8,733,000
Hong Kong, China	9,351,235
Korea	5,586,536
Southeast Asia	
Cambodia	n.a.
Indonesia	6,228,340
Malaysia	3,626,450
Philippines	2,453,960
Singapore	3,860,100
Thailand**	7,400,000
Viet Nam	n.a.
Australia*	5,117,000

*Notes. * Year ended September 30, 1996 ** Estimated.*
Source. PATA (1997), PATA Annual Statistical Report 1996, Pacific Asia Travel Association.

Tourists are sensitive to environmental factors in making decisions on their destination. Reports of poor sanitation and accounts of incidents of illnesses and deaths resulting from pollution including that from sewage contamination are considerations that are likely to influence the promotion, or otherwise, of group tourism in major source countries such as Japan. There is, at present, no valid basis for estimating the loss of revenue to the curtailed visits of tourists. The converse is increased number of tourists due to reports of clean environmental conditions for tourists. Assuming that the effect is a ten per cent decline in tourist arrivals, this would translate to a corresponding decline in revenue earned from the tourist industry. In this case, the sum would be of the order of $10 billion – a substantial sum to lose as a result of poor sanitation.

4. THE NATURE OF SEWAGE

This section is intended to provide an understanding of the nature of sewage beginning with an attempt to define the various terms used, before giving an account of the characteristics of sewage, its constituent components and the treatment of sewage or, more generally, wastewater. This will be followed by an examination of the problem of sewage and the status of sewage pollution of the marine environment and related water bodies in the countries under review. It should be noted here that our concern is with the impact on the marine environment and associated freshwater bodies. However, there is no clearly defined partition of sewage on land and in freshwater bodies and in the coastal environment. In this study, no attempt is made to differentiate between sewage found in these environments. In any case, the effects on humans are likely to be indirect through contamination of food through contact with water that has been exposed to sewage.

The underwater profile of most of the coast of Korea and China is steeply inclined, The bottom topography of the coastal waters around the South China Sea are very different. Some 70 per cent of these waters are less than 600 m deep. This is in part due to the heavy discharge of sediments from large rivers into the South China Sea. The large and small embayments in particular, such as the Tonkin Gulf, the Gulf of Thailand, Jakarta and Manila bays, all receive heavy sediment loads from rivers that discharge into them. In all of these cases, the large urban centres along these rivers have badly contaminated the waters within the deltas and shallow bays. There is, however, a lack of clear evidence on the damage of the marine ecosystems by sewage and more is known about the destruction of mangroves, coral reefs and seagrass beds from direct human activities. Sedimentation and coastal reclamation are most frequently cited as reasons for the damage of these marine resources.

The problem of sewage is serious in semi-enclosed bays, estuaries and shallow water environments (both marine and freshwater bodies) such as lagoons and lakes that experience little flushing action. There are many such water bodies that may be natural or man-made in all of the countries under consideration. Where the water from freshwater bodies, including rivers, is used for human consumption, it is imperative that proper sanitation is undertaken to avoid people from being infected by waterborne diseases such as typhoid and cholera.

The lack of facilities to receive and deliver sewage and sewage treatment plants in most countries is responsible for health hazards resulting from water-borne diseases arising from contaminated surface water. This report draws attention to the problem of sewage contamination as a result of floods from severe storms including typhoons, excessive rainfall and tsunamis generated by earthquakes, that are common in many parts of Indonesia and the Philippines. Typhoons frequent the coast of northern Australia, the south coast of Java, Philippines, Viet Nam, southern China, and occasionally, as far north as Korea.

4.1 Definition of Sewage

There is a number of terms, including ‘sewage’, used in the discussion that need to be clarified initially. Sewage, with or without the presence of industrial waste, is probably the commonest and most widespread contaminant of inshore and nearshore waters (Preston and Chester, 1996: 35–36). A dictionary definition of sewage is ‘the mixture of waste from the human body and used water that is carried away from homes by sewers’ (*Longman Dictionary of Contemporary English*). In effect, this definition suggests that:

(a) Sewage is a fluid.
(b) It is carried away in a sewer, defined as ‘a pipe or passage under the ground that carries away waste material and used water from houses and factories.’

In accepting these definitions we should nevertheless note that other liquid waste discharges that do not flow through sewers might be identical in composition to sewage as defined above. This is especially true in many Asian cities where sewerage systems are largely absent. In the present review, attention is focussed on domestic sewage or household sewage although it is not possible to separate wastewater generated by industrial and commercial establishments. Thus, for the purpose of this study, “sewage” refers to several components that have very different characteristics. These are:

(a) domestic waste (both grey and black water);
(b) industrial wastewater; and
(c) storm-water.

(a) and (b) may be thought of as the ‘spent water’ (or ‘wastewater’) supply of the community and is approximately equal in volume to the amount of water abstracted for industrial and domestic use. In this region, most of this waste does not flow into sewers (which are non-existent) but is discharged directly into the nearest available watercourse. (c) is equivalent to urban run-off and in many cases flows directly into rivers or the sea. Where there is an absence of a sewerage system, much of the untreated sewage is mixed with surface water. It is here that flooded areas are especially susceptible to sewage contamination. Even with centralised sewerage systems, heavy floods can cause back flows within the system and cause sewage to be mixed with flood water. In cities with a separate drainage from the sewerage system, storm-water is collected and discharged, with little or no treatment, into rivers or the sea.[2] Where sewers are present, the infiltration of groundwater into the system can also contribute significantly to the volume of sewage generated, especially when these are poorly maintained. Although a properly laid sewer is watertight when constructed, ground movement and ageing may allow water to enter the sewer if it is below the water table (Lester, 1996: 93). On the other hand, seepage of sewage into the surrounding soil can lead to contamination of groundwater.

In places where there is no sewerage system, the term ‘night soil’ is used to refer to human faecal waste. Like sewage, it is a potent pollutant, but can be put to beneficial use, e.g. as fertilisers, if it is properly treated and the material carefully handled. Use of untreated wastewater and night soil can and does lead to diseases but it is an accepted traditional practise in many rural farming communities.

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[2] In Singapore a significant volume of this storm-water is channeled into retention ponds and used to augment domestic water supplies.

One other term used in this report is 'sanitation' and it is defined as "the measures, methods and activities that prevent the transmission of diseases and ensure public health". Sanitation refers to the provision and ongoing operation and maintenance of a safe and easily accessible means of disposing of human excreta, garbage and wastewater, and providing an effective barrier against excreta-related diseases (Del Porto, 2000). The author gives a number of historic examples of epidemic-scale outbreaks of cholera, typhoid fever, gastroenteritis, hepatitis and dysentery. One example relates to a world-wide epidemic of cholera in 1961 that began in Indonesia and spread to eastern Asia and India.

This report covers all of the above, unless the term 'sewage' is used specifically to mean human waste. Although discussion is centred on urban sewage, it is recognised that in rural areas, agricultural wastes are also important sources of sewage. This comes in the form of animal waste generated by dairy farms, cattle ranches, sheep and goat farms, piggeries, duck and snake farms and chicken batteries or hatcheries as well as more exotic birds such as ostriches, quails, etc. Also, many agricultural processing plants such as rubber factories, processing plants for palm oil, coconut oil, and other crops can generate large quantities of liquid waste that can contaminate streams, freshwater bodies and coastal areas when they are discharged without treatment. Cities with proper sewerage and wastewater treatment plants are still subjected to animal dropping from domestic animals and pets. This applies especially to affluent cities.

4.2 Characteristics of Sewage

As the 'spent water supply' of the community, sewage is a complex mixture of suspended and dissolved materials, which constitute organic pollution (Lester 1996: 95), though its liquid portion is almost entirely water. As a rough guide, the quality and strength of sewage effluent are described in terms of biological oxygen demand (BOD) and suspended solids (SS). BOD refers to the quantity of oxygen used in the biochemical oxidation of organic matter. When used as a test of sewage strength, the quantity of oxygen used is related to the duration and temperature of the process. Usually this is the five-day demand at 20ºC and is expressed as milligrams per litre (mg/l) (Auld, 1976: 468). The SS are determined by weighing after filtration of a known volume of sample through a standard glass-fibre filter paper, and is also expressed as mg/l (Lester, 1996: 96).

Domestic sewage is 99.9 per cent water and 0.1 per cent total solids on evaporation (Figure 3). About two-thirds of the solids are organics, comprising mainly of nitrogenous compounds (proteins and urea), carbohydrates (sugars, starches and cellulose), fats (soap, cooking oil and greases). The inorganic compounds include chloride, metallic salts and road grit when the combined sewage is used. Thus sewage is a dilute, heterogeneous medium that tends to be rich in nitrogen (Lester, 1996: 97).

In the case of domestic sewage, its components can also be divided into several groups as shown in Table 8. The presence of pathogenic and toxic components means that it poses health and aesthetic risks to human populations and is a vector through which contaminants may reach the marine environment (Table 9). Bacteria in great numbers and possibly enteric viruses are present in raw sewage. It is for these reasons that it is desirable to treat sewage before it is discharged into rivers or the sea. Untreated sewage may also contaminate surface water and freshwater bodies and mix with drinking water. It may then contaminate foodstuffs and cause pathogens to multiply rapidly especially during warm conditions.

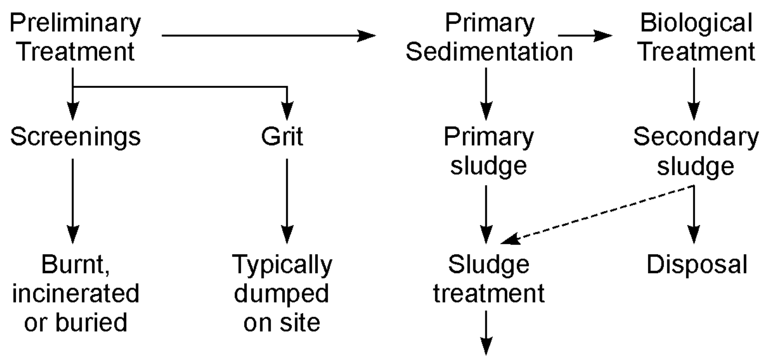

Figure 3 Composition of a Typical Sample of Raw Sewage
Source: Lester (1996).

Table 8 Components of Wastewater

Component	Of special interest	Environmental effect
Micro-organisms	Pathogenic bacteria, virus and worms, eggs	Risk when bathing and eating shellfish
Biodegradable organic materials	oxygen depletion in rivers, lakes and estuaries.	
Other organic materials	Detergents, pesticides, fats, oil and grease, colouring, solvents, phenol, cyanide	Toxic effect, aesthetic inconveniences, bio accumulation
Nutrients	Nitrogen, phosphorus, ammonia	Eutrophication, oxygen depletion, toxic effect.
Metals	Hg, Pb, Cd, Cr, Cu, Ni	Toxic effect, bio accumulation
Other inorganic materials	Acids, e.g. hydrogen sulphide, bases	Corrosion, toxic effect
Thermal effects	Hot water	Changing living conditions for flora and fauna
Odour (and taste)	Hydrogen sulphide	Aesthetic inconveniences, toxic effect
Radioactivity	Toxic effect, accumulation	

Source: Henze et al. (1997)

Table 9 Sewage Derived Pathogenic Organisms and Their Effects on Humans

Aetiological agent	Mode of transmission to humans[a]	Diseases/Symptoms
Salmonella typhi	Fish or shellfish	Typhoid
S. paratyphi	Fish or shellfish	Paratyphoid
S. typhimurium	Fish or shellfish	Salmonellosis; gastroenteritis
S. enteritidis	Fish or shellfish	Salmonellosis; gastroenteritis
Vibrio parahaemolticus	Fish or shellfish	Diarrhoea, abdominal pains
Clostridium botulinum	Fish or shellfish	Botulism (high fatality rate)
Staphylococcus aureus	Fish or shellfish	Staphylococcal intoxication, nausea, vomiting, abdominal pain, prostration
Clostridium perfringens	Fish or shellfish	Diarrhoea, abdominal pain
Erysipelothrix insidiosa	Skin lesions	Erysipeloid–severe wound inflammation
Hepatitis virus	Shellfish	Infectious hepatitis
Heterophyes heterophyes	Fish or shellfish	Heterophyiasis: abdominal pain, mucous diarrhoea (eggs may be carried to brain, heart, etc.)
Paragonismus westermani (P. ringeri)	Crabs, crayfish or contaminated water	Flukes in lungs and other organs
Anisakis matina	Marine fish (notably herring)	Anisakiiasis; eosinophilic enteritis
Angiostrongylus cantonensis	Shrimps or crabs	Eosinophilic meningitis.

Note: In most cases contamination by the organism is not transmitted to humans unless the food has been inadequately stored or cooked.
Source: Preston & Chester, 1996, p. 39.

Urban surface runoff is also recognised as a significant source of water pollution, and is usually not channelled into the sewerage system but directly into drains, streams and rivers and hence coastal waters. Rainwater has the effect of collecting many kinds of waste material including street litter, debris of household or commercial litter, lawn and garden litter, leaves, abrasives and chemicals used for ice control, oil and grease from motor vehicles and machinery, chemicals used as pesticides, herbicides and fertilisers, droppings from birds and animals, and substances in stack emissions deposited from the air (Auld, 1976: 470).

4.3 Bacteriological Aspects of Wastewater and Night soil

The danger with sewage, which includes urine, faeces and sullage water is that they contain a host of pathogens as listed in Table 10. These micro-organisms-- bacteria, viruses and parasites -- include indirect or direct communicable diseases. The most common pathway is via faecal-oral contact either by ingestion with food or water, or by contaminated fingers or utensils. Some pathogens can survive outside the host body for long periods of time, e.g. in sewage and occasionally in soil, from where they may be retransmitted to water and food. Some other diseases may be transmitted by vectors. Hence, the collection, transport, treatment and disposal of excreta are an essential part of the protection of health in any community. Details of the role of water in the transmission of diseases are given in White (1972) (see also Feachem *et al*. 1983, and JICA, 1997 for details on bacteriological aspects of sewage, and UNEP, 1988 on possible impacts of domestic wastewater).

Table 10 Occurrence of Pathogens in Urine, Faeces and Sullage Water

Pathogen	Common name for infection caused	Present in		
		Urine	Faeces	Sullage
Bacteria				
Escherichia coli	Diarrhoea	Yes	Yes	Yes
Leptospire interrogans	Leptospirosis	Yes		
Salmonella typhi	Typhoid	yes	Yes	Yes
Shigella spp	Shigellosis		Yes	
Vibrio cholerae	Cholera		Yes	
Viruses				
Poliovirus	Poliomyelitis		Yes	Yes
Rotaviruses	Enteritiis		Yes	
Protozoa (Amoeba or cysts)	Roundworm		Yes	Yes
Ascaris lumbricoides	Liver fluke		Yes	
Fasciola hepatica	Hookworm		Yes	Yes
Ancylostoma duodenale	Hookworm		Yes	Yes
Necator americanus	Schistosomiasis	yes	Yes	Yes
Schistosoma spp	Tapeworm		Yes	Yes
Taenia spp	Whipworm		Yes	yes
Trichuris trichiura				

Source. World Health Organisation (1992) quoted in JICA (1997), p. 160.

4.4 Treatment of Sewage

Sewage treatment is usually undertaken to avoid pestilence and nuisance (disease and odour) and to protect potable supply. In some cases, e.g. the United Kingdom, sewage may be treated to a higher standard so that the final effluent may be abstracted for treatment to produce a potable supply after varying degrees of dilution and self-purification (Lester, 1996: 94–95). Conventional sewage treatment is a three-stage process that includes preliminary treatment, primary sedimentation and secondary (biological) treatment, as shown schematically in Figure 4. In addition, some form of sludge treatment is employed, typically using anaerobic digestion.

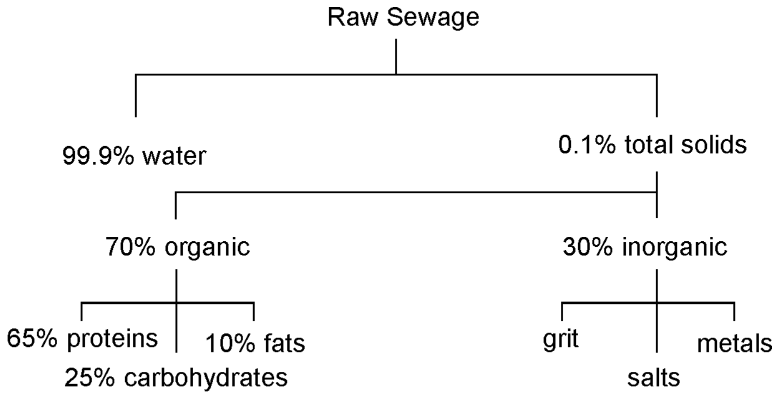

Figure 4 Flow Diagram of a Conventional Sewage Treatment Works
Source: Lester (1996)

The preliminary treatment processes are intended to remove large floating (scum) and suspended materials. While they do not significantly reduce the pollution load, the sewage is rendered more amenable to treatment by removing large objects that could form blockages or damage equipment. After primary treatment, the raw sewage (containing approximately 400 mg/l SS and 300 mg/l BOD) enters the first stage of treatment that reduces its pollutant load through primary sedimentation or mechanical treatment. During primary sedimentation, about 55 per cent of the SS are removed and, because some of these solids are biodegradable, BOD is reduced by 35 per cent. At this stage floating scum is also removed and combined with the sludge. As a result the effluent now has an SS of about 150 mg/l and a BOD of about 200 mg/l. In some circumstances this may be acceptable for discharge to the sea or estuaries without further treatment (Lester, 1996: 97–101).

Secondary (biological) treatment of sewage aims at reducing the BOD to less than 20 mg/l. Typically, secondary treatment is carried out by means of either the percolating filter (also referred to as a trickling or biological filter) or activated sludge treatment. In both cases, microorganisms oxidise the BOD and a secondary sedimentation tank is used to separate the microorganisms from the final effluent. Sewage treatment thus results in the production of a final effluent suitable for discharge into the environment and one or more sludges, which may require treatment prior to disposal.

Sludge treatment and disposal is often given insufficient attention in discussions on wastewater treatment and may account for 40 per cent of the operating cost of a wastewater treatment facility (Lester, 1996: 113). Prior to treatment, the sludge contains between 1 and 7 per cent solids, which are usually highly putrescible and offensive. Sludge is the product of primary sedimentation of raw sewage and the by-product of secondary biological treatment of settled sewage. Sludge from primary sedimentation is particularly offensive with a pronounced faecal odour and is likely to become putrescent and thus cause a nuisance. Secondary sludge consists largely of bacterial solids; while less offensive than primary, it may still become putrescent. The main aim of sludge treatment is to render it easier and cheaper to dispose of the sludge consistent with minimising any nuisance or adverse effects on the environment. A wide range of treatment processes is used. They include thickening by stirring or flotation; digestion, aerobically or anaerobically; heat treatment; composting with domestic refuse; chemical conditioning with either organic or inorganic materials; dewatering on drying beds, in filter presses, by vacuum filtration or centrifugation; hearth drying; incineration in multiple hearth or fluidised bed furnaces and wet air oxidation (Lester, 1996: 114).

There are now available new waterless or dry composting toilets that destroy faecal bateria and at the same time produce fertiliser. Anaerobic technology has been promoted, in one case by a German organisation, to a number of Asian countries in a seminar held in Ho Chi Minh City in December 1996. This provides an alternative to expensive centralised sewage treatment plants. Decentralised units of anaerobic septic tanks primarily for the digestion of agricultural residues and effluents are newly developed biogas plants and co-fermentation high-rate digestion systems capable of operating under warm conditions. These have proven to be efficient in treating high-strength organic wastewater from agro-industries, food industries and chemical and pharmaceutical industries in addition to domestic sewage. The meeting recommended that centralised wastewater treatment plants should be adopted only as a last resort. Decentralised systems are capable of producing significant savings in installation costs of sewerage systems, generating reusable products and tap water (Deutsche Gesselschaft fur Technische Zusammenarbeit (GTZ GmbH), 1997).

5. VALUE OF MARINE AND COASTAL RESOURCES

A detailed description of the marine and coastal environments of the ten countries covered in this study was earlier presented in the companion study (Chia and Kirkman, 2000). The region's waters support an unparalleled diversity of marine fauna and flora. They contain one-fourth of the world's most productive mangrove forests and nearly one-third of the world's coral reefs. Around 30per cent of the world's coral reefs, one-third of the world's mangroves, as well as many other important critical habitats are found in the region. An estimated value of the coral reefs in Southeast Asia amounts to $112.5B annually (Ruitenbeek, 1999). The region comprises the world's richest marine biodiversity and produces about 41per cent of the total fish catch in the world. Not surprisingly, the coastal communities derive most of their protein requirements from fish and depend on marine resources either directly or indirectly for employment and a source of income. This includes burgeoning marine tourism that needs clean water and beaches, a rich marine life and attractive seascapes (See section 3.3) A study on economic valuation of coastal and marine resources in the Straits of Malacca (GEF/UNDP/IMO, 1999) gives these estimates shown Table 11. It is assumed that the net value of the fisheries resources and aquaculture stocks in the Straits is around 12 per cent of the gross value of the fisheries stocks. The net revenue from fisheries and aquaculture is valued at $ 681.7 million in 1995.

Table 11 Gross and Net Value of Fisheries and Aquaculture in the Malacca Straits, 1995

	Indonesia		Malaysia		Singapore	
	Gross	**Net**	**Gross**	**Net**	**Gross**	**Net**
Fisheries	875.1	458.5	686.3	154.4	8.4	1.6
Mangroves	753.6	424.2	352.5	70.4	4.2	0.8
Mudflats			49.4	27.9		
Coral reefs	105.4	32.7	10.2	2.0		
Seagrass			10.5	2.1		
Seaweed	16.1	1.6	2.9	0.5		
From ecosystems	875.1	458.5	425.5	102.9	4.2	0.8
From outside ecosystems			260.8	51.5	4.2	0.8
Aquaculture	170.9	17.1	97.9	39.0	18.6	11.1
Shrimp			37.4	15.0	8.4	1.6
Finfish			33.7	7.9		
Moluscs			26.8	16.1		
Total	**1,046.0**	**475.6**	**784.2**	**193.4**	**27.0**	**12.7**

Source. Based on Sasekumar et al. (1998) shown in GEF/UNDP/IMO (1999), Table 9, p. 18.

Apart from fisheries and aquaculture, there are also many other marine and coastal resources in the Straits of Malacca in this case. Coastal and marine tourism, as discussed earlier in Section 3.3, constitutes an important element in valuing the coastal and marine environment. Mangroves and coral reefs ecosystems yield numerous valuable products and benefits as do clean beaches and seascapes. The value of these resources in any situation depends on a number of factors including: level of use of the resources, their accessibility, social and economic status of the population that determines the perception of the value of these resources. A part of the perceived value is associate with the local culture of the population that exhibits certain preferences in tastes and use of the sources such as fish and other sea products. The perceived value of the coast and the sea from the point of view of recreation is rising and is amenable to being developed.

Information of the value of marine and coastal resources elsewhere in the East Asian region and Australia is sketchy and scattered. There are a number of sensitivity studies undertaken on these resources in the region. Spatial information is now more easily available through the use of remote-sensed information and the use of geographic information systems (GIS). Attempts at producing environmental profiles and integrated coastal zone management (ICZM) of selected areas of the core countries of the Association of South East Asian Nations (ASEAN), namely, Brunei, Indonesia, Malaysia, the Philippines, Singapore and Thailand were undertaken under the auspices of the International Center for Living Aquatic Resources Management (INCLARM). A number of ICZM type studies have also been undertaken in project supported by the Asian Development Bank as in Viet Nam. There is an opportunity for collating these useful information for management of coastal and marine resources in the region under review.

The East Asian Seas region is also considered a major hub of maritime trade, with a significant number of international and domestic seaports situated along the coastline. The ports provide a sea link between the neighboring countries and also serve as gateways to regional markets with major trading partners in the West. [http://www.pemsea.org/pemseanews.html#1.1]

6. IMPACT OF ANTHROPOGENIC ACTIVTIES

Most of the ten countries' national reports express deep concern over the pollution of rivers from polluting activities arising from large urban areas, industries and commercial facilities including tourist facilities along rivers or lakes within the catchment area. There is also concern with pollution of semi-enclosed bays arising from large coastal urban centres. The concern here is with sewage from domestic, industrial and commercial sources, and less so with that from agricultural sources. Details presented in this section on impacts arising from anthropogenic activities are drawn mainly, but not exclusively, from case studies in the overview of land-based pollution in the East Asian region (Chia and Kirkman, 2000).

Table 12 lists rivers with pollution problems in some of the 10 countries discussed. Most of the countries consider rivers to be of major importance to their socio-economic development (Table 13). They report problems arising from uncontrolled discharge of untreated sewage, especially from industrial plants, into water courses, lack of wastewater treatment facilities, and collection of garbage. Table 14 highlights the activities contributing to a reduction of water quality of rivers in these countries. In the case of industrial effluent, the impact will certainly be reduced through its treatment before being discharged into the environment.

Many of the uses of river water require water of a minimum standard; river pollution by sewage would therefore result in the loss of these uses to the country and hence generate the need to find alternative sources. Research is needed to quantify the cost of sewage pollution so that the benefits of treating industrial and domestic effluents can be evaluated. It is equally necessary to find ways to treat wastewater without incurring the very high cost of modern, large-scale wastewater treatment facilities especially for isolated industrial plants, animal farms, tourist facilities and the like.

Table 12 Rivers in Selected East Asian Countries with Pollution Problems

Cambodia	China	Indonesia	Philippines	Thailand	Viet Nam
Mekong Bassac Tonle Sap	Huaihe Heihe Liaohe Taihu Chaohu Lake Dianchi Lake	Ciliwung Citar Cipinang Surabaya Mas	Tullahan-Tenejeros San Juan Zapote-Las Pifias Pasig Meycauyan Marilao Pampanga Iloilo	Chao-Phraya Tha-Chin Mae Klong Bang Pakong Mun	Saigon Tolich Set Song Cau Tseuong Canal in HCM Dong Nai Song Lo Loch Chay Song Nhui

Source: ESCAP (1998), p. 10.

Table 13 Importance of Water Sources to Socio-economic Development in Selected East Asian Countries

Source	Cambodia	China	Indonesia	Philippines	Thailand	Viet Nam
Natural Lakes	Major	Minor	______	Major	Major	Minor
Unregulated Rivers	Moderate	Minor	Moderate	Major	Moderate	Moderate
Regulated Rivers	Major	Major	Major	Major	Major	Moderate
Dams, Tanks	Major	Major	Major	Major	Major	Major
Groundwater	Moderate	Major	Moderate	Major	Major	Minor

Key

Minor Importance	(light shading)	Major Importance	(dark shading)
Moderate Importance	(hatched shading)	No Data	______

Source: Adapted from ESCAP (1998), p. 47.

Table 14 Activities Contributing to Water Quality Problems in Rivers in Selected East Asian Countries

Activities	Cambodia	China	Indonesia	Philippines	Thailand	Viet Nam
Untreated industrial effluent	Moderate contributing factor	Major contributing factor	Major contributing factor	Major contributing factor	Major contributing factor	Major contributing factor
Treated industrial effluent	+ + +	Major contributing factor	Moderate contributing factor	Moderate contributing factor	Moderate contributing factor	———
Untreated sewage	Major contributing factor	Major contributing factor	Major contributing factor	Major contributing factor	Major contributing factor	Only contributing factor
Treated sewage	+ + +	Major contributing factor	———	Moderate contributing factor	Moderate contributing factor	———
Deforestation	Major contributing factor	Moderate contributing factor	+ + +	Major contributing factor	Major contributing factor	Only contributing factor
Grazing	Minor contribution factor	Minor contribution factor	+ + +	———	Moderate contributing factor	Minor contribution factor
Cropping	Moderate contributing factor	+ + +	Major contributing factor	———	Moderate contributing factor	Only contributing factor
Landfill	Moderate contributing factor	+ + +	———	Major contributing factor	Moderate contributing factor	Minor contribution factor
Extractive industries	———	Minor contribution factor	———	Moderate contributing factor	Moderate contributing factor	Only contributing factor
Feedlots	Minor contribution factor	———	Minor contribution factor	———	Major contributing factor	———
Urban storm-water	Major contributing factor	———	Major contributing factor	Major contributing factor	Minor contribution factor	Only contributing factor
River regulation	Moderate contributing factor	+ + +	———	Moderate contributing factor	Minor contribution factor	Minor contribution factor
Natural occurrence	Moderate contributing factor	Minor contribution factor	———	Major contributing factor	———	Minor contribution factor

Key

Not a contributing factor	+ + +	Major contributing factor	(dark shading)
Minor contribution factor	(light shading)	Only contributing factor	(darkest shading)
Moderate contributing factor	(hatched shading)	No Data	———

Source: ESCAP (1998), p. 58.

Table 15 Status of Recognised Uses of Rivers in Selected East Asian Countries

Water Use	Cambodia	China	Indonesia	Philippines	Thailand	Viet Nam
Treated Household	Minor Importance	Minor Importance	+ + +	Major Importance	Major Importance	Major Importance
Untreated Household	Major Importance	Minor Importance	Major Importance	Moderate Importance	Major Importance	Only Use
Town Water	Moderate Importance	Minor Importance	+ + +	Moderate Importance	Major Importance	Major Importance
Irrigation	Major Importance	Major Importance	Major Importance	Major Importance	Major Importance	Major Importance
Livestock	Moderate Importance	Minor Importance	Moderate Importance	Major Importance	Moderate Importance	Only Use
Fisheries – Farming	Minor Importance	Minor Importance	Major Importance	Moderate Importance	Major Importance	Only Use
Fisheries – Natural Harvest	Major Importance	Minor Importance	Major Importance	Moderate Importance	Major Importance	Minor Importance
Effluent Reception – Domestic	Major Importance	Major Importance	Major Importance	Major Importance	Major Importance	——
Effluent Reception – Industrial	Moderate Importance	Major Importance	Major Importance	Major Importance	Major Importance	——
Recreational	Minor Importance	Minor Importance	Moderate Importance	Minor Importance	Moderate Importance	——
Environment Conservation	Moderate Importance	——	+ + +	Major Importance	Major Importance	Only Use
Industrial Water Supply	Moderate Importance	Moderate Importance	Major Importance	Minor Importance	Minor Importance	Only Use
Hydropower	Minor Importance	Minor Importance	Major Importance	Minor Importance	Moderate Importance	Only Use

Key

Not a use	+ + +	Major Importance	
Minor Importance		Only Use	
Moderate Importance		No Data	——

Source: ESCAP (1998), p. 67.

7. REGIONAL PERSPECTIVES

The following sections provide highlights of problems related to sewage pollution of the marine environment and related freshwater bodies encountered in individual countries covered in this study.

7.1 Tropical Australia

In northern Australia the problem of pollution from sewage is minor and restricted to localised areas downstream of urban settlements and will not have significant impacts on the sparsely populated coastal areas of the vast territory. The largest township is Darwin with a population of over 80,000 and the situation may become serious if the town is severely damaged by tropical cyclones that occur during the last and first quarter of the year.

7.2 Cambodia

The major source of river pollution from sewage is the city of Phnom Penh and other urban settlements along the river systems in the country. It was mentioned in the Cambodia TDA national report that the only existing sewage treatment plant has not been in operation due to a lack of funds. At present all wastewater is discharged, without treatment, into rivers that enter into the Tonle Sap. In addition, dumping of solid waste into the rivers and their tributaries has become general practice as facilities and management for its proper collection, transport and disposal are lacking. This poses serious concern for water quality in the river courses and the Tonle Sap where the pollution levels are becoming high. Mention was also made of the increasing use of pesticides and herbicides for agricultural purposes. As at 1997, Cambodia indicated that there was no remedial work carried out and no plans to carry out such works on rivers in the near future (ESCAP, 1998: 5, 59). The largest coastal township is Sihanouk Ville, where there is considerable interest from foreign investors in establishing manufacturing plants due to the advantage of access to the deepsea port. In anticipation of fast growing urban population and an influx of industrial plants, there is an opportunity here to adopt measures to counter the problem of sewage pollution of the marine environment.

The construction of floating houses and dwellings over rivers, an illegal practice, is linked to the high rate of population growth and poverty of the people. Most floating houses have been built on the Tonle Sap River and Tonle Sap Lake. All kinds of domestic waste are discharged into the water from these houses, leading to the spread of epidemic diseases such as cholera and dysentery. Based on water quality data analysis carried out by the Phnom Penh Water Supply Authority, the number of total bacteria and coliform in the area exceeds the water quality standard of the World Health Organisation (ESCAP, 1998: 99).

While Cambodia is not heavily industrialised, water pollution by industrial waste does occur in some areas because most factories and cottage industries have been built on the banks of waterways without regard to their potential environmental impacts. At present, all wastewater and some solid waste generated by these factories are directly discharged into the rivers without pre-treatment. The rapid rise in the numbers of cottage industries in urban and rural areas is an increasing cause of concern for water quality management.

The Mekong River Committee Secretariat has been collecting and analysing water quality samples from nine points in the main stream of the Mekong, Bassac and Tonle Sap rivers and in Tonle Sap Lake since August 1993. No data are available for the tributaries and heavy metals, bacteria and pesticides have not been measured. However, the data collected show:

a. Low dissolved oxygen levels in the Bassac River, Tonle Sap River and Tonle Sap Lake during the dry season. The lowest dissolved oxygen levels (1–1.5 mg/l) occur in the Tonle Sap River and Tonle Sap Lake from March to May when there is no flow, and because industrial, agricultural and urban development activities along the bank of the river have increased. This shows that the Tonle Sap River and Tonle Sap Lake have been polluted by the discharge of oxygen-demanding waste into the water without treatment.

b. High concentrations of organic matter (COD: 8–10 mg/l) have occurred in the Bassac and Tonle Sap rivers, but the values are lower than the Global Environment Monitoring Standard (COD: 18 mg/l).

c. The concentration of total suspended solids in the river water of Cambodia is very high in the wet season, reaching about 400–650 mg/l during July, August and September.

d. The high TSS has led to dramatically increasing sedimentation of Tonle Sap Lake. In the 1960s, sedimentation rates of 2 cm per year were recorded. In 1992, a survey conducted by the World Bank showed that the sedimentation rates of the lake have increased by 4 cm per year, which increases the chances of the lake drying up in the future (ESCAP, 1998, 100).

7.3 China

There is a wide range of pollution sources that contribute to the degradation of water quality of the rivers of China. The direct discharge of approximately 80 per cent of untreated industrial and domestic wastewater into surface water bodies has seriously polluted more than one third of all rivers in the country. It is estimated that China produces more than 20 billion cu m of municipal wastewater each year, of which only 7 per cent (1.4 billion cu m) is treated (Wang 1997).

In the Haihe River Basin, it has been reported that untreated and treated effluent cause a number of water quality problems including high loads of COD, ammoniacal nitrogen and volatile phenols. Untreated and treated sewage has been identified as causes of problems with nitrogen (ESCAP, 1998, 59).

The city of Guangzhou, with a population of 4 million, faces a shortage of water due to organic pollution by domestic sewage as well as increases in the discharge of industrial effluent into the Pearl River, its main source of water. Heavy metal pollution was a major problem in the 1970s, but this has been largely brought under control. While the Guangzhou City Government enacted environmental protection laws, the impact of these measures has been limited, and the water quality of the Pearl River continues to be seriously threatened by existing and future development (Tao and Hills, 1999).

The central government recognises the severity of the problem and has committed itself to solving it. However, there is tension between the central and provincial governments over their respective priorities and interpretation of national policy on the environment. Among other issues, there is a lack of willingness to pay for sewage treatment, especially amongst upstream provinces and municipalities which benefit much less from sewage treatment than downstream users. China's institutional and legal structures are also weak at both the central and provincial levels. Under the 1988 Water Law, local and regional water resource bureaux have autonomy to plan and manage water supply, pollution and basin management systems in their areas. The absence of an active central co-ordinating body thus results in a great deal of water infrastructure planning originating at the local rather than the national level (Chotrani, 1999a).

The Special Administration Region (SAR) of Hong Kong is rightfully known as the Pearl of the Orient and has a high level of economic development and social organisation. The very high population density and intensive development and industrialisation has put tremendous pressure on the marine and related environments. Massive land reclamation and decades of industrial development have seriously damaged and polluted the environment. It shares, with coastal mainland China, the problem of increasing incidents of red tide (see section 7.3.1) and is concerned with the dwindling number of marine animals including the Chinese White Dolphin (*Sousa chinensis*) and Indo-pacific Humpback Dolphins, one of 79 cetacean species (Hong Kong Dolphin Watch Limited <http://www.zianet.com/dolphins/info.htm>).

Hong Kong SAR has evolved its legislation separately under British control. Environment impact assessment legislation was only adopted in 1997 (see Table 18) under the Environmental Protection Department. The SAR has an existing set of sewage treatment plants across the territory and is currently constructing a sophisticated deep-tunnel sewerage system called the Strategic Sewage Disposal Scheme (SSDS) that is designed to provide a comprehensive solution to Hong Kong's sewage problem (see section 8.3.2 in this report).

7.4 Indonesia

The ongoing industrialisation and urbanisation in Indonesia have placed an additional serious strain on water resources due to water quality degradation. Urban populations are estimated to have increased from 22 per cent in 1980 to 41 per cent in 2000. In the first half of the 1990s, 73 per cent of the urban population had access to sanitation, while for the population as a whole access to sanitation increased from 30 per cent to 51 per cent between the first half of the 1980s to the first half of the 1990s (Table 1). However, it was reported elsewhere that less than 3 per cent of urban households have access to municipal sewerage systems and only about 10 per cent have access to piped water (Atkinson, 1999).

The Brantas River basin, located in East Java, is a medium-sized river with a catchment area of 12,000 sq km. The river is representative of many other Indonesian rivers with respect to high pollution loads, high sediment transport loads, exposure to seasonal floods and droughts, dense population and increasing industrial and agricultural activities. These are indicative of the problems of other rivers receiving discharged from urban settlements.

The condition of water quality in the Brantas River basin varies with season and location. In general, rivers have a high pollution assimilation capacity during the rainy season due to the higher water flow rate and dilution effect. However, the Brantas River Basin exhibits a steady decline of water quality during the rainy season. In the wet season soil erosion and sediment originating from volcanoes contribute to high sediment loads in the river system, making the river water very silty. These sediment loads, together with domestic solid waste thrown into the rivers and waste material from factories, often fibre from paper mills, result in very high suspended solid loads (70–500 mg/l compared to 20–150 mg/l in the dry season). Values of organic pollutants and nutrients represented by BOD, nitrogen and phosphorus are also higher in the rainy season.

During the dry season, when the dilution effect of the monsoonal water does not occur, BOD ranges from 5 to 12 mg/l for most of the river system. Low-flow conditions and with high pollution loads from industrial and domestic sewage overload the rivers with soluble and insoluble organic pollutants. The water quality at the beginning of the rainy season from December to February shows the highest value of both organic and inorganic parameters. The value of BOD and SS range from 6 to 15 mg/l and 70 to 500 mg/l, respectively.

The Surabaya River is one of the most contaminated rivers in the Brantas River basin in terms of organic pollutants exhibiting BOD values from 10 to 20 mg/l. In particular, the section of the Surabaya River running parallel to the Mastrip road is heavily contaminated largely due to the pollution load generated by industries occupying a 10-km strip. The next most contaminated stretch of the river is upstream of the Brantas River, near Malang City, where the BOD is 8 to 15 mg/l. Eutrophication is already in progress in the Brantas River with nutrients flowing into the reservoir. The obvious indication of this is the high value of phosphorus and low transparency of the reservoir water (ESCAP, 1998: 13, 59, 106, 108).

In a survey of Indonesia coral reefs, Edinger *et al.* (1998), found that reefs subjected to land-based pollution (sewage, sedimentation and/or industrial pollution) showed a 30–50 per cent reduction of biodiversity at 3 m and a 40–60 per cent reduction at 10 m depth when compared to unpolluted reefs. The reefs of Jakarta Bay are now nearly dead and many of the Jakarta Bay islands are now submerged as a result of dead and dying corals due to pollution by industrial waste and sewage.

7.5 Korea

The sources of water pollution in the Republic of Korea comprise point sources such as domestic sewage, industrial wastewater, and livestock wastewater together with non-point sources such as run-off from roads and farmland. The total quantity of wastewater generated daily from point sources in 1996 was 24.5 million tonnes. About 63 per cent (15.5 million tonnes) of the total originated from domestic sources and about 36 per cent (8.9 million tonnes) originated from industrial sources, with the remainder being generate from livestock farms. The resulting BOD load amounted to 6,440 tonnes per day, of which industrial wastewater contributed 49 per cent, domestic sewage 43 per cent and livestock wastewater 8 per cent.

Based on 1994 data, the BOD load from non-point sources is estimated to be equivalent to about 20 to 30 per cent of the total load from point sources. In addition the per capita rate of generation of domestic sewage was calculated to be 325 l/d in 1994.

While two-thirds of the country is served by piped sewage systems, treatment facilities are still using antiquated equipment, and much sewage flows directly into the rivers, untreated. At the end of 1996, the nation's sewage treatment facilities were able to handle only 52.8 per cent of all daily sewage generated nation-wide. Currently about 30 per cent of the sewage is believed to leak from sewer pipes due to cracks in the pipes and wrong connections at household or industrial sources. Storm-water and groundwater also enter the pipes through the cracks creating capacity problems at treatment plants, especially during wet weather (ESCAP, 1998: 134, 135).

Inadequate sewerage and wastewater treatment is the principal environmental problem in Seoul. The capacity of Seoul's sewerage treatment plants in 1997 was only 3.5 million cu m/day; as a result 6 million cu m/day of untreated sewage is discharged into the Han River, downstream of Seoul. While separate sewers for storm-water and sewage were installed in the southern area (new town), the northern area (old town) of Seoul uses combined sewers that channel both storm-water and sewage. During rainy days, the wastewater generated is three time the designed capacity of the sewer; amounts over and above the design capacity are discharged directly into the Han River (*Asian Water and Sewerage*, March 1997a).

In an effort to protect sources of surface water, the government embarked on a ten-year programme to provide sewage treatment for agricultural and fishing villages at a cost of US$800 m in 1995. The government is also building new treatment plants and sewer lines at a cost of US$10 billion from 1996–2005 to raise the proportion of sewage treated from 55 per cent to 80 per cent (*Asian Water and Sewage*, May 1998).

7.6 Malaysia

According to Dorai and Murugian (2000) the proportion of population served with centralised sewerage systems in the country was a mere 3.4 per cent in 1970, 40 per cent in 1980 and still only 5.0 per cent in 1990. For the same years, the proportion using septic tanks and communal sewerage systems were 17.2 per cent, 21.8 per cent and 37.3 per cent. The rest of the population employ a variety of systems including pour-flush system, bucket latrines, pit latrines, hanging latrines. The proportion with no facilities declined frm 17.7 per cent in 1970 to 6.3 per cent in 1990. These figures show a far less satisfactory situation compared with those shown in Table 5 from data supplied by the World Bank Most facilities are in poor condition and existing facilities are generally 15 to 20 years old. Privatising sewage services was seen as the solution to the government's failure to expand its sewerage system to keep up with urban development. However, over the last twenty years, there has been progressive improvements in the provision of sewerage and sewage treatment plans in cities and towns as well as in all major development projects in the country. This is achieved by the adoption of 'structural plans' for each city and town on the one hand, and, on the other, since 1987, the requirement for environmental impact assessments for development projects. One example is the Penang Island Structural Plan where, under the section on public utilities, specific plans for the disposal of sewage and solid wastes and the prevention of pollution from these wastes are considered (Municipal Council of Penang Island, n.d.). In the case of Penang Island, there were existing centralised sewerage systems in George Town and Bayan Lepas. It is planned to extend this to cover more areas through the construction of centralised pig waste and domestic sewage treatment plants. In addition, the use of non-waterborne toilet systems such as the bucket system, pit latrines and other non-flush systems are to be removed and eventually to have all buildings within public sewered areas connected to the sewerage system.

As with the Penang Island Structural Plan, there is a similar plan for Tawau in the East Malaysian state of Sabah. As at the time of the adoption of the Tawau Comprehensive Development Plan in 1984, there was no centralised sewerage system nor was there a sewage treatment plant in the city. Untreated sewage from the city was, until then, discharged directly into the sea through a town outfall sewer. The plan was to built large-scale stabilisation lagoons first at the northern area to be completed by 1995. The privately operated treatment plants would then be connected to the public main and would be decomissioned. Two reserve sites, each 30 ha in size, were proposed. There are Tanjung Batu and Kinabutan at the eastern and western end of the coastal town and would be sufficient to meet the requirements of the city till the year 2000 with provisions for additional needs for the future (Huszar Brammah and Associates, 1984).

In 1993, the Federal Government granted a 28-year concession with Indah Water Konsortium Bhd (IWK) to plan, design, construct, operate and maintain sewerage within 143 local authority areas. However, there are still formidable obstacles before all wastewater is treated before discharge. It is estimated that more than US$4 billion over the next 28 years is needed if this target is to be achieved (Fernandez, 1998). However observers say that the privatisation of sewerage services in Malaysia has been a 'disaster'. IWK has not been financially viable, even though it is obligated to expand the existing sewerage systems and connect households using septic tanks to them (Chotrani, 1999b).

7.7 Philippines

Wastewater from households, especially in highly populated urban areas, contributes largely to the pollution of metropolitan water bodies, more so as sewage collection and treatment facilities are lacking. Industrial wastewater discharges are sources of a range of pollutants in receiving waters, most notably organic substances. Other pollutants include heavy metals and other toxic or hazardous chemicals (ESCAP, 1998: 61).

Records from the Department of Environment and Natural Resources show that 65 per cent of the 74 designated water quality monitoring stations in various parts of the country have water quality below the targeted beneficial use classification of the water. 47 per cent of river and 60 per cent of coastal stations have water quality less than the lowest use classification. Examples are the Pasig River in the National Capital Region, where BOD ranges from 20 to 120 mg/l, far exceeding the appropriate limit of 7 mg/l; and the Iloilo Coast and Yasay Beach, where coliform counts of 12,500 MPN/100ml and 300,000 MPN/100 ml, respectively, have been recorded well beyond the safe limit of 1,000 MPN/100ml. High levels of oil and grease have also led to the destruction of shellfish and fish-farming areas in Manila Bay.

The Environmental Management Bureau has identified 416 principal rivers in the country, based on a list prepared by the National Water Resources Board. These rivers each have a drainage area of more than 40 sq km. Of these rivers, between 30 and 40 are classified as polluted, some to a critical degree.

Pollution from solid waste is heaviest in urban areas, and is primarily brought about by inefficient solid waste collection and/or inappropriate disposal systems. In Metro Manila in 1995, 63 per cent of the 6,400 tonnes of solid waste generated daily was collected, of which 72 per cent was disposed of in open dumpsites. The remaining uncollected refuse was burnt, recycled by scavengers or indiscriminately dumped in various waterways. Wastewater coming from households, especially in densely populated urban areas, is a major contributor to the pollution of water bodies, as sewage collection and treatment facilities are lacking. The situation is particularly severe in Metro Manila where only 15 per cent or 1.2 million people, are served by the sewerage system. A further 600,000 households (about 4.8 million people) in Metro Manila have septic tanks, the majority of which are not maintained. The remaining 3.6 million use wastewater disposal methods such as pit privies, trench latrines, 'sit-and-throw' facilities, and 'sit-over-the-river' facilities. The estimated BOD load from domestic wastewater into the rivers and coastal waters of the National Capital Region is 320 tonnes per day. Water pollution coming from the mining industry, aside from tailings which amount to 57 million tonnes per year, is due to the generation of by products such as cyanide and mercury (ESCAP, 1998: 132).

The most highly polluted river systems in the Philippines are located in Metro Manila, and comprise the Tullahan-Tenejeros River, the San Juan River, the Zapot-Las Pinas River and the Pasig River systems. Except for the upstream parts of the Marikina River, which is a tributary of the Pasig River, pollution by domestic and industrial sewage generated by the five cities and four municipalities it passes through, has 'virtually extinguished aquatic life' in the river which once served as a habitat for 25 varieties of fish and 13 types of aquatic plants. Today there are only six species of fish and two types of plants that can tolerate polluted water. Along the banks have also developed squatter colonies of about 12,000 households while another 2,000 families live in houses on stilts or under bridges in 'sub-human conditions'. These settlements have no sanitary facilities and their solid and liquid wastes are discharged directly into the river (Cruz, 1997).

Since 1989, the Philippine government has set up the Pasig River Rehabilitation Programme (PRRP), initially with a grant of US$15 million from Denmark. From 1990 to 1991, an extensive study was conducted to look into the feasibility of rehabilitating the Pasig River. This has resulted in the establishment of the Pasig Rehabilitation Secretariat, which will establish a framework plan for the rehabilitation of the river and has established working groups composed of government agencies and private sector organisations. Among the initiatives of the programme are: (a) commercial and industrial liquid waste management, (b) solid waste management, (c) squatter resettlement, (d) riverside management, (e) water quality monitoring, (f) public information, and (g) public activation.

7.8 Singapore

The city-state of Singapore is the only country in the study area with a comprehensive sewerage system serving the entire population. The country's strong economy has enabled it to pay for state-of-the-art technology. This is complemented by the government's strict enforcement of environmental regulations. Since 1972, some S$2.5 billion (US$1.47 billion) has been invested in the sewerage system and legislation has been put in place to require industries and the few farms remaining to treat their effluent to prescribed standards before discharging into the sewerage system or open watercourses.

Presently sewage is treated at six treatment works connected to 145 pumping installations through a network of 2,750 km of sewers. In 1998, 475 million cu m of sewage were treated to a minimum standard of 20 mg/l for BOD and 30 mg/l for suspended solids. The discharge of treated sewage effluent into the coastal waters of Singapore represents a BOD load of 9,500 tonnes/year.

Although Singapore is heavily industrialised, the quality of inland and coastal waters remains generally high. Monitoring is carried out regularly through 19 coastal and 43 inland monitoring points. Studies of heavy metal concentrations in marine sediments conclude that heavy metal pollution in the coastal regions of Singapore is still relatively low. However, higher levels of heavy metals are discernible in waters in the southern portions and in parts of the Straits of Johor that are affected by industrialisation (Orlic′ and Tang, 1999, Wood *et al.,* 1997). Flammang *et al.* (1997) noted that concentrations in *Diadema setosum* from Singapore coral reefs decreased with increasing distance from industrial sites.

Presently, the Ministry of the Environment is implementing a deep-tunnel sewerage system (DTSS) to replace the current system at an estimated cost of S$6–9 billion (US$3.5-5.3 billion). This system will be completed by the year 2015 and will centralise sewage treatment at two sites at Changi and on Jurong Island located at two ends of the main island of Singapore. Decommissioning the existing sewage treatment plants will free up to 290 ha of land for higher value developments, and with increased efficiency; the new system will result in savings of S$5 billion in the long run. Another major benefit of the DTSS is that sewage effluent presently discharged into the Straits of Johor will be diverted to the Straits of Singapore through deep-water outfalls up to 5 km away from the shore. This should help abate the pollution in the Straits of Johor and fulfil Singapore's responsibilities under an agreement with Malaysia to clean up the Johor Straits (*Asian Water*, December 1998).

7.9 Thailand

The Chao Phraya river basin is the largest in Thailand with a total drainage area of about 178,000 sq km, or 38 per cent of the total area of the country. The lower reaches of the Chao Phraya river system is heavily polluted. It flows through the fertile plains of the central region and the Bangkok Metropolitan Region (BMR) before draining into the Gulf of Thailand near Samut Prakan. The resident population of the BMR is approximately 8 million, but this figure increases by about 50 per cent during the day. Domestic wastewater is the major source of river pollution in Thailand. Most domestic wastewater is discharged into rivers with very little or no treatment, leading to high levels of BOD and pathogens. Industrial discharges from distilleries, textile factories, pulp and paper mills; sugar mills and tapioca factories are major sources of pollution. Other sources of pollution particularly including piggeries and duck farms, which contribute high BOD levels, and aquaculture ponds.

Upstream of Bangkok, there are small to medium-sized urban centres, typically well below 100,000 people and wastewater discharges are predominantly domestic in nature with only a low percentage attributable to industrial sources. There are, however, scattered small-scale industries throughout the catchment. These range from small rice-processing plants, fish drying and produce rendering to larger slaughterhouses and meat processing facilities.

The 331-km Tha Chin River separates from the main Chao Phraya on the western side upstream of Chainat and flows through the central plain and the BMR into the Gulf of Thailand in Samut Sakorn Province. The upper reaches of the Tha Chin River are predominantly agricultural. The lower reaches of the river, like those of the Chao Phraya, are heavily contaminated. Piggeries, duck farms as well as the large number of industries within the BMR produce a potent pollutant mix that the river cannot absorb.

The Bang Pakong River is located in eastern Thailand and flows into the Gulf of Thailand. There are two main tributaries to this river, namely the Nakorn Nayok and Prachinburi Rivers, and these combine at Chachoeng Sao to form the Bang Pakong River. Water quality monitoring data shows that the Bang Pakong River has problems with low dissolved oxygen levels and high coliform counts, while BOD is a moderate problem. High coliform counts are also a problem in the Nakorn Nayok and Prachinburi rivers, but in other respects water quality in these rivers is fair to good except in populated locations. Domestic wastewater is the main cause of pollution.

7.10 Viet Nam

Waterways in Viet Nam identified as having the most serious water quality problems are those in Hanoi and Ho Chi Minh City, followed by the Cau River, the Dong Nai River and the Saigon River. In Hanoi most of the pollution problems in the canals originate from domestic and industrial wastewater, estimated to be 300 million l/d and 115 million l/d, respectively, and storm-water. These canals eventually discharge into the Nhue River, via the Toloch, Set and Lu Rivers. In Ho Chi Minh City, discharge of domestic sewage and industrial effluents (500 million l/d) are causing increasing water quality problems. Waste being discharged from the Than Luong industrial area to the Than Luong Canal are causing high levels of BOD, SS and concentrations of heavy metals including mercury. The Cau River is polluted by industrial waste and domestic sewage, particularly from the town of Thainguyen. Discharges from Thainguyen represent 15 per cent of the average dry season flow in this river. The Dong Nai and Saigon Rivers are affected by domestic and industrial wastewater discharges.

In addition to the above, the Red-Thai Binh River is affected by pollution due to industrial discharges, particularly from the Lam Thao and Viet Tri areas, domestic wastewater and run-off from agriculture. The total wastewater discharge from the Lam Thao, Viet Tri area is about 585 mil l/day, of which the Bai Bang paper mill contributes 150 mil l/d, all discharging into the Red River. Wastewater from this area contains toxic substances such as lead, mercury, and pesticides as well as organic material and nutrients (ESCAP, 1998: 62). Other streams with water quality problems due to industrial effluents include the Thuong River in Bac Giang Province and the Tambac River in the city of Hai Phong (ESCAP, 1998: 18–19).

8. SOCIAL AND ECONOMICAL IMPACTS FROM SEWAGE POLLUTION

Land-based sources of pollution contribute the major portion of pollution in the marine environment. These pollutants include organics, nutrients, sediments, litter and plastics, metals, radionucliides, oil/hydrocarbons and polycyclic aromatic hydrocarbons (PAHs). The major source of organic pollutants in coastal waters is domestic sewage from both rural and coastal urban centres. The problem of pollution has increased significantly in recent years primarily due to the lack of services, policies and plans for collection, treatment, disposal and the overall management of domestic sewage. Apart from Singapore, the major cities in the region are lacking in sewerage systems and sewage treatment capacity, and a large proportion of domestic and industrial effluent is discharged untreated into rivers or the sea. The level of domestic sewage pollution is particularly high in the Upper Gulf of Thailand, Manila Bay, and the west coast of Peninsular Malaysia, north coast of Java and along Jakarta Bay (Koe and Aziz, 1995: 11). This section is aimed at examining the social and economic impacts of sewage, focusing in particular on the impact of sewage on health and fisheries.

8.1 Impact on Marine Resources

The magnitude of the damage done by untreated sewage will depend on the value of the resources damaged and the extent of the damage. Effects of untreated sewage may be direct, as a result of contamination of fisheries and aquaculture due to discharge of coliform bacteria or indirect through the formation of red tides that kill fish and enhancement of epiphytes and phytoplankton blooms which smother underwater plants.

The presence of untreated or inadequately treated sewage and its impact on coastal and marine resources varies greatly and is complicated by numerous other factors. The obvious destruction and damage of mangroves and coral reefs is due mainly to man-induced physical removal and destruction through over-exploitation and the use of destructive exploitation methods. The nutrients from sewage may enhance the growth of macrophytes and/or phytoplankton. Sewage can create harmful algal blooms (HABS) and can damage mangroves, coral reefs and seagrass beds through direct contamination or through the reduction of light through the water column.

Apart from the harmful health and sometimes lethal effects of red tide contaminated seafood (see Section 7.3.1) an important aspect of the impact of sewage is its impact on health through water-borne diseases resulting from sewage contamination of surface water and food. This is discussed in the following section. The effects of floods in urban settlements is particularly well known. However, there is no systematic analysis and estimates of the effect of floodwater in the spread of human and animal faeces and its consequent spread of waterborne pathogens with resultant infection. Flood water can persist for periods of many weeks and exacerbate the spread of diseases resulting in many fatalities in affected communities.

8.2 Impact of Sewage on Health

Human (and animal) excreta is the principal vector by which a large number of communicable diseases are transmitted and spread. Some of these diseases rank as the chief cause of death, especially in societies where poverty and malnutrition are prevalent. Diseases such as diarrhoea, cholera, hookworm infection and schistosomiasis cause many deaths, impair the quality of life and make the individual more liable to die from superimposed infections. In the Philippines, Malaysia, Indonesia and Viet Nam, frequent outbreaks of viral hepatitis and typhoid are related to pollution by sewage (Linden, 1990: 8). These diseases, along with many others, are spread from the infected individual to new victims through excreta, which is why the collection, transport, treatment and disposal of human excreta are important to protect the health of the population (Feachem *et al.*, 1983: 3).

Four groups of disease causing pathogens -- viruses, bacteria, protozoa and worms, may be found in excreta (Tables 9 and 10). Potential pollution extends not only to surface waters but also to groundwater. In a 1987 survey, in Chiang Mai in northern Thailand, where there was no sewerage system, of 22 wells, 71 per cent contained faecal coliform counts higher than the levels recommended by the WHO (Karnchanawong *et al.,* 1988). In Malaysia, it is estimated that 80 per cent of organic pollution of rivers is due to domestic sewage. The faecal coliform count at the mouth of the Klang River is estimated at 30,000/100 ml. High levels of pollution are also noted up to 6 km off the coast of Port Dickson where 20 sewage outlets from hotels, army camps and surface drains along the beach discharge wastewater directly into the sea. On the island of Penang, where 22.7 million litres of untreated sewage is discharged each day mainly into rivers that supply drinking water, an average of two cases of gastro-enteritis, associated with pathogens found in sewage, is reported each day (Sastry, 1995: 59). The actual number of individuals infected is likely to be higher. This unsanitary disposal of excreta may favour the breeding of insects such as mosquitoes, flies and cockroaches that have nuisance value and may act as vectors of other human diseases.

8.2.1 Viruses

Many types of viruses may infect the intestinal track and be passed on to the faeces where they may infect new human hosts through ingestion or inhalation. Often viral infections do not give rise to any clinical illness. For example, it is estimated that paralytic poliomyelitis occurs in only one out of 1,000 poliovirus infections. However, the absolute number of cases is high, as most children in developing countries are infected (Feachem *et al*., 1983).

8.2.2 Bacteria

A large number of commensal bacteria of many species are found in the normal stool of healthy human beings. Because these bacteria are ubiquitous and numerous, they are used as an indicator of faecal pollution. On occasion bacteria may give rise to disease. Pathogenic or potentially pathogenic bacteria normally infect their host by ingestion (in water, on food, on fingers, in dirt), but may also enter the body through the lungs or the eyes (after rubbing the eye with faecally contaminated fingers). At some time, an infected individual passes on a large number of bacteria in the faeces, thus effecting the spread of infection.

Diarrhoea is the major symptom of many bacterial intestinal infections; at the same time the bacteria may also invade the body from the gut and cause either generalised or localised infections. This invasion is characteristic of typhoid infections and other enteric fevers caused by salmonella.

A carrier state exists in all the bacterial infections listed in Table 16. Thus a proportion of perfectly healthy individuals in communities where these infections are endemic will be excreting pathogenic bacteria. As these carriers are mobile, they play an important role in transmitting the infections they carry by widely dispersing their faeces. While man excretes some bacteria entirely (or almost entirely), a wide range of animals also excretes others. This limits disease control through improvements in human excreta disposal alone because this is not likely to affect transmission from animals to humans. However, typhoid, shigellosis and cholera are assumed to be entirely human infections (Feachem *et al.*, 1983, pp. 9–10).

Table 16 Viruses, Bacteria and Protozoa Excreted in Faeces

Pathogen	Disease	Can symptomless infection occur?	Reservoir
Virus			
Adenoviruses	Numerous conditions	Yes	Man
Enteroviruses			
Poliovirus	Poliomyelitis, paralysis and other conditions	Yes	Man
Echoviruses	Numerous conditions	Yes	Man
Coxsackie viruses	Numerous conditions	Yes	Man
Hepatitis A virus	Infectious hepatitis	Yes	Man
Reoviruses	Numerous conditions	Yes	Man and animals
Rotaviryses, Norwalk agent and other viruses	Diarrhoea	Yes	Probably man
Bacterium			
Campylobacter festus ssp. *jejuni*	Diarrhoea	Yes	Animals to man
Pathogenic *Escherichia coli*	Diarrhoea	Yes	Man
Salmonella			
S. typhi	Typhoid fever	Yes	Man
S. paratyphi	Paratyphoid fever	Yes	Man
Other Salmonmellae	Food poisoning and other salmonelloses	Yes	Animals and man
Shigella spp.	Bacillary dysentry	Yes	Man
Vibrio			
V. cholerae	Cholera	Yes	Man
Other Vibrios	Diarrhoea	Yes	Man
Yersinia enterocolitica	Diarrhoea and septicemia	Yes	Animals and man
Protozoon			
Balantidium coli	Diarrhoea, dysentery and colonic ulceration	Yes	Man and animals (especially pigs and rats)
Entamoeba histolytica	Colonic ulceration, amebic dysentery and liver abscess	Yes	Man
Giardia lamblia	Diarrhoea and malabsorption	Yes	Man and animals

Source. Feachem et al. (1983), pp. 8, 12.

8.2.3 Protozoa

Many species of protozoa can infect humans and cause diseases, of which several species are harboured in the intestinal track of man and other animals where they may cause diarrhoea or dysentery. Three species, *Gardia lamblia, Balantidum coli* and *Entamoeba histolytica*, are considered to be frequently pathogenic. Each of these three infections is characterised by an asymtomatic carrier state; in the case of *Entamoeba histoytica* it is the carriers which are primarily responsible for continued transmission (Feachem *et al.,* 1983: 12).

8.2.4 Parasitic worms (*helminths*)

Many species of parasitic worms or helminths have human hosts. While some can cause serious illnesses, others generate few symptoms. Most helminths do not multiply within the human host, and this has important implications in understanding their transmission and the means of control. In helminthic infections, it is important to determine whether a person has an infection, and the quantity of worms within the person. Worm burdens are not evenly distributed among their human host within an infected community. Thus, a few people will carry a heavy burden of worms leading to illness and even death, while many will carry a light intensity of infection. Although it is easy to see the public health importance of heavy infection, it is far harder to assess the disability in the lightly infected majority where 'consequences are likely to be non-specific and effects cumulative with those of other infections' (Feachem *et al.,* 1983: 13).

Table 17 lists helminths excreted by humans. Their life cycles before reinfecting humans can be complex. The helminths are classified into two main groups: the roundworms (nematodes) and those worms with flat cross-sections. These flatworms again form two groups: tapeworms (castodes) which form chains of helminth 'segments' and flukes (trematodes) which have a single flat, unsegmented body. The roundworms may cause mechanical obstruction (*Ascaris*), rectal prolapse (*Trichuris*), itching around the anus (*Enterobius*) or anaemia (hookworm). They may divert food to themselves and produce severe abdominal pain, though in many cases they are symptomless. Adult tapeworms create health problems mainly by depriving their host of nutrients. Of the trematodes, some inhabit and damage the liver (*Clonorchis*) or lungs (*Paragonimus*). The schistosomes live outside the intestines in the small blood vessels; those eggs that fail to escape from their host may damage several organs. Intestinal flukes, which are transmitted through food, may occur in large numbers but cause relatively mild symptoms (Feachem *et al.,* 1983: 13).

8.3 Fate of Pathogens in Sewage Treatment

In order to limit the spread of infections transmitted through human excreta, one objective of sewage treatment is to destroy excreted pathogens. The degree to which sewage or night soil is to be treated depends on what is to be done with the sludge, compost or sewage effluent. Thus, it is an acceptable engineering practice to discharge untreated sewage into the sea provided the outfall is designed to ensure no pollution of beaches or shellfish growing areas occurs. However, if the effluent is to be used for irrigation or as a source of raw water, then the system should be designed with a very low degree of pathogen survival.

Table 17 Helminthic Pathogens Excreted in Faeces

Helminth	Common name	Disease	Transmission	Distribution
Ancylostoma duodenale	Hookworm	Hookworm	Man=>soil=>man	Mainly in warm wet climates
Ascaris lumbricoides	Round worm	Ascariasis	Man=>soil=>man	World wide
Clonorchis sinensis	Chinese liver fluke	Clonorchiasis	Man or animal=> aquatic snail=>fish =>man	Southeast Asia
Diphyllobothrium latum	Fish tapeworm	Diphyllobothriasis	Man or animal=> copepod=>fish=>man	Widely distributed foci, mainly temperate regions
Enterobius vermicularis	Pinworm	Enterobiasis	Man=>man	World wide
Fasciola hepatica	Sheep liver fluke	Fascioliasis	Sheep=>aquatic snail=> aquatic vegetation=> man	World wide in sheep and cattle raising areas
Fasciolopsis buski	Giant intestinal fluke	Fasciolopsiasis	Man or pig=>aquatic snail=>aquatic vegetation=>man	Southeast Asia, mainly China
Gastrodiscoides hominis	n.a.	Gastrodiscoidiasis	pig=>aquatic snail => aquatic vegetation=> man	India, Bangladesh, Vietnam, Philippines
Heterophyes heterophyes	n.a.	Heterophyiasis	Dog or cat=>brackish-water snail=>brackish-water fish=>man	Middle East, southern Europe, Asia
Hymenolepis nana	Dwarf tapeworm	Hymenolepiasis	Man or rodent=>man	World wide
Metagonimus yokogawai	n.a.	Metagonimiasis	Dog or cat=>aquatic snail =>freshwater fish=>man	East Asia, Siberia
Necator americanus	Hookworm	Hookworm	Man=>soil=>man	Mainly in warm wet climates
Opisthorchis felineus	Cat liver fluke	Opisthorchiasis	Cat or man=>aquatic snail=>fish=>man	USSR, Thailand
O. viverrini	n.a.			
Paragonimus westermani	Lung fluke	Paragonimiasis	Pig, man, dog, cat or other animal=>aquatic snail=> crab or crayfish=>man	Southeast Asia, scattered foci in Africa and South America
Schistosoma haematobium	Schistosome	Schistosomiasis; *bilharziasis*	Man=>aquatic snail =>man	Africa, Middle East, India
S. japonicum			Animals and man =>snail=>man	Southeast Asia
S. mansoni			Man=>aquatic snail=> man	Africa, Middle East, Central and South America
Strongyloides stercoralis	Threadworms	Strongyloidiasis	Man=>man	Mainly in warm wet climates
Taenia saginata	Beef tapeworm	Taeniasis	Man=>cow=>man	World wide
T. solium	Pork tapeworm	Taebiasis	Man=>pig (or man) =>man	World wide
Trichuris trichiura	Whipworm	Trichuriasis	Man=>soil=>man	World wide

Source. Feachem et al. (1983, pp. 14–15)

The treatment of night soil (which comes from 'dry' systems) is usually achieved by a combination of time and temperature, although other environmental conditions such as sunlight and oxygen availability are also important. Generally effective processes are those that retain the excreta for a long time (> 1 year) or raise the temperature to over 55°C or effectively combine to reduce the chance of pathogens surviving. In this regard, warm climates facilitate the process.

Conventional sewage works were originally designed to prevent gross organic pollution in European and North American rivers and were not intended to achieve a higher removal of excreted pathogens. Feachem *et al*. (1983, 90–91) strongly argue that sewage effluent from most conventional sewage plants discharge effluent of poor microbiological quality even if they conform to established physicochemical standards (i.e. < 30 mg/l SS and < 20 mg/l BOD). From a public health viewpoint, such effluent is unsuitable for discharge into freshwater where such freshwater is to be used, without treatment, for domestic water supplies by downstream populations or for direct reuse in agriculture without (costly) tertiary treatment process; and even here effluent chlorination may not be completely effective. Instead they suggest that multi-cell waste stabilisation ponds with a minimum retention time of 20 days are a low cost and effective solution to pathogen removal, where land is available.

8.4 Effects on the Coastal Ecosystem

The discharge of domestic and industrial waste was ranked as the chief source of pollution of the coastal waters of the South China Sea (Talaue-McManus, 2000). In most countries there is sparse information on the nature and rate of pollutants generated, and there is at present a great need to monitor major pollutant sources.

The discharge of raw sewage or effluent from into coastal waters represents a large input of organic material into the marine ecosystem. According to the TDA overview (Talaue-McManus, 2000), an estimated 5.7 tonnes of BOD is generated each year by countries in the South China Sea region (excluding Singapore and Brunei). Of this, only 11 per cent of BOD is removed by sewage treatment. The BOD generated by these states is expected to increase to 6.6 tonnes/year in 2005. If the amount of BOD removed by sewage treatment is not significantly increased, the coastal waters of the Sunda Shelf may become seriously polluted.

A large component of sewage discharge is organic waste, which, if not in excessive quantities, can be broken down by micro-organisms using oxygen at the expense of other biota. Thus a simple measurement of the pollution load is the biological oxygen demand (BOD). Generally the effects of sewage pollution include reduction of the oxygen content of the water, increased turbidity, stimulation of bacterial and algal growth and microbial pollution (Linden, 1990: 8). At low oxygen levels (< 2 mg/l), the environment becomes unsatisfactory for most fish (Turner and Rabalais, n.d, p. 67). What is important to note is that the effects of sewage pollution are dependent on the quantity and characteristics of the effluent discharged as well as the characteristics of the receiving waters. There is also a growing body of evidence that synergistic effects may exist between the various components in the effluent; the total effect of the effluent may be greater than the sum of the effect of each component taken individually (Gay *et al.*, 1993, 77).

Figure 5 shows the effect of an effluent on the water quality and ecology in a river. At the point of entry there is a sharp decline in the oxygen concentration of the water corresponding to a large increase in the BOD caused by micro-organisms, both in the effluent and the river, breaking down organic matter. As organic matter is depleted, the microbial populations and the BOD decline, while the oxygen concentration increases.

The effluent will also contain substantial amounts of nutrients mainly as nitrates, nitrites and phosphates that can contribute to the eutrophication of rivers and coastal waters. Sewage effluent acts as a nutrient subsidy, which impacts the reef directly and indirectly. At low levels of nutrient input, primary production of benthic algae is enhanced without affecting biomass, species composition or trophic structure. Moderate levels of nutrient enrichment cause increased primary production and biomass in both phytoplankton and benthic algal populations. With further increases of nutrient inputs, shifts in species dominance may lead to blooms of nuisance algae which induce deoxygenation of the water by preventing sunlight from reaching the lower levels of the water body and increase light attenuation by encouraging plankton production.

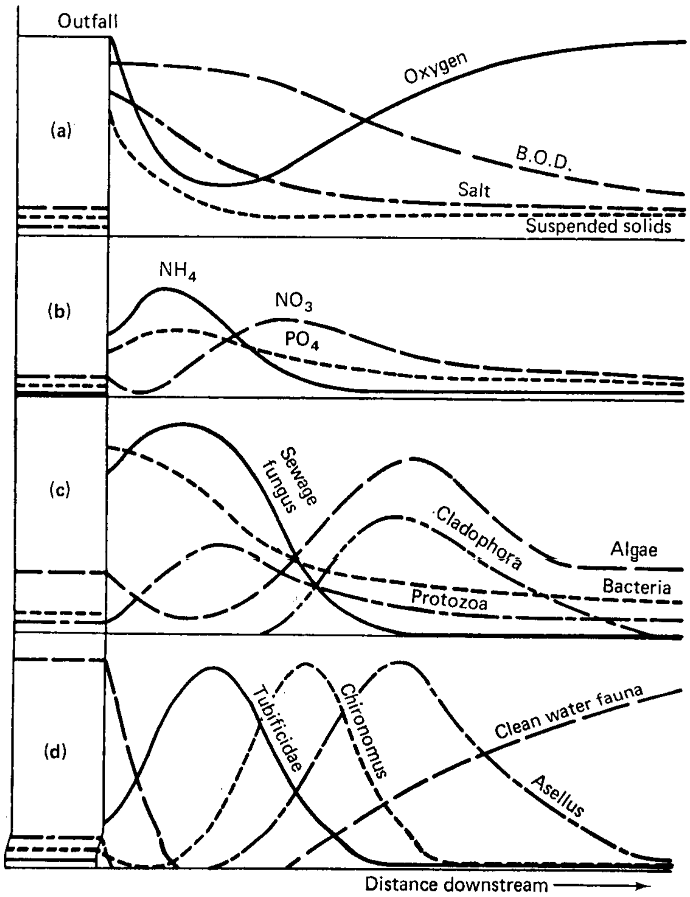

Figure 5 Diagrammatic presentation of the effects of an organic effluent on a river and the changes as one passes downstream from the outfall. (a) and (b) physical chemical changes, (c) changes in micro-organisms, (d), changes in larger animals.

Source: Mellanby (1980).

Coral communities may be indirectly stressed by elevated phytoplankton populations that reduce light penetration and affect coral nutrition through negative impacts on the zooxanthellae. Elevated phytoplankton levels also tend to favour the growth of benthic filter-feeders such as sponges, bryozoans and tunicates that can out-compete corals for space. As benthic algae increase, they colonise coral skeletons, overgrowing living corals, and form thick mats, which kill all underlying organisms by blocking light and trapping sediment. Opportunistic coral species may also dominate or replace other corals. As a result of these indirect effects, the loss of biomass productivity may lead to a net erosion of reefs. At extremely high nutrient inputs, further stress may be exerted on reef-building organisms by promoting sedimentation and toxicity. High levels of nutrient enhance planktonic primary production and lead to increased sedimentation of organic material while high phosphate levels inhibit calcification by corals and coralline algae.

Research on the effect of suspended solids in sewage effluent on coral reefs is lacking (Pastotok and Bilyard, 1985: 173). However, their effects are probably not dissimilar to sediments derived from terrestrial run-off, dredging and filling activities, and the resuspension of bottom solids. Coral polyps reject sediments landing on the surface of the colony, with some species more sensitive to sedimentation than others. In any case, complete burial by sediments for more than several hours is lethal.

At sublethal sediment loads, coral colonies experience decreasing growth rates, possibly leading to the death of all or part of the colony. Decreased light availability, abrasion, and increased energy expenditure for sediment rejection may cause this. Wittenberg and Hunt (1992) also suggest that high sedimentation increases the mortality rate of juvenile corals, leading to lower recruitment rates for the entire colony. High sedimentation rates may also lead to forms of corals that are more resistant to sediments.

Seagrass beds are sensitive to water clarity, and their loss is observed following a decline in water clarity. Seagrass beds play an important role in the lifecycle of some species of fish, which require a physical structure to escape from predators when young. Thus the loss of seagrass beds would probably lead to a decline of the potential harvest on dependent fisheries (Turner and Rabalais, n.d., p. 68).

Chemicals such as PCBs, metals, chlorine, phosphate, pesticides and petroleum hydrocarbons commonly found in sewage effluent affect corals and other reef organisms. However, their effects have received little attention in the literature. In addition hydrogen sulphide released from anaerobic sediments is also toxic to corals and may be partly responsible for coral mortality near sewage discharge sites. Anoxic conditions in deep water due to the discharge of untreated sewage have been report in areas such as Manila Bay and the coastal waters off Jakarta. There, bays are more or less permanently anoxic, as are large areas of the bottom waters of the Straits of Malacca and the Gulf of Thailand (Linden, 1990, 8).

Sewage-related effects on coral reefs have been the result of stimulatory (via nutrient subsidy) rather than the inhibitory (toxic) nature of sewage effluent (Grigg and Dollar, 1990, 444). In general, the detrimental effect of sewage pollution is due to the shifts in competitive advantage towards species that can take advantage of the increased nutrients, leading to a shift in the ecological balance of the marine ecosystem. However, it is possible for the ecological system to recover when the source of pollution is removed, as in the case of Kaneohe Bay, Oahu, Hawaii where the sewage was diverted to a new deep-ocean outfall (Smith *et al.,* 1981, Henderson, 1992).

It should also be mentioned that there are substances that may be referred to as 'floatables' present in wastewater. They include such materials as plastics, rags and paper as well as grease and oils. Sewerage systems that do not include treatment but deliver the wastewater into rivers and coastal waters are the main source of this form of pollution. They are a common sight in coastal waters and form an unsightly film, or field, on the water surface and on beaches and rocky shores and also gathered around mangroves. With age, these materials sink to the bottom and accumulate on the seabed. Plastic bags have been known to kill marine animals and clog up the gills of fish (see UNEP, 1988).

8.5 Red Tide and its Impacts

Massive outbreaks of algae (dinoflagellates) and blue-green algae (cyanobacteria) commonly known as red tides (HAB) occur over a wide latitudinal range and affect all of the countries under review.[3] The colour of the water when there is an outbreak of HAB varies from pale green to chocolate dark brown and may have the appearance of fresh blood. Its cause is not completely understood and there is no direct correlation between pollution levels and its occurrence. The algae becomes toxic and it depletes oxygen supply at the upper layers of water and kills fish at lower levels. Albeit, the association between HABs and sewage is not clearly understood (see, for example, Preston and Chester, 1996, and Anderson, 2000). Out of several thousand species of micro-organisms, only two dozen or so algae are known to form HABs. It is not known, for example, when the toxin is released in a red tide outbreak, but it is clear that domestic sewage as well as animal wastes and especially fertilisers used in agriculture and other purposes are major contributors to the incidence of the phenomena. High temperatures during warm weather conditions, and stagnant water are contributing factors. Incidents of red tide have become more frequent. Paralytic shellfish poisoning (PSP), causes by dinoflagellate blooms of species such as *Gonyaulax* and *Pyrodinioum*, has caused illness and even death.

Incidence, size and duration of algal blooms in coastal areas of the South China Sea have increased since several decades ago according to a recent report. This was attributed to worsening pollution from industries, agriculture, fish farms and no doubt also untreated domestic sewage. Red tides cost China more than US$100 million each year. In July 1999, a red tide was observed to cover an area of some 15,000 sq km in the Bohai Sea and another of 5,800 sq km on 3 May, 2000. Near the river port city of Changzhou, south of Beijing, shrimp farmers were forced to close their ponds to avoid contamination by red tides. Red tides also occurred off Shanghai in the Zhoushan Archipelago, in July, several large-scale red tides were reported there (Shanghai Environment Bureau, 18 May 2000; 14 July 2000) and further south in Fujian and Guangdong provinces. Recently, China reported numerous red tides in the South China Sea (Shanghai Environment Bureau, 21 June 2000; Bangkok Post, April, 2000). One positive development is the commissioning of a 100,000 tonne/day water treatment plant in Qingdao, Shandong Province. In 1998, there were 22 red tide outbreaks along China's coast including one that lasted more than 40 days and affected 8,000 sq km (Pollack, 2000). The National Maritime Surveillance Headquarters (CMSH) Northern Sea Branch was able to predict an outbreak on 9 July 2000 in the Liaodong Bay, Bohai Sea. That red tide covered an area of about 900 sq km and lasted only one day (Shanghai Environment Protection Bureau, 18 July 2000). In May 2000, 1,000 sq km of sea area was discoloured in the Shejiang fishing zone.

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[3] The basic bio-ecology, its occurrence, and toxicological aspects of harmful algal blooms (HAB) are described in detail in the website of the International ocean Commission (IOC) Harful Algal Bloom Programme (http://www.ioc.unesco.org/hab/) and that of the National Office for Marine Biotoxins and Harmful Algal Blooms at Woods Hole Oceanographic Institution (http://www.redtide.whoi.edu/hab/).

A massive algal bloom around Hong Kong devastated 75 per cent of the entire stock of Hong Kong's fish farms. In all, it is estimated that between 1997 and 1999, the direct economic losses from 45 major red tide incidents directly cost 2 billion Yuan ($240 million) (Shanghai Environment Bureau, 21 June 2000). A news report said that a serious outbreak of red tide in April 1998 engulfed a stretch of coastal waters in Guangdong and devastated the fishing industry in the vicinity of Hong Kong. There was an estimated loss of 350 tonnes of fish and cost US$4 million. In Hong Kong itself, a red tide killed at least 1,500 tonnes of farmed fish with an estimated value of US$32 million. Affected fishermen and fish farmers not only suffered direct losses but tainted fish cannot be sold. They also went into debt to fuel vendors and boat hirers and their small incomes, in many cases, pushed them into permanent indebtedness (Chu, 2000; BBC News Online, 18 April 1998 http:// news6.thdo.bbc.co.uk/). The same incident in Hong Kong forced the closure of five popular beaches and people were advised not to consume fish. Sewage and the El Nino were blamed for prolonging the red tide outbreak. Widespread outbreaks of red tide on the coasts of Hong Kong and Guangdong during March to April 1998 resulted in mass fish kills in the marine aquaculture areas of Dapeng Bay, Hong Kong and the estuary of the Pearl River (Ho and Man, 2000). The damage was estimated by the authors at more than HK$400 million (US$50 million).

Many of China's lakes and rivers suffer from severe pollution from industrial effluent and domestic sewage. Rapid industrialisation and urbanisation have been blamed for the worsening situation. Dianchi, the largest lake in the province of Yunnan and the main source of drinking water for the city of Kunming, has suffered from blue-green algal blooms for the last three decades. In 1999, the algae covered 20 sq km or one-fifth of the total area of the lake. Major efforts have been made to curb the problem. Four sewage treatment plants with a total capacity of 365,000 tonnes of wastewater per day were built around the lake. A major campaign was launched to stop most of the 253 factories from dumping their industrial effluent into the lake. These projects cost the government a total of 3 billion yuan (US$361 million) over the 1990s. However, the network to collect sewage is incomplete and more than 80 per cent of domestic sewage together with fertilisers and pesticides still flow into the lake through 16 rivers (Shanghai Environment Protection Bureau, 11 April 2000). Similar efforts, as in the Grand Canal, are reported elsewhere in China to control severe water pollution. The city of Shanghai, for example, generates 7.7 million cu m of sewage daily and a large proportion of it is discharged directly into rivers. However, as in the case of Dianchi, Shanghai has completed 194 projects designed to improve the local water environment (Shanghai Environmental Bureau, 5 March 2000).

Although there is no specific mention of algae blooms in Taihu Lake in Jiangsu province, the lake is highly polluted from agricultural wastes, and discharges of sewage from unplanned urban settlements and illegal industrial plants that have sprouted up around the waterbody since the 1980s. There are 3,333 ha of fish ponds in the lake well beyond the 1,000 ha allowed and planned. The lake is also used by shipping and there is uncontrolled spillage of oil and wastes of all kinds that enter the water. A World Bank loan of US$250 million was used to undertake projects to treat wastewater and a total of 10 billion yuan (US$1.2 billion) over the 1990s was spent on a clean up the lake before the end of 2000. Thus far, the planned 82 water purification plants that have a total capacity to teat 29 million tonnes of polluted water day have not been completed while no real progress has been made on 55 of the plants. There is some danger that the lake purification project will not succeed (http://www.envir.online.sh.cn/eng/news/200/07/231.htm). The situation is indicative of the problem of polluted waterbodies in the country.

The Philippines suffers from frequent and widespread outbreaks of red tides. One newspaper report says that the Government's Red Tide Task Force banned the gathering, harvesting, transporting and selling of shellfish in the wake of the presence of red tide poison in shellfish. Affected areas reported are Calbayog waters in Calbayog City, Samar; Cancabato Bay, Tacloban City; Dumaguillas Bay, Zamboanga del Sur; Masinloc Bay, Zambales; Tanguines Lagoon, Camiguin Province; Juag Lagood, Matnog, Sorsogon. The ban on shellfish started in March 1994 after the level of red tide poison in these places had gone beyond the allowable limit of 40 μg/100g of shellfish meat (*Manila Bulletin*, 26 April 1995).

In Malaysia, for example, no red tide cases were reported before 1970. One report on an impounded water body, Lake Kenyir, in the state of Terengganu on the east coast of Peninsular Malaysia shows that the lake water contains sufficient nutrients to make it eutrophic. The sources of nutrients are domestic, agricultural, industrial, commercial and recreational activities around the lake. Most of the holiday chalets use septic tanks and some discharge untreated sewage directly into the water. It was noted that a modern centralised system would be expensive and would take a long time to construct. It was recommended that a smaller stand-alone system, the Gappei-shori Johkasou system, that treats wastewater through sedimentation, purifying pollutants through a biological process, storing separated sludge and disinfecting wastewater by using chlorine be employed (Fatimah, 1996).

9. ENVIRONMENTAL GOVERNANCE: MANAGING SEWAGE

Within Asia, some 90 per cent of sewage is untreated and is discharged directly into freshwater bodies and the sea. According to a report by the World Resources Institute, UNEP, UNDP and The World Bank (1998), two decades after a UN Water Conference declaration that all people should have the right of access to drinking water in quantities and quality equal to their basic needs, 1.4 billion people still did not have access to safe drinking water, and 2.9 billion did not have access to adequate sanitation. The two related issues of providing improved water supply and sanitation services to those who have no access to them would help to reduce the incidence of water-related diseases and to improve the quality of life. The report also quotes studies made to show that improvements in water and sanitation coverage can reduce the incidence of diarrhea, ascariasis, guinea worm, schistosomiasis and other water-related diseases. The report notes that the task is daunting and nations are barely able to keep up with population growth and recommended that measures should be tailored to suit individual circumstances rather than to adopt simple universal solutions.

The problems commonly encountered in the implementation of sewage management are similar to those dealing with waste management as noted in the Global Waste Survey by the International Maritime Organisation (Ross, 1995). The issues noted are:

- inappropriate, incomplete or diffused waste management legislation and regulations
- inadequate enforcement of existing regulations and limited monitoring capability
- data on existing waste generation, treatment and disposal are scattered among a number of institutions and organisations
- insufficient or inadequate waste management facilities and services including poor operation and maintenance of existing facilities and service
- lack of skilled human resources and equipment in the public and private sectors, and
- access to and affordability of appropriate technologies, processes and practices (Ross, 1995, pp. 2-3).

Fundamental requirements in any management system have to include the adoption of appropriate and adequate laws and regulations to control the problem of sewage. This is tied in with a strongly supported and efficient organisational structure supported by effective enforcement of environmental law and regulations. Management of pollution has to be integrated with well-conceived land-use plans as part of long-term social and economic development planning. Additionally, discussion must involve the question of financing the expensive sewerage system and sewage treatment infrastructure. Finally, the social and cultural constraints to effective management of sewage should be considered.

9.1 Legal Provisions and Organisational Framework

It is worth repeating here that "a comprehensive set of legislation and well-endowed environmental institutions empowered by law are two pillars on which a country must possess (sic) in order to effectively manage the country's environment" (Chia and Kirkman, 2000). A full and detailed discussion on the legal provisions for land-based pollution as well as the organisational framework for implementing environmental policies is presented in the companion review for the ten East Asian countries and in Section 9 in the overview report by Chia and Kirkman (2000). Problems relating to the implementation and enforcement of environmental regulations including the management of sewage are dealt with in the same report. In general, there is no separate legal provision for dealing with sewage in all of the countries reviewed. The control of pollution by sewage is covered under the overall environmental law or under legislation governing water pollution. Atkinson (1999) provides a review of environmental law and legislation in Asian countries. Section 9.2 below considers the use of environment impact assessments (EIAs) in Malaysia as a means of controlling environmental pollution including pollution from sewage.

The 1972 Stockholm Conference on the Human Environment and the UN Conference on Environment and Development (UNCED) in 1992 have a signal effect on some if not all of the countries in the region under review. In the case of China, the Government convened the first China National Conference on Environmental Protection held in Beijing in 1973. This was the beginning of China's environmental policy. The State Council established the Leading Group on Environmental Protection in the following year and in 1979, the Environmental Protection Law was enacted providing a sound legal basis for enforcement. The country has since issued 28 environmental administrative regulations including the Water Pollution Prevention and Control Law (1984), 70 rules and 375 national environmental standards. There are also over 1,000 local environmental regulations. China's *Agenda 21 – White Paper on Population, Environment and Development in the 21st Century* was released in 1994 in preparation for the Earth Summit. In 1998, the National Environmental Protection Agency (NEPA) was upgraded to the status of a Ministry and named the State Environmental Protection Administration. Provincial Environmental Protection Bureaus were also established to coordinate environmental work at the lower levels. They see to the implementation of state policies, law, regulations and standards and they undertake monitoring, supervision and registration of pollution discharges, issuing pollution discharge permits, and investigating pollution cases by the State Environment Protection Agencies (SEPA) (Harashima, 2000).

In the case of Thailand, the effect of the Stockholm Conference may have prompted the country to incorporate environmental protection statements in the country's Fourth National Plan (1977-1981). Environmental protection was reinforced in the Seventh and Eighth national plans. During the first half of the 1990s, new and amended legislation was passed and institutional changes were made to enhance the work on environmental protection. This led to the enactment of the 1992 Enhancement and Conservation of National Environment Quality Act and repealed the 1975 Environmental Acts with the intention of strengthening environmental law in the country. The Ministry of Science, Technology and Environment was set up in 1992 thus giving high priority to the work of environmental protection (Harashima, 2000).

Most countries are concerned with the problem of sewage as a matter of priority because of the impact on human health and quality of life rather than a concern for environmental degradation and resource damage. Application of the polluter-pays principle and the adoption of environmental impact assessments are directed at business enterprises. For newly emerging countries at an early stage of economic development, there is an opportunity to institute effective laws and regulations from the start. Such laws and regulations will require intended and newly established factories, processing plants for agricultural and primary commodities such as minerals and timber, hotels, resorts, hospitals, etc. to install adequate facilities to treat wastewater and sewage before they are allowed to operate. A precautionary approach that anticipates problems and prevents the discharge of untreated wastewater and sewage should be adopted.

An integrated pollution control system should be adopted based on well-conceived and appropriate environmental laws and regulations. Advantage should be taken of the expertise and assistance available within the region in the form of international environmental organisations and agencies in more advanced countries. Sound physical or land-use planning and the development of planned industrial parks, coastal resorts and tourist and recreational zones will provide a broader framework for control of sewage. Clearly, there is a need to pay attention to environmental needs in all development plans in each country rather than taking an entirely sectoral approach to development planning.

9.2 Environmental Impact Assessment (EIA)

Governments use EIA requirements as an effective legal instrument to extract from developers a predicted assessment of environmental damage expected as a result of development projects. The predicted potential problems are then addressed before commencement of the development. An environment management plan (EMP) is in some cases required to provide assurance that the protection and remediation of the damaged environment, arising from the project, are carried out. The process of putting together an EIA or an Environmental Impact Statement (EIS) requires involving all interested parties in the proposed development and providing the necessary information to the key people who are required to make informed decisions (see Watling and Nadarajah, 1996). Water quality standards, effluent and sewage discharges must meet with prescribed standards. EIAs are mandated in seven of the countries reviewed in this report (Table 18). If properly implemented, EIA helps to optimise the use of renewable resources and ensures the success and lengthens the life of a developed project. It is also a self-regulation mechanism where developers come up with their own targets and solutions rather than merely reacting to regulations and meeting legal requirements. An EIA is a systematic process that examines in advance the potential environmental consequences of development to an area. It is aimed at preventing rather than curing environmental pollution and damage.

Table 18 Status of Environment Impact Assessment (EIA) in Selected East Asian Countries

Country	EIA authority	EIA legislation date
Cambodia	Council for the Development of Cambodia	*Ad hoc*
China	National Environment Protection Agency	1981
Hong Kong, China	Environment Protection Department	1997
Indonesia	Environment Management Agency	1987
Korea	Ministry of Environment	1981
Malaysia	Department of Environment, Ministry of Science, Technology and Environment	1987
Philippines	Department of Environment and Natural Resources	1977
Singapore	Urban Redevelopment Authority	Ad hoc
Thailand	Office of the National Environment Board	1978
Viet Nam	Ministry of Science, Technology and Environment	1993

Source. Briffett (1999), p. 146.

Malaysia's EIA is prescribed under its Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 of the Environmental Quality Act 1997 that came into effect the following year. The Department of Environment under the Ministry of Science, Technology and Environment issued detailed guidelines for various sectors such as the one for coastal resort development projects (DOE, 1994), development of resort and hotel facilities in hill stations (DOE, 1995a), Tourist and Recreational Facilities in National Parks (DOE, 1995b), Coastal and Land Reclamation (DOE, 1998). In all, a total of nearly 2000 EIA submissions were received and approved (Table 17). The number of EIA submissions increased over the years and reached nearly 400 in 1996. Of particular interest are those concerned with sewage of which there was a total of 183, or 9.3 per cent of the total number of cases, over the period shown (Bahrin and Teh, 1997). In the earlier period, approval for projects required up to one year but this has been cut down to three months.

The EIA process passes the burden of environmental protection to project developers. Legislation giving effect to EIA requirements also formalises the procedure so that all projects above a certain size must have an EIA, providing that there are no loopholes allowing projects to proceed without due process. Initially, EIAs are regarded as a necessary evil that adds costs to the projects. However, the number of EIA submissions increased from 35 in 1989, a year after the requirement came into effect, to a total of 386 in 1996 (Table 19) indicating that this has gained acceptance and the process has become well established and is taken seriously. Both private enterprise and the government authority have gained experience and greater expertise in the process. Nevertheless, there are shortcomings:

(1) it takes place at a relatively late stage of the decision-making process and hence cannot address many issues determined at the strategic level. Alternative solutions may already be eliminated by decisions at a high strategic level of policy and planning;

(2) there are cumulative effects and impacts that fall outside project-level EIA procedures that cannot be adequately addressed;

(3) once approval for the project has been received, the task of carrying out the protection measures passes out of the environmental agency to some development agency that may not have the capacity or interest to ensure that they are carried out.

Table 19 Number of EIA Statements Approved by the Department of Environment, 1 April 1988-30 April 1997

Activity	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997 Jan-Apr	Total
Housing	1	3	9	21	26	37	49	55	102	27	330
Recreation and resort development	0	0	15	33	36	46	62	57	44	24	317
Infrastructure	0	1	17	40	33	36	43	56	56	17	299
Quarry	0	3	13	17	23	44	38	56	60	22	276
Industry	1	9	16	24	23	26	16	46	45	11	217
Sewage	1	3	10	1	13	29	40	32	41	13	183
Petroleum	4	5	14	10	11	15	12	11	9	4	95
Power generation	2	3	1	5	6	13	6	2	3	1	42
Agriculture	0	1	0	3	3	3	6	9	6	1	32
Mining	1	1	7	1	2	1	9	1	6	2	31
Land reclamation	0	2	2	3	7	3	1	7	1	3	29
Forestry	0	0	2	9	4	1	6	2	1	1	26
Irrigation and drainage	1	1	0	3	5	4	3	5	1	0	23
Ports	0	1	2	0	0	4	3	6	4	1	21
Extended Economic Zone	0	1	0	3	0	4	3	0	1	1	13
Water supply	0	1	3	2	2	1	1	1	1	0	12
Transport	0	0	0	0	1	0	1	1	3	0	6
Fisheries	0	0	0	1	1	0	0	2	0	0	4
Railways	0	0	1	0	0	0	0	0	1	1	3
Airports	0	0	0	0	0	1	0	0	1	0	2
	11	**35**	**112**	**176**	**196**	**268**	**299**	**349**	**386**	**129**	**1,961**

Source. Malaysian Department of Environment (1997), p. 16.

In order to deal with (2), Malaysia is moving towards a macro-EIA approach that takes into account the cumulative effects of environmental impacts arising from all the development projects in a particular area. Also, a strategic environmental assessment (SEA) approach has been adopted as an attempt to analyse and evaluate the environmental effects of a proposed policy, plan or programme as a top-down strategy and complements the process of project-level EIAs (see Ariffin *et al*. 2000). Watling and Nadarajah (1996, p. 24) also point out the need for environmental monitoring and auditing by independent environmental auditors to ensure compliance. In addition, the developer must carry out biological monitoring to ascertain the bio-accumulation of pollutants in filter feeders as an indicator.

9.3 Land-Use Planning and Pollution Control

Most cities in the East Asian region have master land-use plans for residential, commercial and industrial and other uses. Ideally, these plans should provide for sanitation and wastewater disposal facilities. In this way, the more pollution-prone industrial areas would be appropriately zoned to simplify the task of wastewater management. In the case of Singapore, approval for new developments is contingent on the Ministry of the Environment being satisfied that these developments can be served by the existing public sewerage system or that adequate on-site sewage plants are provided. In the case of industrial developments, the Ministry also assesses the manufacturing process and ensures that measures to minimise waste generation are incorporated, and that the effluent will be treated to comply with prescribed standards. The Ministry also inspects the building after it is completed to ensure that it complies with its standards (Loh *et al*., 1995; Lee, 1995: 65–66).

There is rapid urban population growth throughout the East Asian region requiring that new and expanded urban settlements be provided with appropriate sanitation facilities to ensure that a high quality of life is maintained. However, with the additional examples of Malaysian and Korean cities, there is still a general lack of physical planning and the financial and technical resources to implement modern large-scale sewerage and wastewater treatment plants. Major proportions of large cities in the region are without modern sanitation and the cost of providing such systems would be beyond the reach of city administrations in the foreseeable future. There is insufficient attention paid to urban centres other than the capital cities and the largest regional centres in most countries in the region. The advantage of planning and early execution of plans to provide sanitation systems should be taken in anticipation of future growth.

In addition to urban planning, all countries have ambitious plans to set aside new areas for population settlement, commercial, industrial-port, tourism and recreational developments. Many of these schemes are located on the coast and along banks of large rivers. There is clearly an urgent need to integrate such regional plans with existing national plans and to provide for the necessary infrastructure to deal with the problem of wastewater. This is to ensure that expected benefits of increased economic activities are not diminished by the heavy cost of environmental degradation and pollution including that arising from sewage pollution, and that the quality of life for local communities is not compromised.

9.4 Measures to Deal with Sewage Pollution

In addition to basic requirements to establish appropriate legal and planning frameworks backed by sufficient financial, technical and human resources, there are several measures that need to be considered for managing sewage pollution.

9.4.1 Provision of sewerage systems and sewage treatment plants

Apart from the DTSS that Singapore (see Section 6.8) is currently putting in place, the Hong Kong SAR Government, has adopted a number of Sewage Master Plans, and has begun to put in place a comprehensive sewerage and sewage treatment system for the territory. The decade-long Strategic Sewage Disposal Scheme (SSDS) was started in 1992 and it is designed to (1) collect, treat and divert sewage away from sensitive and semi-enclosed waters such as Tolo Harbour and Deep Bay where there are large-scale developments, (2) biological treatment and disinfection of flows to waters of moderate assimilative capacity such as Mirs

Bay and Port Shelter, (3) chemical treatment and disinfection will be provided as a minimum for major discharges to waters of relatively high assimilative capacity such as to the north of Lantau island, and (4) septic tank and soak-away systems will be replaced by proper sewage systems for all significant development. The Hong Kong sewage strategy is based on a set of Water Quality Objectives (WQOs) that define the maximum levels of pollutants that are acceptable. The value of the WQOs vary depending upon the resources and uses to be protected and the nature and sensitivity of the receiving waters (Hong Kong Environment Protection Department, 2000).

Hong Kong's SSDS has a daily capacity to treat only 1.5 mil. tonnes of raw sewage generated by residents in Hong Kong. The wastewater will be collected by a system of deep tunnels and the treated effluent will be discharged via a long pipeline into the South China Sea (Ho and Man, 2000). The Singapore and Hong Kong schemes are by far the most ambitious (and expensive) sewerage schemes in the entire East Asia region under review.

Table 20 provides a partial list of sewage treatment plants in Cambodia, China, Indonesia, Philippines, Thailand and Viet Nam. It emerges that China's major cities of Beijing, Shanghai, Tianjing and Chengdu have built major systems to cater to a large proportion of the cities' population. Scattered news reports indicate that China is in the process of putting in many more systems to deal with wastewater. In Southeast Asia, only Singapore can claim to have a comprehensive sewerage system with sophisticated treatment plants to deal with all sources of wastewater. Within the East Asian region, it is safe to say that most cities other than those listed in Table 20 have inadequate coverage of sewerage networks and do not have sewage treatment plants. Raw sewage is discharged directly into water courses and coastal waters.

Table 20 A Partial List of Sewage Treatment Plants in Selected East Asian Countries

Country/ city	Pop`n	Study Year	Centralised Sewage Treatment Plant: Sewage treatment plant	Collection system	Area covered: Separate	Combined	Total	Capacity: Daily max.	Treatment process	Sludge disposal	Reuse	Pop. covered
	('000)				(ha)	(ha)	(ha)	(m3/day)				('000)
Thailand												
Bangkok	5,600	1997	Si Praya	Combined		270	270	30,000				
Pattaya	75	1996	Jomtien	--		1,000	1,000	20,000	ASe&CFF			
Khon Kaen	145	1997	Khon Kaen	--		2,760	2,760	25,500	SP			
Nakorn Rachasima	19	1996	Central Treatment Plant	--		500	500	32,400	SP			
Indonesia												
Jakarta	211	1997	Setiabudi	Separate	560		560	42,768	AL			
Yogyakarta	35	1997	Bentul	--	738		736	15,500	AL			
Cirebon	264	1997	Ade	Mixed	114	120	234	4,320	SP			
Medan	42	1996	Probrayang	Separate	500		500	8,000	ASB			
China												
Beijing	7,050	1995	Gaobeidian					500,000	AS	Two-stage mild temp. digester Dewatering	Irrigation	4,230
Shanghai	8,690	1995	Eastern suburbs	Mixed				400,000	AS	Two-stage mild temp. digester dewatering	Irrigation /industry	5,200

Country/ city	Pop`n	Study Year	Centralised Sewage Treatment Plant									Pop. covered
			Sewage treatment plant	Collection system	Area covered			Capacity	Treatment process	Sludge disposal	Reuse	
					Separate	Combined	Total	Daily max.				
	('000)				(ha)	(ha)	(ha)	(m3/day)				('000)
Tianjing	4,610	1995	Jizhuangzi					260,000	AS	Two-stage mild temp. digester dewatering		2,800
Xi'an	2,750	1995	Beishiqiao	Combined				150,000	OD	Dewatering	Irrigation	1,650
Chengdu	1,740	1995	Sanwayo					150,000	AS	Two-stage digester dewatering		1,000
Viet Nam Hanoi	2,900	1995?	No treatment	Combined			3,300					580
Ho Chih MinCity	4,580	1995?										2,290
Hai Phong	1,558	1995										467
Hue	1,000	1995?										300
Da Nang	50	1995?										25
Cambodia Phnom Penh	800	1994		Combined								50
Kompong Som	31	1994										5
Battambang	45	1994										10
Kompong Cham	33	1994										8
Siemriep	15	1994										3
Philippines Manila Central system		1996	No treatment				2,617		No Treatment			
Ayala		1994					600	42,000	AS	2-step anaerobic digest	Fertiliser Land improve-ment	
Dagat Dagadan		1994					333		AL & SP	No		
Quezon							1,000					

AD: Anaerobic digestion AL: Aerated lagoon ASB: Anaerobic sludge blanket
CFF : Combined fixed film OD: Oxidation ditch SP : Stabilisation pond UASB: Upflow anaerobic sludge blanket
Source. JICA (1999); Nippon Jogesuido Sekkei Co Ltd (1996, p. III-2).

9.4.2 Sewerage systems in Metro Manila

A World Bank report (Gunnerson, 1988) gives some graphic details of the situation in Manila as of 1980. Metro Manila includes four cities (Caloocan, Manila, Pasay, and Quezon) and 23 municipalities and covers an area of 1,500 sq km, of which one-third is urban. The population was then 6.7 million and it has grown to ten million by the year 2000. Population densities are high, especially in the Tondo area, where large squatter settlements extend over tidal flats. An estimated two million people live in 415 blighted areas with poor sanitation, overflowing sewers and few people can afford sewerage. The slightly more affluent are provided with pit latrines, vault and cartage systems, or septic tanks. Septic tanks are desludged by commercial operators and news reports suggest that the sludge is not properly disposed of and most probably ending in water courses and coastal areas away from the densely populated areas.

The first sewerage system was constructed in the early 1900s to serve about 1,800 ha in central Manila. 'Black water' from septic tanks, cesspools, vaults and pits that are improperly designed and 'grey water' from kitchen, bath, and laundry wastes drain to the nearest watercourse. The report added that "typhoid, cholera, and gastroenteritis are endemic" (Gunnerson, 1998: 311). However, there are affluent areas in Manila that are served with piped water and have septic tanks with effluent dispersed into covered drains.

The report estimated that Metro Manila generated 760 mil. l/d of sewage. About 1.14 million of the population living in 2,450 ha of the service area in 1980 were served by public sanitary or combined sewer systems. Another 2.28 million of the population living in 10,970 ha of the service area were served by communal or single septic tanks of varying standards of efficiency. The remainder had pit latrines or, in some pockets, there is no service at all and sewage is discharged into street gutters, open canals or rivers.

The main sewerage system served 828,000 people living within the central service area. It includes a collection network, seven lift stations, trunk sewers and an outfall pump station, force mains, and an ocean outfall at Tondo. Currently the submarine part of the pipe has been washed away and raw sewage is discharged near the mouth of the Pasig River. The only other sewerage system is privately owned with a treatment plant that serves the modern Makati area of 650 ha and some 60,000 people.

The World Bank provided assistance for the development of a master plan for Manila's sewerage system. It is designed as a conventional sanitary sewer collection system, a main interceptor below the bed of the Pasig River and submarine outfalls into Manila Bay. The total costs for just the outfall and pumping station are estimated at US$35.7 and US$9.7 million, respectively. The proposal was to install the entire system *after* the year 2000. The report notes that the plan could not succeed without improvements of other public services and housing upgraded at the same time. Also, the programmes and projects proposed are being carried out by agencies that are difficult to coordinate and occasionally have overlapping jurisdiction and technical conflicts (Gunnerson, 1988: 315, 317).

In the early 1990s, the Philippines Government requested the Government of Japan for assistance to undertake a new study on the water supply and sewerage master plan for Metro Manila (the JICA Plan). A study of the scheme was undertaken and the report was completed in February 1996 (Nippon Jogeisuido Sekkei Co Ltd, 1996). The report covered not only the long-term development of the water supply and sewerage for Metro Manila but also an institutional, organisational, operational and financial strengthening plan for the implementing agency, - the Metropolitan Waterworks and Sewerage System (MWSS) responsible for eight cities, including the National Capital Region (NCR), and 29 municipalities in Metro Manila, Cavite and Rizal provinces. The population of NCR was projected to increase from just under 8 mil. in 1990 to 12.44 mil. in 2015, an increase of 1.6 times, while adjoining Cavite and Rizal would increase from 0.46 mil. and 0.98 mil. to 0.88 mil. and 2.44 mil. respectively representing increases of 1.9 times and 2.5 times for the two areas during the same interval. The most densely population areas are circumscribed by the boundaries of the NCR.

The JICA study reports that, as of 1994, less than 10 per cent of the NCR was covered by some form of sewerage network. Generally, conditions have not improved from the late 1980s report by the World Bank (Gunnersen, 1988). There were four sewerage systems in operation in the study area, all of which were separate collection systems under MWSS supervision. Only 7 per cent (46 sq km of the total of 636 sq km) of the NCR was covered by sewerage systems. Some one million persons, or 11 per cent of the NCR population, have access to the systems. Within the NCR, 91 per cent of the households, 79 per cent in Rizal Province, and 84 per cent in Cavite Province have water-sealed sanitary toilets. These septic tanks are connected by separate plumbing systems that receive only night soil or combined pipes that deliver all the sewage. The absorption field after sedimentation/digestion sometimes does not function properly and overflow into the drainage system occurs. Desludging of the septic tanks is undertaken infrequently by MWSS (Table 21) due mainly to difficulties in finding suitable disposal sites. Table 21 also shows target levels of the Metro Manila Sewerage system.

Table 21 Target Levels of the Metro Manila Sewerage Maser Plan

Category	Item	Existing	Target	Remarks
Sanitation	Regular desludging of septic tanks	Once in more than 15 years in NCR	Once in 5-10 years in target year 2015 in Level III supply area	Projection from 2010 to 2015 is necessary because the Master Plan covers up to 2010
Sewerage	Sewer access rate (service coverage)	Less than 10% of NCR	Nearly 30% of MWSS jurisdiction	Depends on cost constraints
	Effluent quality from treatment plant	Ayala wastewater treat-ment plant discharges over 65 mg/l BOD	Effluent less than 30mg/l to all proposed treatment plant	Possible that Ayala treatment plant meets standard after the Master Plan is completed

Source. Nippon Jogeisuido Sekkei Co Ltd (1996, p. III-8)

From the above report, it appears that there was little progress made since the World Bank Master Plan was undertaken while the city has expanded considerably in the interval. The rehabilitation and expansion of the Manila Central System as well as the construction of the Tondo Pumping Station and its outfall were said to be completed in 1990, but work on these projects is still needed and formed part of the work on the Manila Second Sewerage Project (see below). Other planned projects were not implemented. There was also a plan to undertake a septic tank desludging programme. The above report also mentions the Asian Development Bank (ADB) study "Manila Second Sewerage Project" formulated in 1994 with financial assistance from the World Bank. The project includes a sewage expansion scheme for the Manila Central Sewerage System and focussed on sewage management.

The JICA Plan took into such considerations as ease of disposal of sludge, low construction and maintenance costs, easy operation and maintenance and efficient use of available land. It set a target level for BOD at 30 mg/l. The Plan recommended five sewerage systems including existing plants and service areas. It also recommended a complete rehabilitation of the existing Ayala plant. In all, the five systems cover 15,588 ha and serve 5.144 million population. In other words, even if the targets are reached, it would still serve less than half of the population of Metro Manila.

As for the sanitation plan involving on-site treatment facilities, consideration was given to groundwater level and permeability of the absorption field. Recommendations were made for construction of communal-scale septic tank, Japanese-type Johkasou/bio-module, anaerobic sludge blanket reactor, and the Korean-type of treatment facilities. The report emphasised that regular desludging is indispensable for proper management of septic tanks. Based on 1995 costs, the project would come to Peso 17.65 billion (US$686.7 million). It is envisaged that the entire project will be completed by 2015.

9.4.3 Sewerage and sewage treatment plants in Bangkok

In the case of Bangkok, there are now two wastewater treatment plants in operation under the Bangkok Metropolitan Authority. Table 20 above gives some details of the Si Praya Sewage Treatment Plant. The Din Daeng Wastewater Treatment Plant and sewerage system collects sewage from mainly domestic sources and storm-water. It is built on an area of 270 ha and has a capacity of 30,000 cu m/day (JICA, 1999). It serves an area of 38 sq km and over one million residents in Central Bangkok, or approximately one-sixth of the total population of the city.

A third system and the largest and most ambitious project is the US$700 million Samut Prakarn centralised Wastewater Management Project that straddles both sides of the Chao Phraya River in south eastern metropolitan Bangkok. The scheme is 30 per cent completed and is expected to begin operation in early 2002. It will have a capacity of treating 500,000 cu m/day of wastewater. It is jointly financed by the Thai Government, the Asian Development Bank and the Japan Bank for International Cooperation. When completed it would help to clean up Thailand's most polluted province benefitting more than one million inhabitants. In order to recover costs, the project will institute a polluter-pays principle. Each sector will pay in proportion to the pollution it generates. Thus, industry will contribute 80 per cent of the cost in proportion to the amount of wastewater it generates. The commercial sector will pay about 12 per cent of the cost while the residential sector about 8 per cent of the total cost (Gill, 2000)[4].

9.5 Selection of Appropriate Sewerage Systems

For centralised pipeline sewerage systems, an important difference is the use of combined storm-runoff and sanitary wastewater collection systems and the separated pipes for household sewage. The former uses large conduits and is regarded as a false economy and may entail adverse environmental impacts. The combined system will also require much larger treatment facilities. It is recommended that the combined systems should be avoided for the following reasons:

- Larger volumes of water are collected, thus greater treatment capacity will be required
- Combined sewers are rarely designed to carry the peak run-off discharge of high intensity tropical storms. There is therefore a danger that excess flow from the combined wastewater may overflow into drainage system and water bodies
- In dry periods, when sanitary discharges make up the entire combined sewer flow, water movement is sluggish. Solids may then be deposited and corrosive chemicals generated
- Combined sewerage systems require larger diameter pipes of expensive, high quality materials. By installing separate systems, the large diameter pipes conveying storm-water may be built from cheaper materials, while the high grade piping required for sewage can be of a smaller diameter
- If combined sewers are used, catch basins must be installed at each storm-water inlet to intercept grit and prevent the escape of unpleasant odours. This expense can be avoided if separate carriage systems are installed (see Association of Water and Sewage Works Consultants Japan, 1999; UNEP, 1988).

[4] Reprinted from *Bangkok Post* 24 Sept 2000 [http://www.bkkpost.samart.co.th/news/BParchive/BP20000924/240900_Perspective03.html].

Where resources are limited, storm-water collection is lower in priority and may be accommodated by a surface drainage ditch system. Albeit, regular inspections and maintenance are necessary for separated sewage pipes to ensure that bad connections and dislodged joints are identified and remedied to avoid contamination of soil and surface water. At the other end of the scale is the deep-tunnel sewerage systems that are now being constructed in Hong Kong and Singapore (see section 6.8). The systems employ sewage pipes deep below the ground connected to existing pipes and covering a large area. The sewage is then delivered to large central treatment plants. In the case of Singapore there are just two, one at the eastern and the other on the opposite end of the island. Treated sewage is then delivered by undersea pipelines to the sea. The advantage for a highly urbanised and land-short city is that the system frees up land occupied by existing plants that can be used for higher-valued land use. The realised land value together with the gains from economies of scale from the few larger treatment plants offset the high cost of construction.

Details of the various types of sewerage systems are available from standard engineering texts such as Feacham *et al.* (1983). The text by the Association of Water and Sewage Works Consultants Japan (1999) offers a simple and easily understandable source. Appendix I reproduces short descriptions of the various domestic sewage treatment methods from *The Environmental Guidelines for Domestic Wastewater Management* published by UNEP (1988). Various types of small-scale on-site sewage disposal systems are described in Appendix II. There are two basic types: the dry and the wet systems. The dry systems include the pit latrine, composite toilets and the cartage system while the wet system comprises the aqua privy and septic tanks. There are many other variants of on-site systems and various names are given to them as in Table 22.

Table 22 Types of Sanitation Systems

Sanitation system	Suitable for rural areas	Population density where suitable	Construction costs	Operating costs	Ease of construction	Water requirement	Permeable soil required	Off-site facilities required
Pit latrine	Yes	L	VL	L	Very easy	None	Yes	None
VIP latrine	Yes	L	L	L	Easy	None	Yes	None
Twin-pit latrine	Yes	L/M	M	L	Needs builder	None	Yes	None
Pour-flush toilet	Yes	L/M	L	L	Needs builder	Water nearby	Yes	None
Septic tank and soak-away	Yes	L	H	H	Needs builder	Multiple tap	Yes	Sludge disposal
Small- bore sewerage (sewered pour-flush)	No	H	H	M/H	Needs engineer	No	No	Sludge disposal, sewers, Treatment
Sewerage	Yes	H	H	M	Needs engineer	No	No	Sewers, Treatment

Legend: H: High M: Medium L: Low
Source. London School of Hygiene and Tropical Medicine (1988), quoted in JICA (1997), p. 160.

Adequate sanitation and sewage treatment and disposal are essential for protecting the environment and maintaining the health of any community. For developing countries which can ill afford to build and maintain expensive, comprehensive sewerage systems and sewage/wastewater treatment plants, it is imperative that smaller, inexpensive but efficient sewage disposal systems be identified and adopted for use. This is necessary if the problem of pollution of water bodies and the marine environment is to be adequately managed.

Developing a successful sanitation system is a complex social activity depending on planners, administrators, corporation workers and the individual user (Feachem *et al.*, 1983: 119). Sound financial management and sensitivity to local customs and practices are of fundamental importance in ensuring the success of such schemes.

Governments need to examine the feasibility of providing small-scale and inexpensive sewage disposal systems in urban centres unlikely to be provided with large-scale modern sewerage and wastewater treatment plants. This has not been sufficiently explored or discussed in the region but is clearly a matter worth pursuing in the absence of available financial resources in most parts of East Asia. Developing systems based on small-scale sewage disposal facilities, however, is likely to impose heavier demands on management capabilities of city administrations and is no less complex a task compared with implementing large-scale systems. Also, strict enforcement of compliance would be required. The experience of western countries that have successfully implemented such schemes should be examined.

In deciding on the type of sewerage system to be adopted, there are many constraints that must be taken into consideration. Table 22 summarises the main factors that need to be considered in choosing among a number of sanitation systems. For larger systems especially, the availability of land in urbanised areas must be taken into account. In the case of the Manila centralised sewerage systems proposed in the JICA Plan, a comparison (shown in Table 23) is made for the different systems considered for adoption. Table 23 also compares small-scale on-site sanitation systems to large-scale off-site centralised sewerage systems ranking such considerations as technical efficiency, financial and institutional arrangements and community participation possibilities.

It should be noted that the Swedish International Development Co-operation Agency (SIDA) and the International Water Association (IWA) are jointly promoting the concept of ecological sanitation methods encouraging the employment of small-scale community-based solutions incorporating stakeholders. Encouragement should be given to long-term system approaches for sanitation solutions and deploying technologies that convert excreta (and household waste) to valuable resources. Efforts are being made to promote the use of waterless (anaerobic) toilets that utilise the valuable nutrients in excreta.[5]

[5] Information from brochure announcing the 11th Stockholm Water Symposium, August 13-16, 2001, organised by Stockholm International Water Institute (SIWI) and Dr Ausaf ur Rahman (pers. comm.).

Table 23 Comparisons among Various Centralised Systems for Metro Manila

	Inland treatment system (ITS)			Ocean outfall system (OOS)	Improved ocean outfall system
	Small-scale	Medium-scale	Large-scale		
Description	Plan area divided into several areas each with treatment plant	Plan area divided into larger areas each with treatment plant	Plan area divided into fewer large areas each with treatment plant	Collection same as large-scale ITS, wastewater discharged without treatment	Primary treatment is added to OOS before discharging
Environmental impact	No adverse impact on water bodies	No adverse impact on water bodies	No adverse impact on water bodies	No adverse impact on water bodies	No adverse impact on water bodies
Flexibility	Plants can be built first in priority areas	Has some of advantage as small-scale ITS	Local areas affected by long trunk main and remote plant site	Local areas affected by long trunk main and remote plant site	Local areas affected by long trunk main and remote plant site
Effectiveness	Too many plants increases complexity	Intermediate between small and large-scale ITS	Effective central control and operation	Same as large-scale ITS but requires checking Bay water condition	Same as large-scale ITS but requires checking Bay water condition
Investment impact	Each plant is small and investment is efficient	Moderate investment benefits	Initial investment benefit low	Initial investment benefit low	Initial investment benefit low
Comparative costs	Low	High	Very high	Moderately high	Very low

Source. Nippon Jogesuido Sekkei Co Ltd (1996), p. III-15.

Table 24 Comparative Analysis of Sanitation Programmes by Major Selection Determinants

Wastewater	On-site		Intermediate scale		Off-site
Determinant (strategy)	**Black**	**Gray**	**Black**	**Gray**	**Gray**
(1) Technical					
BOD removal (environmental Pollution control)	1	2	2	4	4
Pathogen removal (public health Improvement)	2/4*	2/4*	2/3	2/3	2/3
Process stability	3	2	3	3	4
(2) Economic and financial	4	2	4	3/4	1
(3) Institutional	2/4	2/3	2	2	1
(4) Community involvement	4	4	4	4	1

Legend: 1- poor efficiency, relatively difficult, higher costs; 2 - fair efficiency, not very easy, higher costs; 3 - good efficiency, relatively easy, reasonable costs; 4 - high efficiency, easy, very low costs

Source. International Institute for Hydraulic and Environmental Engineering (1990) from JICA (1997), p. 161.

There is clearly no unique choice for any one situation nor is it easy to choose from many alternatives and options. There are also new technologies now being made available. Countries badly affected by the current financial crisis are likely to be seriously constrained by the lack of funds for building large-scale sewerage systems that require high initial costs. Delays of sewerage schemes, as in the case of Manila, may be due to funding difficulties particularly in the post Asian financial crisis period. Privatisation offers a way out for governments where the costs can be borne by private enterprise and cost recovery based on a user-pays basis. However, the ability of the poorer sectors of the population to pay becomes a matter of concern.

An additional consideration is the design of the system in terms of technology, depending on the level of treatment. The scale of the system is determined by whether it is to cater to existing needs or future demand. If it is over-designed, it can become too expensive to operate and maintain. The availability of trained technical personnel to operate the system is also an important consideration.

The Japanese Johkasou is a sophisticated system built to high standards and especially suitable outside the dense urban areas with large volumes of sewage. It serves small residential communities and operates outside centralised sewerage systems. It can be designed to serve five to 10,000 individuals and is widely used in Japan where there are some 7.8 million systems installed. The system treats wastewater from flush toilets and grey water from households (the gappei-shori system) or for black water from flush toilets only (the tandoku-shori Johkasou system) and is effective in removing pathogens. The system is amenable to modification for developing countries (JICA, 1997b).

9.6 Participation of Private Enterprise

Several countries in the region, including Malaysia, Thailand and the Philippines, have chosen to pass on the provision of sanitation services to private operators. For governments, it is an alternative to state-managed systems in response to the problem of meeting urgent needs and difficulties on the part of the government to keep up with the fast pace of urban growth and industrial and commercial development. Privatisation is also practised in all countries that have privately developed industrial parks and complexes as well as tourist and recreational developments. In all countries, private enterprises are required to build facilities to treat effluent to a required standard before discharging into public sewers. There is, however, a need to monitor such schemes in order to ensure a high standard of performance of private operators. The state would need to render technical and administrative assistance, especially with small private operators. Industries with similar needs for disposing industrial effluent should be encouraged to join together to build common facilities for wastewater treatment. The situation is different in the case of residential development where, in the case of Singapore, the state undertakes the provision of sanitation facilities and houses are connected to the public sewers. In most other countries, private housing development schemes are required to provide their own sewerage systems and sewage treatment plants.

In the case of Manila, the city`s government decided to privatise the water supply and sewerage services. The Manila Water and Sewerage System (MWSS) is to be downsized. It will retain ownership of fixed assets but will transfer operational and investment responsibility to private operators who will act as concessionaires. They will share responsibilitiy for the operation and maintenance of the infrastructure common to the East and West zones. The number of employees working for MWSS would be reuced from 7,400 to just over 2,000 with the concessionaires absorbing 5,100. MWSS will exercise regulatory functions and will monitor performance relating to complaince with the agreement, asset condition and customer service.

Reasons for going the privatisation route include slow procurement, downsizing problems due to political discord, low salaries and financing difficulties. The objectives of privatisation are (1) to shift the financial burden to the private sector; (2) to improve service standards and to rehabilitate and expand the system; (3) to increase operating efficiency; and (4) to minimise the tariff impact on consumers (ADBI, 1999). There is little difference in the objectives between the Manila and the Malaysian cases (see Section 7.6 and the Malaysian Sewage Pollution Case Report).

Dorai and Mohan (2000) report that the task of providing sanitation facilities falls on the Local Authorities in Malaysia. The government launched the National Sewerage Development Programme (NDSP) with the aim of providing modern sewerage systems in all major urban centres in the country. Following this, master plans for sewerage systems were drawn up for 19 major urban centres. However, due to inadequate funding to the Local Authorities, only a few were constructed and most did not even get started. Also for political reasons, it was not possible to raise tariffs to a level sufficient to pay for such large undertakings. The authorities were also plagued with lack of expertise and skilled manpower to operate these systems. Initially, the private sector was involved only in consultancy and construction of the systems. Numerous septic tanks and community treatment systems were built and the Local Authorities were unable to deal with the problem of operating and maintaining these systems. A number of Local Authorities contracted out the operation and maintenance work to private contractors with mixed results. There were problems of contract packaging, specifications and supervision of the work carried out. It became clear that the government could not meet the needs of a rapid pace of development and urbanisation. The decision was to go the privatisation route but on the basis of a limited period concession for a complete privatisation of sewerage services.

Accordingly, the Malaysian Government enacted the Sewerage Services Act (ASA) that confers upon the Federal (central) Government the executive authority pertaining to matters relating to the provision of sewerage services in the country. The Office of Director General of Sewerage Services (DGSS) was created and it has the authority to privatise all aspects of sewerage services. The Department of Environment (DOE) under the Ministry of Science and Technology is responsible for the Environmental Quality Act and matters dealing with sewage comes under its jurisdiction. A Concession Agreement was drawn up in December 1993 awarding a 28 year contract to a single private company, Indah Water Konsortium (IWK). Details of such matters as the scope of concession, target of coverage, catchment planning and tariffs are given in Dorai and Murugian (2000).

Dorai and Mohan (2000) who work for IWK discuss the following problems encountered:

- Underestimation of the magnitude of the overall task
- Unclear and incomplete specification of the role of the various players including government agencies leaving many intractable problems to the concession company
- Insufficient customer acceptance
- Lack of understanding of the workings of the sewerage system on the part of the people leading to

- Resistance to tariffs for desludging services that are higher than previously charged
- Financial difficulties face by the concession company as a result of the above
- Lack of locally available manpower and technical skills

Apart from the above problems listed, Dorai and Mohan (2000) give a list of difficulties encountered. In order to reduce the pressure on the concession company, the government provide soft loans to it particularly for upgrading works and for expanding the systems using newer technologies. The authors also suggest a thorough review of the experience gained, clearer definition of the role of all stakeholders, stronger political will.

9.7 Disposal and Re-use of Sludge and Treated Water

Sewage may be regarded as a resource (Table 25) rather than simply waste matter to be dumped into the environment. Biogas reactors designed for village-scale use have been in existence for many years, and are used in China and Viet Nam. In the construction industry, sewage sludge has also been used to make bricks and other building materials. In Malaysia, an estimated 12 million tonnes of animal wastes were produced by cattle, swine, poultry, sheep and goat in 2000 (Choo and Yogendran, 1989 cited in Fauziah and Rosnani 1996). Animal wastes and domestic sewage can be used as fertilisers especially on sandy soils, for vegetable production and algae and fish cultivation. The composition of animal manure varies according to the type and age of the animal, feed consumed, bedding used, and waste management system. Chicken dung is often mixed with inorganic fertilisers with favourable results for vegetable growing. In Malaysia, inexpensive natural gas makes it uneconomic to use animal waste for generating biogas.

Table 25 Nutrient Content of Animal Waste and Sewage Sludge

Waste	N (%)	P (%)	K (%)
Cattle dung	2.00	0.65	2.00
Poultry dung	3.99	2.10	1.52
Pig dung	1.90	1.30	0.34
Goat dung	2.00	0.87	2.17
Sewage sludge	2.62	0.64	0.11

Source. Fauziah and Rosenani, 1996, p. 34.

The land application of night soil has a long tradition in the agricultural practices of many cultures in the region. If the night soil or sewage sludge is properly composted, it can make an excellent soil conditioner and fertiliser. Nitrogen is valuable especially for crops with a long growing season. The organic content of the sludge can help improve the soil structure and helps to stimulate beneficial biological activity in the soil [http://www.etc-waste.int/Activities/0000224.htm]. If separate sewers are used, the sludge produced does not contain plastics and is therefore preferred as a fertiliser. However, sludge and night soil contains a large number of pathogens that may threaten human health, and so careful handling and processing is necessary. Sewerage systems, especially those that serve industrial areas, deliver wastewater that contain toxic substances such as heavy metals. It is therefore desirable to set limits for contaminant concentrations in order to protect the soil and humans from pollution. The Japanese Johkasou system was developed with the specific target of returning night soil as fertiliser to crop land (JICA, 1997b).

Treated sewage effluent may also be a resource, especially in water stressed areas. In the western states of the USA, treated sewage effluent has been used for many years as nutrient rich irrigation water. There are plans in Thailand to use treated wastewater to irrigate coastal mangroves and to create a water mound to protect the heavily depleted and increasingly polluted groundwater reserves in the Bangkok region (Yuwaree and Taylor, 1998). Treated water can also be used to water golf courses, public parks and roadside plants. It can also be used for irrigating reforestation areas and to recharge underground aquifers (Manning and Kirkman, 1993). Along coastal areas, this may help to prevent salt intrusion especially where water is withdrawn in large amounts for domestic and other uses.

In Singapore, the Jurong Industrial Water Works was built in 1966 to produce a supplementary source of water for the industries in the Jurong Industrial Estate. The plant treats the effluent from the Ulu Pandan Sewage Treatment Works and had an original designed capacity of about 45,000 cu m per day. It was expanded in 1992 to 65,000 cu m/day and subsequently, in 2000, to the present capacity of 125,000 cu m per day. The treated water is stored in a reservoir from thence it is fed into a separate underground piping system for industrial purposes. It serves about 50 factories in the Jurong and Tuas industrial estates. The treated water is used for cooling, washing and processing purposes. Factories using the water include the paper, textiles and steel mills, chemical plants, shipyards and a petroleum refinery. The factories are charged at a rate of S$0.40 per cu m of industrial water consumed subject to a minimum of $50 per month.[6]

9.8 Financial Management

The World Health Organisation suggests that adequate financial management is essential if there is not to be service disruption or environmental health degradation after sanitation systems are installed. Any sanitation system installed must be sustainable in terms of cost containment. This includes having enough funds to implement the system, as well as the financial liquidity to keep such systems in good working order. Ideally there should be a strong partnership between the end user and the agency responsible for sanitation (WHO, 1994). Ideally such systems should be developed on the basis of the user-pays principal, but this may not be practical where a monetary economy has not developed sufficiently or where the level of income is low, especially in squatter areas.

Nevertheless, cities with existing problems may need to take mitigation action and implement less costly but practical ‘second-class’ solutions to immediate problems while building up their capacity to implement ‘first-class’ solutions. For example, the aeration of ditches, canals and stagnant waterways in Bangkok proved to be an inexpensive and effective measure to raise the natural assimilative capacity of these water bodies and stop anaerobic conditions from developing. In effect this coverts Bangkok’s existing open sewers into sewerage treatment plants with no objection by the inhabitants and minimal social impact, while reserving the ponds to retain run-off for flood control (*Asian Water and Sewage*, May 1997).

6 Pamphlet issued by the Ministry of the Environment, Singapore.

9.9 Social and Cultural Considerations

The local social and cultural conditions need also to be taken into account when designing and implementing sanitation systems. For example, the choice of canal cleaning material used by the community may prove incompatible with the disposal system selected and cause it to malfunction. Other cultural norms may dictate that separate facilities need to be provided for men and women, or that privacy needs to be respected in the design of public toilets.

In many rural areas people may find the bush more acceptable and more comfortable than pit latrines. This is especially so when latrines are hot, malodorous and fly ridden. It is therefore important that sufficient health education be given on the importance of maintaining hygiene and the practical aspects of using latrines.

There remains the essential long-term need for countries to develop educational and public awareness programmes to impart knowledge on the proper sanitation and health care related to problems of sewage pollution. Here, community participation can be usefully employed to reduce the incidents of contamination and misuse of public facilities.

10. SOCIAL AND ECONOMIC OPPORTUNITIES AND CHALLENGES

Most countries that share the borders of the South China Sea have identified hot spots and sensitive areas caused by land-based pollution, including sewage, that have adversely impacted on the marine environment. Figure 6 in Talaue-McManus (2000) identifies hot spots associated with large urban centres, some along major rivers in inland locations. In addition, there are also hot spots associated with China's many very large cities that dump large quantities of sewage into rivers and coastal waters. There are hot spots in South Korea in coastal waters downstream of the Han River that flows through Seoul and other major cities in that country. Many of the East Asian countries reviewed are also seriously concerned with sewage pollution of rivers and freshwater bodies.

10.1 Opportunities Arising from Provision of Proper Sanitation

Countries in the region are well aware of the benefits of eliminating sewage pollution arising from the reduction of the high costs of pollution induced illnesses and deaths from contaminated water supply and other direct and indirect contagion of waterborne pathogens. Common intestinal diseases are endemic in many cities and tap water cannot be drunk without boiling or treatment. In some cases, sewage pipelines are built over water supply lines and contamination due to leakages are frequent in cities that do not maintain sewage lines properly.[7] A study on water pollution-related diseases including typhoid and paratyphoid, diarrhoea, acute poliomyelitis, infectious hepatitis, and schistosomiasis in Metro Manila found 7,048 deaths in 1988 and 4,660 deaths in 1992 while morbidity cases of all ages was 405,000 in 1988 and 633,000 and for those employed, 47,000 and 252,000 for the same two years (Cortez, Logarta & Bennnagen, n.d.). Any contraction of the health costs and loss of human lives would be very considerable and would help to justify the construction of expensive centralised sewerage systems and sewage treatment plants in the city.

[7] This is shown to be the case in Karachi, Pakistan where the total sewage treatment capacity is less than 15 per cent of the water consumed in the city and many cities in the East Asian region are in similar situations (Rahman, 2000)

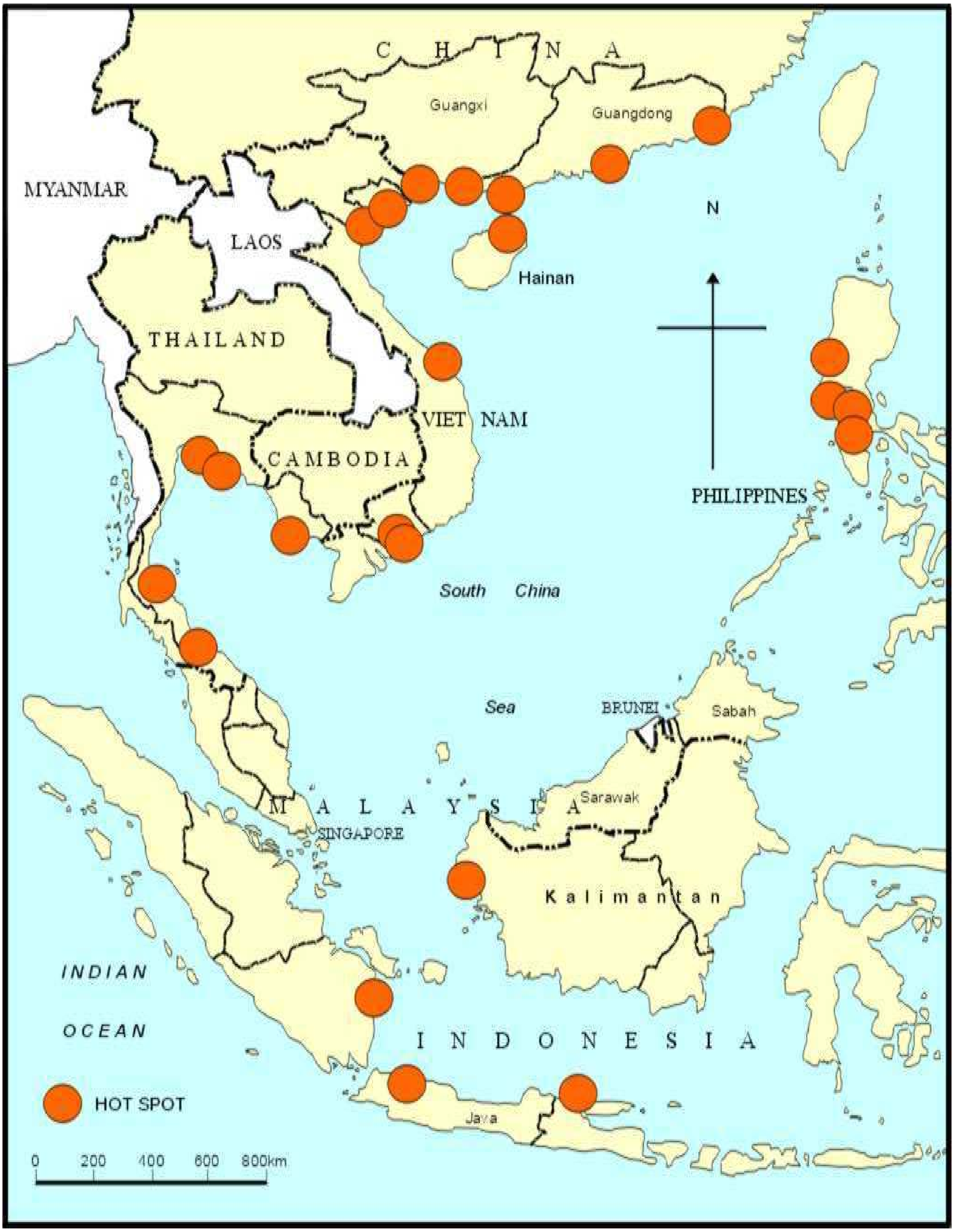

Figure 6 Marine Pollution Hot Spots in South China Sea Countries.

There are opportunities for building a good image of clean cities that offer safe drinking water and uncontaminated rivers and coasts that attract more international visitors. The news reports of high counts of *E-coli* in the coastal waters of the famed Boracay resort area drove many tourists away although the effects were temporary, with assurances of the problem being controlled (see Chia, 2000 for case study on the Philippines). The decision by the Thai government to install a second sewage treatment plant in the tourist destination of Pattaya was partly aimed at this objective. Similar decisions were made in Malaysia's Batu Ferringgi Beach Resort in Penang. In many cases, action was taken only when there were protests from local residents whose livelihood was affected by the discharge of untreated sewage.

The foregoing overview gives details of widespread incidents of red tide in coastal China and Hong Kong. One estimate puts the direct economic losses from 45 major red tide incidents between 1997 and 1999 at US$240 million. In a single case, red tide killed 1,500 tonnes of farmed fish with an estimated loss of US$32 million in Hong Kong (see Section 8.5). As part of a massive pollution control effort, China has invested heavily on building sanitation infrastructure and it is in part aimed at controlling the problem of increasingly severe red tide outbreaks across the coastal waters of the country. Clearly, any success in reducing eutrophication of the sea from discharge of sewage and other pollutants will help to reduce the severity of red tide outbreaks and diminish the cost to fishermen, marine farmers and cut down the incidents of health hazards to consumers of these products.

It is clear that with strong political will it is quite feasible to obtain the necessary technical inputs and financial resources to build large-scale centralised sewerage systems and sewage treatment plants. The World Bank, Asian Development Bank and development assistance from countries such as Japan, Australia and others have been forthcoming in providing grants and loans for this purpose. In spite of severe constraints arising from the financial crisis, Thailand has built a much needed large-scale centralised sewerage infrastructure in Bangkok. The country also built many more sewerage systems in other smaller urban centres, but, according to a JICA source, many of these systems were not put into operation because of too large a designed capacity and the lack of operating funds and technical personnel.[8] Controversy surrounding the Samut Prakan wastewater project provides some insights into lessons and opportunities for other city administrators and governments (see Section 10.4).

10.2 Opting for Medium and Small-scale Sanitation Schemes

Given the high cost of large-scale systems and the rapid growth of many Asian cities, serious attention must be paid toward looking for opportunities of opting for smaller-scale facilities. For the Metro Manila sewerage system JICA proposed a less expensive but still efficient system from among several other options. Also, the scheme covers some 30 per cent of the city's area leaving others to private operators and to smaller on-site systems for smaller and less densely populated communities. Recommendations were made to adopt the flexible Johkasou system and a similar Korean system but modifications are likely to be necessary to reduce the cost of operation. Such schemes may be considered also for smaller urban areas in the region. The JICA report (1998) warns that on-site systems require more frequent desludging and that the problem of proper disposal untreated sludge needs to be resolved.

[8] Yamamoto, K. senior technical advisor, Japan International Cooperation Agency, Tokyo (personnel communications).

There should be considerable opportunities for environmental engineering firms which are already offering services to industrial plants, to create business opportunities in building small and medium sized sanitation facilities. It is likely that there will be a need for government agencies to render technical and partial financial assistance to make many of these projects commercially viable. In any case, fee collection will likely require the cooperation of government agencies.

10.3 Privatisation

Privatisation of building, operating and maintaining sewerage facilities and sewage treatment plants is widely accepted within the East Asian region with the adoption of the polluter-pays principle. The exception is Singapore where wastewater disposal is undertaken entirely by the Ministry of the Environment, although the collection and disposal of garbage and toxic wastes are mainly privatised. It is possible that, when the deep-tunnel sewerage system is completed and in operation, it may come under private management as is the case with the provision of energy by Singapore Power Pte Ltd.

In the case of Malaysia, the experience of privatising sanitation services and upgrading and rehabilitating rundown sewerage treatment plants in the country by Indah Water Konsortium (IWK) and other private companies has not met with success (see Section 7.6 and Malaysia Country sewage report). The reasons for the failure include insufficient technical and management expertise, lack of funds, inadequate pre-publicity and consultation with the public coupled with lack of transparency. Eventually the government took back the responsibility of the operation and management of the numerous systems in the country. In the Philippines, the collection and disposal of sludge and the construction of septic tanks used by most households are undertaken by private enterprises but the result has been unsatisfactory (see Section 9.4.2). In 1998, Manila awarded contracts to two private consortia to run the city's water and sewage services (1998c). It is not know how well this new approach has helped to improve Manila`s sanitation services.

While there is a need to undertake a thorough investigation of the experience of more countries with privatized sanitation services, it is clear that there is no guarantee that this will offer a solution to the provision of these services. The Singapore model of the government taking full responsibility of sanitation in the country may not be appropriate for other cities in Asia. This and the experience of other countries suggest at least the following conditions relating to privatization:

- It is important to gain credibility in the eyes of users through a track record of sound management experience;
- Careful planning of a programme of pre-publicity and consultation with key community groups to gain confidence and acceptance by the public. Full support by the relevant government authorities is also essential;
- A thorough study of the costs of operation and maintenance of the sewerage system and wastewater treatment plants should be undertaken to ensure that the most appropriate systems are built and that there is sufficient revenue to cover all expenses with a reasonable return of profits to the operator;
- Selection of suitable private enterprises, both local and foreign, to be granted the right to provide sanitation services should be based on proof of their technical capability and financial capability;

- There should be a system of licensing of all such accredited operators and, where necessary, a bond imposed to ensure the delivery of efficient services;
- Fees charged should be based on a user-pays principle and they should be within the means of the majority of households and deemed reasonable;
- The government may need to provide a subsidy in the construction of the facilities, cover a part of the operating costs and consider this to be part of providing an essential basic social service; and
- The government should monitor the management of the sanitation service, provide technical assistance where needed, and undertake periodical audits of the private enterprises concerned.
- Technical and management training may be necessary.

The Asian financial crisis that began in mid 1997 has seriously constrained the capacity of governments to meet the very considerable financial requirements of building large centralised sewerage systems and sewage treatment plants. For megacities of over five million people a comprehensive coverage of the densely settled city cores costs in the order of a billion dollars. Many governments have turned to private enterprises to remove the financial burden with the belief that they can find the necessary funds and technical expertise to undertake the task of providing sanitation services. If properly managed, public-private partnerships (PPPs) offer very substantial opportunities in meeting existing needs of urban centres and providing timely facilities and services to fast expanding urban areas. Over time the country can build up the necessary technical and management capability to offer high-quality services and raise awareness of the general public of the importance of good sanitation and safe water. Achieving this goal of involving effective PPP is also in keeping with the institution of EIAs and broader participation of both industry and the general public.

10.4 The Experience of the Construction of Bangkok`s Samut Prakan Wastewater Treatment System

The Samut Prakan Wastewater Management Project, expected to cost a total of 22.95 billion baht, was approved in 1995 and construction began in February 1998 and is expected to be completed by 2002. A chronology of events related to the project is given in a *Bangkok Post* report (28 May 2000). The initial feasibility study was funded by the Asian Development Bank in 1992. An ADB grant of US$350,000 was given to the National Environment Board for this purpose. Some 80 % of the wastewater comes from factories, 10 % from households and the rest from commercial establishments. It will benefit 600,000 people and 6,570 factories in the area. The Pollution Control Department (PCD) revealed that of the 26 wastewater treatment facilities only five were fully functional (Janchitfah, 2000a). The project has turned out to be highly controversial and there are many newspaper reports on it. It was reported that the Science, Technology and Environment Minister had ordered the Counter Corruption Committee (CCC) to investigate the safety requirements and alleged irregularities in the project's bidding process and contract (Inchukul, 2000a). Local residents in the Klong Daan district have the following objections to the project:

(1) the wastewater plant is not designed to treat heavy metals and hazardous chemicals though most of the inputs will be from factories,
(2) the treated water could contain hazardous chemicals that may damage coastal fisheries and the local economy,

(3) the project site is vulnerable to sea erosion, flooding, land subsidence and acidic corrosion,
(4) economic returns of the project are highly questionable,
(5) there were irregularities in the purchase of the land for the plant,
(6) the process of decision-making at the local government level was not transparent,
(7) the project violates the constitutional rights of the local communities, and
(8) the project violates the country's environmental and industry laws (Janchitfah, 2000b).

In March 1999, a group of 84 local residents in the fishing community met and set up a committee. They were able to raise over 240,000 baht in just one day. The protestors called for a public hearing committee to be established (*Bangkok Post* 23 July 2000). Earlier, the Deputy Prime Minister, Suvit Khunkitti, had threatened to dissolve the Wastewater Management Authority set up in July 1995 on grounds of its ineffectiveness. The blame was shifted to the Science, Technology and Environment Ministry that did not provide for an adequate budget and the required staff support (Inchukul, 1999b).

The Pollution Control Department released a statement based on the findings of technical experts giving technical details of the extended aeration activated sludge (EAAS) system and claimed that the plant is capable of treating more than 100,000-500,000 cu m/day of wastewater. The designed system is expected to be efficient and the electricity costs will be only 1 baht per cu m. The project has a five-step strategy to overcome the problem of odours including setting up a 700 m buffer zone from the boundary of the plant site to the nearest residential areas and 1.5 km from the main odour generating units. The treated water will be discharged into the inner Gulf of Thailand where the nitrogen load should be diluted. The current situation of contaminated waterways and coastal areas will improve with the removal of untreated wastewater. The system will reduce nitrogen and BOD levels by as much as 95 per cent and 65 per cent, respectively. Total nitrogen concentration will be about 15 mg/l, better than the 20 mg/l target set. The treated water will have a BOD of less than 20 mg/l and suspended solids of less than 50 mg/l well within the permissible standards. Overall, up to 95% of the pollutants will be removed by the Samut Prakan system (Janchitfah, 2000a). On the question of suitability of the site for the plant, assurance was given that the design of the plant takes into account the problem of land subsidence in the area (Kanwanich, 2000).

Based on an estimated 525,000 cu m/day of wastewater, some 36,000 tonnes of sludge will be produced each year. Without the plant this would have been dumped into the canals (*klongs*) or into the sea. Two large storage basins will have the capacity to hold sludge for five years. A study was conducted to determine the market for treated sludge. Secondary sludge can be used as a soil conditioner and has other uses. In the Bang Poo and Bang Phli industrial estates more than 20 % savings will be realised by these estates by being connected to the new system. Otherwise, the cost of maintaining and upgrading the existing system will be substantial. (*Bangkok Post* 28 May 2000). In a separate report, the project is said to give a two % financial return and an 18 % economic return. Some factory owners are reluctant to join in the new project as they already have their own system that already cost them 50 million baht to build. The Bang Phli Industrial Estate treats wastewater at just 10 baht per cubic metre while the PCD charges 12 baht/cu m (Janchitfah, 2000a).

The experience related in the media of the construction of the Samut Prakan Wastewater Treatment Plant offers some important lessons in the provision of sanitation facilities. It is complicated by the involvement of not only residents but also factory owners and commercial operators affected by the construction of the facility. There is clearly considerable ignorance of the benefits and risks of the plant indicating once again the need for a careful programme of pre-publicity and greater transparency. The situation quickly became politicised in contrast to the total silence from the public in the case of Singapore`s construction of the massive deep-tunnel sewage system. The difference being the high credibility of the Singapore authority and the already established system of fee collection in the latter case. In addition, the siting of the facility became a major issue in the Samut Prakan case and much time and effort could well have been saved with proper community consultation.

10.5 Recycling and Re-use of Sludge

In rural agricultural communities, night soil is traditional used as a fertiliser for growing vegetables -- but not wet padi -- although it brings along considerable human health risks. Replacing this with treated sludge as fertiliser greatly reduces the health hazard. Small amounts of untreated sewage can be used to fertilise fish ponds but there is the same reservation. Untreated sewage or treated wastewater can also be used to irrigate parks, gardens and forests although there is need for proper collection and delivery of the material. Groundwater recharge using domestic wastewater offers a means of disposal and enables wastewater to restore water to a quality suitable for reuse. It also helps to raise the water table and fertilises the soil (UNEP, 1988). There is also considerable opportunity for the use of recycled water, i.e. treated wastewater to a sufficiently safe quality for industrial use and even for human consumption. A recently reported case of a wastewater treatment plant in Bedok, Singapore, is producing `newater`, drinking water of a high degree of purity. New technology using superior filters and membranes has made it possible to recycle water on a large scale. This facility together with seawater desalination will help the country to meet the additional need for potable water for at least 15 years (Teo, 2001) and already the Jurong plant is producing recycled water that supplies 5 per cent of the water for industrial use. For urban areas in dry climatic conditions or with a pronounced dry season, this option constitutes an important opportunity for conservation of scarce water resources.

A well-appreciated opportunity is the use of treated sludge for a variety of uses: fertiliser, road building, construction and landfill material. Sludge from human waste does not comprise toxic substances and, if it is delivered in separated pipelines, can be used to produce good quality sludge for agricultural and house garden fertiliser. For land-short cities, sludge can be burnt in incinerators to produce electricity and has the effect of reducing bulk as in the case of Singapore where recently the treatment of sludge to produce useful material has been made mandatory. A major problem for many cities is the shortage of dumping or landfill sites. Incineration offers one solution to this problem. In smaller urban settlements, sewage can be treated to produce biogas that can be used as a source of energy to supplement and reduce the use of electricity. Mention has been made of the Japanese Johkasou system that has been developed with this objective in mind.

Attention has been drawn toward the use of waterless or dry sanitation instead of water-borne methods of sanitation. The former are a well-tested and valid alternative especially for rural, low-density, low income areas as well as in high-density low-income areas. These systems are based on urine-separating toilets, with no or little water added. This method reduces the use of valuable water that is in short-supply in many cities especially in dryer regions. It also generates fertilisers both from urine and solid faecal material (see Falkenmark, 2000).

10.6 Political Will

Among the East Asian countries reviewed, there are some cases of success in the battle against sewage pollution. The successes of China including Hong Kong, South Korea, Malaysia and Singapore only serve to highlight what can be done to meet the challenges of providing an urban environment that is safe from pollution by sewage. Clearly the benefits, both existing and potential, of rapid development must be weighed against the high cost of environmental degradation and adverse impacts arising from sewage pollution on health and the loss of quality of life of urban inhabitants and communities. This can only be achieved by exercising a high degree of political will to set aside always limited financial resources. Privatisation and the judicious use of small-scale alternative systems can be employed to great effect. There remains the critical element of political will on the part of the respective governments to push through complex and costly management schemes to provide proper sanitation for urban residents. From the experience of several countries, long-term physical planning coupled with carefully laid education and training programmes and good use of the media ensure success and smooth implementation of sanitation schemes.

10.7 Regional/International Co-operation

East Asia should recognise the critical need to provide proper sanitation in urban areas. There are considerable opportunities for regional co-operation at least in the Association of South East Asian Nations (ASEAN) where there is a permanent committee of ASEAN Senior Officials on the Environment (ASOEN) where regional environmental matters are dealt with. Over the years, there have been a number of environmental agreements made including the 1981 Manila Declaration on the ASEAN Environment and the 1984 Bangkok Declaration of the ASEAN Environment, the 1987 Jakarta Resolution on Sustainable Development and the Kuala Lumpur Declaration on Environment and Development. Under the Asia Pacific Economic Cooperation (APEC), there is a Ministerial Declaration of the Declaration on Environmental Sound and Sustainable Development (see Sakumoto 1995).

The efforts of ASEAN has not been sufficiently focussed on dealing with sewage pollution and there is a need to move toward the European Union (EU) programme of adopting a common set of laws and regulations, pollution standards, regular reports of the status of sewage management in member countries (see European Commission, 2000). The EU has the authority to monitor compliance with and enforce regulations adopted. In this regard, ASEAN (and East Asia) has still a long way to go to emulate the achievements of the former, but this is the challenge for the region. There are considerable resources within the East Asian region that can be effectively used to meet the need to undertake massive training of technical and management personnel required to implement a long-term programme of sewage management. Much can be learnt from an exchange of information and educational programmes within the region.

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APPENDIX I TYPES OF DOMESTIC SEWAGE TREATMENT SYSTEMS

The Environmental Guidelines for Domestic Wastewater Management published by UNEP (1988) offers a short description of the main types of sewerage systems. Brief descriptions of the systems are presented in order of increasing mechanisation and complexity.

(1) Anaerobic ponds and lagoons (primary treatment) - can be used as a primary phase of treatment in warm climates. They require no power specialised equipment. No algae activity or aeration is involved and hence they can be deep and have relatively low land requirements. Effluents generally require further treatment before discharge into receiving waters or re-use on land. They can reduce BOD by 30-70 per cent. There is an odour nuisance and should therefore be sited downwind or at some distance from settlements.

(2) Waste stabilisation ponds (primary/secondary/tertiary treatment) - These are the most simple of all comprehensive waste treatment processes. The incoming wastewater is held in shallow pond for a relatively long detention period (up to 20 days) to allow organic matter to be stabilised by microbial activity. Passing through a series of such ponds yield a virtually pathogen-free treated water. In the maturation pond or fish pond the degree of treatment is considered tertiary. The system operates under natural conditions and requires no sophisticated equipment. Where abundant land is available and in warm tropical conditions, the process is simple, efficient and reliable.

(3) Mechanically aerated lagoons (secondary treatment) - Mechanically aerated lagoons use 10-20 per cent of the land compared with stabilisation ponds because of their greater depth (2.5-5.0 m) and shorter retention time. They give BOD removals of 79-90 per cent in the treatment of domestic sewage. Coliform removal is between 90-99 per cent under warm conditions using single-celled lagoons. Aerated lagoons can be easily upgraded both in volume and in aeration capacity in response to population increases or to higher quality effluent requirements.

(4) Trickling filters (secondary treatment) - This is an attached growth system using a fixed bio-film on a solid medium (stone or plastic). High BOD removal is accomplished by transference from percolating wastewater to the bio-film. In addition to domestic sewage, the process can tolerate and treat certain concentrations of toxic substances such as cyanide, phenols, and formaldehyde. There are two types of trickling filters -- low and high rates. Low-rate trickling filter is a low capacity system useful for small communities because of easy, reliable and energy-efficient operation. Construction is simple, local materials can be used. Pumping can be avoided by using the natural slope of the land. High-rate filter is useful in situations with large flows of domestic wastewater. Settling of solids in ponds is required before and after filtration. Sludge must be removed on a continuous basis and requires further treatment. Good plant design and operating practices are necessary to guard against odour nuisance arising from sludge production and storage.

(5) Activated sludge process (secondary treatment) - This is more complex than the trickling filter process but relies on the same basic biological principles. The surplus sludge must first be removed and treated. It is considered less robust than the trickling-filter method. About 20-30 per cent nitrogen removal occurs in conventional activated sludge plants. A major advantage of this process is the relatively low land requirement.

(6) Tertiary treatment plants - These are designed to remove specific wastewater constituents. They can be highly complex in design, construction and operation and require highly trained personnel.

(7) Chlorination -- Treated wastewater is sometimes subjected to disinfection by chlorination. This is expected when the treated water is used for drinking, bathing and irrigation purposes. Chlorination does not, however, yield a pathogen-free effluent. In addition, the chlorine itself can be considered a pollutant. The de-chlorination of effluents may therefore be a necessary step to regulate the toxic effects of chlorinated effluent in the aquatic environment.

APPENDIX II SMALL-SCALE SEWAGE TREATMENT SYSTEMS

The following describes a variety of small-scale systems that are in use in Asia and elsewhere. Large systems are expensive to install and require considerable financial outlay to operate and maintain. Most Asian cities, and many elsewhere in the world, are either without such large-scale centralised sewerage systems or have only a small part of the cities served by such systems. The proper installation of sewerage pipes and the expansion of the system of pipes, pumping stations, and sewage treatment works will be expensive in already built-up urban areas. In any case, smaller on-site sanitation facilities are necessary for urban areas not serviced by centralised systems. Hence, attention should be given to small-scale systems described below.

Sewage/Excreta/Night Soil Disposal Systems: Dry Systems

THERE ARE TWO BASIC TYPES OF DISPOSAL SYSTEMS – THE DRY AND WET SYSTEMS.

(1) PIT LATRINES

Pit latrines are the simplest of all on-site disposal systems. Excreta falls into a hole in the ground and a new pit is dug when the hole is about two-thirds full. However, adequate community involvement and health education is required so that community members know how to use it and keep it clean. Fouled and unhygienic latrines become a focus for disease transmission and may make health matters worse than before sanitation intervention. Even if they are well kept, pit latrines are often malodorous, and are likely to be shunned. However, odours can be virtually eliminated by fitting a vent pipe to the pit, i.e. a ventilated improved pit (VIP) latrine. As long as the pits are filled up when about two-thirds full and not reused for longer than a period of one year, pathogens are unlikely to survive. Still, pit latrines may pollute groundwater, and this becomes a concern when groundwater is used as a water source (Feachem *et al.*, 1983: 67–68).

(2) COMPOSTING TOILETS

There are two basic types of composting toilets, continuous and batch. Both require the addition of a carbon source such as garbage, vegetable leaves or sawdust. For the latrine to work effectively, a lot of organic material must be added. The continuous composting toilet has been developed in Sweden, but has no widespread application in the developed world. This is basically a two-chamber unit allowing humus to be removed periodically. Continuous compost latrines work aerobically, and the presence of a vent pipe makes the latrine virtually odourless.

Composting toilets work well within a narrow range of operating conditions. Generally the moisture content of the compost should be between 40 and 60 per cent and the carbon/nitrogen ratio between 15:1 and 30:1—this is the reason why organic matter must be added. They are attractive in areas where water for flushing is limited or where they are cheaper than conventional sewerage systems to abate pollution of the environment. For example, the entire Swedish province of Tanum is converting to composting toilets to reduce pollution of beaches and damage to fisheries (*Asian Water and Sewerage*, March 1997b).

The batch composter is used widely in China and Viet Nam, and the most usual design is the double vault where one vault is in use while excreta is allowed to compost in the other. Unlike the continuous composters, batch composters work aerobically and produce foul gasses that need to be vented (Simbeye, 1980: 32). The advantage of such systems is the production of compost, which may be applied to crops (Feachem *et al.*, 1983, 68–74).

(3) CARTAGE SYSTEMS

Where on-site disposal systems are impractical, e.g. in an urban areas, cartage systems by which night soil may be removed periodically from containers or near the house are more appropriate. One of the oldest, and the generally least hygienic, is the bucket latrine. A squatting slab or seat is position above a bucket, which is filled within a few days. The bucket is positioned adjacent an outside wall and is accessible from the street or back lane. A night soil collector will call regularly (preferably every day, but typically once or twice a week) to empty the bucket. In more sophisticated systems, the excreta (and the small amount of water used for pour flushing and anal cleansing) are stored in sealed vaults under or beside the house and removed by a vacuum truck approximately once every two weeks.

Both systems can provide sanitary waste disposal if they are hygienically maintained. The bucket and vault should be large enough so as not to overflow and contaminate its surroundings. While bucket latrines are almost certain to be malodorous, and discourage use, vaults can be ventilated, making a hygienic and pleasant latrine. Increasing the frequency of collection and the use of water seals and fly screens can reduce the possibility of fly breeding (Feachem *et al*., 1983: 74–77).

The collected night soil can then be disposed off by mixing with sewage and treated in a typical sewage treatment system, dewatered and digested, composted, or sluiced into waste stabilisation ponds. Following adequate treatment, night soil may be used for agriculture, aquaculture or gas production.

Sewage/Excreta/Night Soil Disposal Systems: Wet Systems

Wet (or sewage) systems may be used for washing where the household uses larger volumes of water and a significant amount of sullage or 'gray water' is produced. There are advanced technologies and are generally more expensive and complex than dry systems (Droste, 1982: 157). Two common on-site systems are the aqua privy and the septic tank.

(4) AQUA PRIVY

The Aqua privy is a device that can handle faeces and urine with an input of water (which may include sullage from wash water). However, other sources of organic or solid waste, e.g. corncobs, rags or other materials for anal cleansing, are generally unsuitable inputs for the aqua privy.

The aqua privy is basically a drop pipe with a water seal leading to a holding tank where the waste is treated by sedimentation and anaerobic digestion. It is important to maintain the water seal, and enough water must be added to maintain the water level above the pipe opening. Also the holding tank needs to be periodically desludged. Effluent from the aqua privy is discharged into a soakaway pit or a sewer.

(5) SEPTIC TANKS

Septic tanks are similar to aqua privies, but are meant for households or other establishments using flush toilets and receiving piped water. Septic tanks are also suitable for larger establishments such as a condominium block, hotels or army camps. Within the tank, the sedimentation of solids and bacterial digestion help reduce the organic load and relatively clean effluent is discharged to leaching (seepage) fields or sewers. Like aqua privies, septic tanks also require periodic desludging if they are to work effectively.