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The Impact of Economic Development on Water Pollution: Trends and Policy Actions in Malaysia

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Abstract The paper examines the impact of development activities on water pollution in Malaysia. Hence, the main objective of this paper is not just to examine the trends of development-induced water pollution around the region of the country but to know where the problems are and the policy measures taken by the government. It evaluates the probable causative relationship between problems introduced due to technology employed in water pollution control and governmental policy measures. It examines the relationship between development indicators as sources of pollution and polluted rivers over a period of 12 years. The findings of the paper have shown that despite the policy enforcement actions against the identified sources of water pollution, all the three development indicators (chosen based on those identified sources) still accounted for high percentage of river pollution in Malaysia. The findings of the paper were used to identify the central fact of the location of the problem. Some crucial conclusions of where the problems likely to be, as reflected in the findings, are: (a) the issue of interactive-effects between pollutants that many policy-makers are not aware of. This is when policy measures concentrate only on one source of water pollution; (b) the enforcement strength and/or effectiveness of policy measures themselves; (c) financial constraints to invest in appropriate technology especially sewerage systems for controlling human source of water pollution in the country; as well as those confronting small polluting industries (d) finally, lack of cooperation between government and private business firms to comply with regulatory policies for water pollution control.

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1 Introduction

Water is the basic unit of life. The nature of the water cycle implies that pollution control, water supply and effective sewerage system in a country are parts of the closely knitted elements of water resources management. In Malaysia, about 95% of water source comes from the inland river systems. As the country moves towards the realization of its vision 2020 (i.e., becoming a developed nation) through the implementation of its policy agenda for heavy industrialization, infrastructures, and urban-expansions, the water demands increase steeply and there is greater pressure to preserve the current water resources as well as to find alternative course of actions to improve the water quality. In other words, the consistent and rapid growth of urban-industries in Malaysia has undoubtedly resulted in an increase in economic well being of the citizens on the one hand. However, they had also led to water pollution around the regions of the country.

2 Structural Pattern of Water Pollution and it Sources in Malaysia

Industrial development in Peninsular Malaysia has made significant beneficial contributions to the country's overall economic development. It has generated employment, promoted socio-economic and infrastructural development. However, it has profound effects on the environmental resources because all industries require the use of both renewable and non-renewable resources from the environment. It is obvious that the conversion of these resources into finished or semi-finished industrial products results in residues that are often discharged as wastes into water. These wastes are in solid, liquid or gaseous forms and when discharged indiscriminately could adversely affect the quality of the water.

According to Table 1, approximately 2,292 industries have been identified as significant water pollutant sources in Peninsular Malaysia by the Department of Environment (DOE). The major potentially polluting industries were 928 (40%) food and beverage factories, 324 (14.1%) rubber producing premises and 270 (11.4%) chemical producers. Based on the distribution of water pollution sources by state in Peninsular Malaysia, the majority was found in Selangor (414), Johor (384), Pulau Penang (328) and Perak (253). These are also the most industrialized states in the Peninsular Malaysia.

In terms of organic water pollution load, sewage and animal wastes were the major contributors of water pollution followed by manufacturing and agro-based industries in the country. In the case of pollution load, both the manufacturing and agro-based industries (palm-oil and rubber) contributed only 8% (37 t/day) of Biochemical Oxygen Demand (BOD) loads in 1988 in contrast to 13% (65 t/day) and 79% (385 t/day) of BOD loads from animal husbandry and sewage as shown in Table 2.

It is evident from Table 3 that the magnitude of organic pollution due to BOD discharged according to sectors between 1990 and 1993 increased tremendously from 485 to 1,033 loads. The table shows that organic wastes from animal husbandry are a national problem. This is constrained by land tenure issues and society's low regard for animal husbandry as a backyard rather than a modern industry.

Table 1 Distribution of major point sources of water pollution, Malaysia, 1991

Major water pollution sources/industries								
State	Palm oil	Raw rubber	Rubber product	Food bevera	Textile/leather	Paper	Chem.	Total
Selangor	29	13	132	94	22	15	109	414
Johor	67	41	36	136	59	11	34	384
Pulau Penang.	5	9	35	164	58	14	43	328
Perak	36	26	28	133	13	5	12	253
Kedah	3	29	22	98	9	2	8	171
Terenganu	11	3	6	84	16	–	–	120
Pahang	58	20	3	33	–	1	1	112
Wilaya/P	–	4	26	21	10	13	31	105
Sabah	27	4	3	49	5	11	5	104
Negeri/S	12	22	13	15	2	22	9	95
Melaka	3	12	17	21	7	3	11	74
Kelantan	8	11	1	28	4	1	3	56
Sarawak	6	4	1	38	–	3	4	56
Perlis	–	–	1	14	1	–	–	16
Total	255	198	324	928	206	101	270	2,292
Percent.	11.6	8.6	14.1	40.5	9.0	4.4	11.8	–

Source: Department of Environment, Malaysia, (1991), p. 127

The removal of sewage from urban areas continues to pose problems for water resources in relation to its effective treatment and disposal. The bulk of sewage is water, which is rich in nitrate and phosphate. Biologically speaking, this is a major contributory factor to eutrophication downstream and profoundly altering the characteristics of the aquatic ecosystems of some river systems.

Disposal of domestic and municipal wastes, which include industrial, commercial and household garbage also present a different set of problems. In most of the urban cities of the

Table 2 Organic water pollution by sectors, 1986–1988

Sector	1986			1987			1988		
	BOD (1) load	Percent (%)	Popu. (2) equi.	BOD (1) load	Percent (%)	Popu. (2) equi.	BOD (1) load	Percent (%)	Popu. (2) equi
Agro-based industries	11	2.4	0.22	15	3.0	0.3	12	2.0	0.24
Manufacturing industries	21	4.6	0.42	25	5.2	0.5	25	6.0	0.5
Animal husbandries	60	13.1	1.20	65	12.4	1.3	65	13.0	1.3
Population (sewage equi)	366	79.9	7.32	380	78.4	7.6	385	79.0	7.7
Total	458	100	9.16	485	100	9.7	487	100	9.74

(1) means in tonne/day and (2) means in million, using a BOD load of 0.05 g/capacity/day

Table 3 Organic pollution load discharged according to sector 1990–1993

Year	1990		1991		1992		1993	
Sector	BOD load	Population equivalent	BOD load	Population equivalent	BOD load	Population equivalent	BOD load	Population equivalent
Agro-based industry	15	0.3	12	0.24	30	0.60	28	0.56
Manufacturing industries	25	0.50	25	0.50	27	0.54	77	1.54
Animal husbandry	65	1.30	65	1.30	211	4.20	230	4.60
Population (sewage)	380	7.60	385	7.70	481	9.63	698	13.96
Total	485	9.7	487	9.74	749	14.97	1,033	20.66

Source: Adapted from table 6.28 for Department of Environment: Environmental Quality Data (1992–1995)

Peninsular, particularly Kuala Lumpur and Selangor, the daily quantum of solid wastes generated is more than 134,000 kg/day. Solid wastes are disposed off in landfill sites. Only about 60% are disposed off with the remainder finding their way into the rivers. This further reduces the quality of the water in the rivers. Landfill sites also present another set of problems particularly leachates, which contaminate groundwater, methane gas emissions, which can be hazardous to those living near the sites and obnoxious odours of decaying rubbish. Rivers are usually the recipients of all these polluting materials or loads.[1]

Therefore, river water quality provides a good indication of the levels of water pollution within a river basin where industrial and urban areas are located. Thus, in the 1991 annual River Water Quality Monitoring Program carried out by the Department of Environment (DOE), 87 major rivers were monitored and a total of 2,967 samples from 555 monitoring sites were collected. An assessment of water quality was carried out in terms of the physical, biological and chemical characteristics of the water body. In-situ water quality measurements include parameters such as turbidity, dissolved oxygen salinity, temperature, pH and electrical conductivity while laboratory analyses were performed for as many as 30 other chemical and biological parameters. The river quality in the country on the whole was found to range from good to unsatisfactory in 1991. Out of the 87 major rivers monitored, six rivers were found seriously polluted, 44 rivers were slightly polluted and the remaining 37 rivers were classified as clean. It was found that the continued discharge of untreated or partially treated human and animal (piggery) wastes remained as major sources of organic pollution in Malaysian rivers. Based on the index of ammoniacal nitrogen in 1991, 26 rivers were seriously polluted, 26 were slightly polluted, while 35 were considered clean. The suspended solids, as an indicator of soil erosion that resulted in river siltation, continued to pose major environmental problems in the country's water resources. Based on the assessment of Water Quality Index for suspended solids over a 5-year period, 69 out of the 87 rivers monitored were affected by soil erosion and river siltation. Soil erosion from construction sites has been excessive in Peninsular Malaysia. Many streams have become heavily silted and flooded. It is common practice to remove all vegetation from relatively

[1]Badri MA (1989) Chemical fractionation as a basis for differentiation of toxic metal release potential from aquatic sediment, solid wastes, sewage sludge and polluted soils. In: Singh LS, Singh MM (eds) Proceedings of Asian chemical conference on priorities in chemistry in development of Asia, Kuala Lumpur, Malaysia, 29–31, March, (1984c), pp59–62; see also: Department of Environment. (1989), p. 48

Table 4 Status and trend of river water quality, 1988–1994

	Status in 1994			Pollutant	Overall rate of change (%/year)	Trend for 1988–94			Total[b] (Rivers)
Total[a] river	Polluted	Slightly polluted	Clean			Improved	Deteriorated	Not change	
116	15 (13%)	18 (15%)	83 (72%)	BOD	−0.88	22(25%)	55(63%)	10 (12%)	87
116	66 (57%)	16 (14%)	34 (29%)	SS	−0.91	35(40%)	52(60%)	0(o%)	87
116	36 (31%)	35 (30%)	45 (39%)	NH3-N	−1.72	17(20%)	69(79%)	1(1%)	87
116	14 (12%)	64 (55%)	38 (33%)	Overall (WQI)	−0.92	17(20%)	67(77%)	3(3%)	87

[a] Total rivers monitored in 1994

[b] Total rivers calculated for trend is 87

Source: Department of Environment, 1994

large surface areas of land in the pursuit of economic activities and preparation for constructions of houses and roads in particular. A glaring example of the effect of land clearance for urban development on water resources is that of a housing project site in Damansara Heights in the southwestern suburb of Kuala Lumpur.

The rivers monitored were mostly located in Peninsular Malaysia. The river water quality in terms of organic pollution (BOD) remained relatively unchanged. Domestic discharges accounted for a high proportion of the organic load. Rivers, which are known to receive industrial discharges, recorded high levels of some heavy metal contamination.[2] Some of the heavy metals were found in rivers situated in the west coast of the Peninsular due to more intensive land use and industrialization. Being a Sate undergoing rapid industrialization, Pulau Penang experienced the worst of mercury pollution in River. River Krian and River Jejawi where water samples were found to contain mercury levels exceeded the standard value of 0.004 mg/l. Some rivers were contaminated by lead pollution ranging in concentration from a minimum of 0.003 mg/l to a maximum of 2.40 mg/l. The presence of arsenic and cadmium in most rivers was negligible. In terms of phosphate, among the rivers that exceed the limit of 0.1 mg/l includes River Sepang in Melaka, River Setiu, Ibai, Dungun and Paka in Terenganu, River Baloi, Pontian Endau and Skudai of Johor. Generally, between 1987 and 1994, water quality deteriorated due to BOD amounting to 63%.[3] Within the same period, deterioration in water quality due to both ammoniacal nitrogen and suspended solids amounted to 69 and 52%, respectively, as indicated in Table 4.

In 1997, 81 out of the total 116 rivers monitored by DOE were polluted due to BOD pollution loads. They were mainly from agro-based industries (i.e., palm oil), sewage and manufacturing activities. In Peninsular Malaysia, BOD loads in Johor polluted 17 rivers, eight in Pahang, eight in Terenganu, seven in Perak, eight in Selangor, four in Pulau Penang, three in Kedah, three in Melaka, two in Kelantan, two in Negeri Sembilan and one

[2]Department of Environment (1991) Environmental Quality Report, 1990, Malaysia. Ministry of Science, Technology and Development, Kuala Lumpur, Malaysia, p 68

[3]Department of Environment (1991) Environmental Quality Report, 1990, Malaysia. Ministry of Science, Technology and Development, Kuala Lumpur, Malaysia, p 69

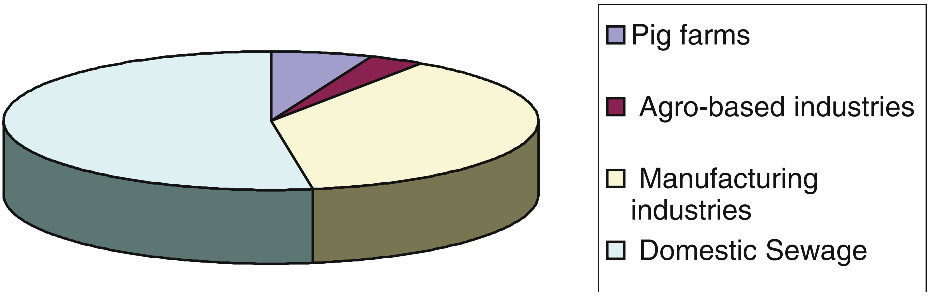

Fig. 1 Distribution of water pollutants by source, 2004, p.53

in Perlis. Over the same period, 93 rivers were polluted by NH_3–N as a result of livestock farming and domestic waste. In Johor, for example, 18 rivers were polluted due to this pollutant, 10 in Pahang, nine in Terenganu, three each in Kelantan, Melaka and Kedah, two in Negeri Sembilan and one in Perlis as well. With regard to suspended solid (SS) from earthworks and land clearing activities, 10 rivers were polluted, four in Selangor, three in Melaka and one each in Langkawi, Penang and Perak.[4] In 1998, 43% of the total rivers monitored by DOE were polluted by ammoniacal nitrogen discharged from both sewage and animal husbandry wastes into the water resources. Suspended Solid pollutants have accounted for 3.4%; 21% by BOD from both agro-based and manufacturing industries.[5]

Between the year 2000 and 2004, the major contributors to water pollution were effluents from manufacturing industries with an estimate of 37.9% and urban domestic sewage facilities, which amounted to 52.6% (Fig. 1) of the total water pollutants in the country. The pollution loads contributed by these pollutants significantly affected the river quality. An analysis of manufacturing industries in 2000 showed that the food and beverage industry constituted 23.7% of the total sources of water pollution, while electrical and electronic industries accounted for 11.4%. The chemical industry was found to contribute 11.2% and the paper industry generated 8.8% of the total pollution. The textile and finishing/electroplating industry accounted for 7.4 and 5.3% water pollution source, respectively.

The effluents from palm oil and rubber factories generated into water resources amounted to 5.3 and 2%, respectively. In general, Selangor, Johor and Perak water resources were severely polluted by these sources.[6] In terms of BOD parameter generated, sewage discharges amounted to 1,023-t/day and manufacturing industry was reported to generate 19-t/day. In the case of agro-based industry, the BOD load was 14-t/day during the period.[7]

Table 5 shows that out of 120 river basins monitored by DOE in year 2001, 60 (50%) were found to be clean, 47 (39%) of them were slightly polluted, while 13 rivers (11%) were categorized as seriously polluted. However, the trend of clean rivers from 1996–2000

[4]Department of Environment (1997) Environmental Quality Report, 1996, Malaysia. Ministry of Science, Technology and Development, Kuala Lumpur, pp 26–7

[5]Department of Environment (1998) Environmental Quality Report, 1997, Malaysia. Ministry of Science, Technology and Development, Kuala Lumpur, Malaysia, p 9

[6]Department of Environment (2000) Environmental Quality Report, 2000, Malaysia. Ministry of Science, Technology and Environment, Putrajaya, p 73

[7]Ibid, p. 75

Table 5 River water quality, Malaysia, 1996–2001

Category	1996		1997		1998		1999		2000		2001	
	No	Percent	No	Percent	No	Percent	No	Percent	No	Percent	No	Percent
Very polluted	13	11.2	25	21.4	16	13.3	13	10.8	12	10.0	13	10.8
Slightly polluted	61	52.6	68	58.1	71	59.2	72	60.0	74	61.7	47	39.2
Clean	42	36.2	24	20.5	33	27.5	35	29.2	34	28.3	60	50
No of river basin Monitored	118	100	117	100	120	100	120	100	120	100	120	100

Source: Department of Environment cited in Compendium of Environment Statistics, Malaysia, 2002, p. 32

continued to decrease from 42 to 34, while the pattern of polluted and slightly polluted rivers was sporadic in nature.

3 Policy Actions for Reducing Water Pollution

3.1 Environmental Policies for Water Pollution Control: An Overview

Malaysia has had pollution-related legislation since the 1920s via the Waters Act 1920.[8] The main objective of the legislation was to control river pollution. However, the legislation was limited in scope and inadequate for handling complex environmental problems that emerged.[9] This led to the establishment of the Environmental Quality Act, 1974 (EQA) for a more comprehensive form of legislation and an agency to control pollution. It is important to emphasize that the Act was designed as a framework for other laws and regulations or orders that were enacted after it. EQA is an enabling piece of legislation for preventing, abating and controlling pollution and enhancing the environmental resources in general. Pollution, as declared in EQA, includes the direct or indirect alteration of any quality of the environment or any part of it by means of positive act or act of emission. Control of pollution was through the mechanism of license issued by the Department of Environment. The mode of control includes prescription of licenses, which were mandatory for the use and occupation of prescribed premises; discharging or emitting wastes exceeding acceptable conditions into the atmosphere, polluting or causing the pollution of any soil or surface of any land; and discharging or depositing any wastes or oil, in excess of acceptable conditions, into inland Malaysian waters.[10]

Currently about 16, out of 43 sets of regulations and orders to prevent environmental damages, are particularly for pollution of various types and enforced by the Department of Environment under the EQA, 1974. One of the three strategies embodied in EQA, 1974 was the regulation of pollution. The other two strategies were for preventing and abating any form of pollution, especially water pollution. Generally speaking, the passing of EQA in 1974 marked a new chapter in national efforts to improve the quality of the environment

[8]For historical account of the introduction and objectives of the *Waters Act 1920*, see Aiken, Sir R. et al., *Development and Environment in Peninsular Malaysia*, (Singapore: McGraw-Hill, 1982), 242–261.

[9]Sham Sani, (1993), *op. cit.*, 74–5

[10]Environmental Quality Act, 1974 and Regulations: All Amendments up to November 2001, Kuala Lumpur: MDC Publisher Printers SDN BHD, at 22. See also *pollution of inland waters, Section 25 of EQA;* see also: Sham Sani, *Environmental Quality Act 1974: Then and Now*, (Bangi: Universiti Kebangsaan Malaysia: Institute for Environment and Development (LESTARI), 1997), 45–7.

conducive to living of the population. It equally represented a new focus in the prevention, abatement and control of water pollution. A close examination of the provisions in section 25 of EQA shows that the Malaysian approach to environmental pollution management is wide ranging in scope and concern not with pollution per se but with pollution that affects the beneficial use of water resources. Beneficial use involves a use of any element or segment of the environment that is conducive to public health, welfare or safety that requires protection from the effects of wastes, discharges, emissions and deposits into rivers. The general scheme of section 25 of EQA, in relation to the preservation of the environment, inclines more towards controlling water pollution. This is to be done through the issuance of licenses by the Department of the Environment. EQA authorizes the minister concerned to prescribe the level of acceptable conditions, even though it may involve some controversial arguments between those affected and the polluters.

To realize the objectives of water pollution control in the country as highlighted in EQA, laws/orders and regulations pertaining to the control of agro-based water pollution episode were chronologically enacted. An indirect measure to prevent water pollution was the Street, Drainage and Building Act enacted in 1974. Section 70A of the Act dealt with the basic requirement for earthwork to ensure the protection of water resources pollution that might arise from earthworks. In this regard, local authorities were empowered to use their discretion to disapprove any activity that may create soil erosion and siltation of water resources. There were several other provisions under this Act that authorized local authorities to control and prevent pollution of inland water. This was more pronounced in Section 7A of the Local Government Act 1976.[11] The Act contains provisions on pollution abatement in general but water pollution control specifically. The local authorities were empowered to curb public nuisance to ensure that the source of drinking water supplies are not polluted. Another regulatory policy for protection of inland waters is the Street, Drainage and Building Act 1974.[12] This act is a federal law enacted to amend and consolidate the laws relating to drainage and building in local authority areas with special reference to infra-structure facilities that should be provided to buildings such as proper access, modern sanitation system and proper drainage system that can protect water pollution.[13] In addition, the local authority is required to properly maintain clear, empty the sewers, drains and watercourses in its area. It can also empty the sewer into the sea or other fit places or conveyed through a proper channel to the most convenient disposal site.[14] The local authority may use its discretion to disapprove any activity that can result in water pollution or soil erosion and siltation watercourse. The Town and Country Planning Act 1976 have also been formulated to include a provision for the prevention of environmental pollution. Though it is not directly prepared for water pollution, it contains provisions on the development and use of the land and measures for the improvement of the physical environment.[15] The inclusion of environmental and social welfare dimensions within the planning process in the Act indicates that the planning process is not simply focused on the

[11]This section applies mainly to State, which have adopted their state law such as: Johor Waters (Amendment) Enactment, No. 14 of 1971; Kedah Waters Enactment, No. 129 of 1971; Negeri Sembilan Waters (Amendment) Enactment, No. 12 of 1971; Selangor Waters (Amendment) Enactment, No.11 of 1971 and Terengganu Waters Enactment, No. 10 of 1971.

[12]See Parts II, III, IV and V of the Street, Drainage and Building Act 1974.

[13]Ibid.

[14]See: Section 54 (2) of the Street, Drainage and Building Act 1974.

[15]See: Section 12 of the Town and Country Planning Act 1976.

built and physical environment, but takes into consideration the social implications and public view of development. In this respect, planning is central to the notion of a balance between development ethos and environmental protection of natural resources.[16] It ensures that development projects will not cause harm to water resources or to ensure that development projects and factories are neither located next to the river nor in close proximity with the rivers.[17] Under the Act 3 of 1970,[18] Malaysian government has formulated the Land Conservation to protect some of the key contributors of inland water pollution such as siltation and soil erosion. In view of the fact that the nature of siltation discharge and erosion that lead to water pollution are from a non-point sources such as activities that involve earthwork operations, logging and land clearance, a regulatory policy was enacted at both state and federal levels in Malaysia.[19] In following the Federal Regulatory Act, many control enactments have been adopted under the purview of the state authority.[20] Other Acts and Regulations include: Environmental Quality (Licensing) Regulations, 1977; Environmental Quality (Prescribed Premises) Crude Palm Oil Order, 1977 and its Amendment in 1982; Environmental Quality (Prescribed Premises) related to Raw Natural Rubber Order, 1978 and Environmental Quality (Prescribed Premises) related to Raw Natural Rubber Regulations, 1978, Environmental Auditing (EA) and Environmental Impact Assessment (EIA).[21]

With regard to the control of municipal and industrial wastewater pollution, Environmental Quality related to Sewage and Industrial Effluents Regulations was enacted in 1979. In fact, the control of industrial emissions caused a concern to the government. To upgrade this, Mahathir's administration in 1981 enacted the Environmental Control of Toxic and Hazardous Waste Management. Environmental Quality Regulations related to Scheduled Wastes was passed in 1989. In order to bring into action, Environmental Quality Orders and Regulations (Prescribed Premises) related to Scheduled Wastes Treatment and Disposal Facilities were simultaneously introduced in 1989. In 1990, the Promotion of Investments Order (made under the Promotion of Investments Act, 1986) was enacted to regulate environmental issues in the context of investment activities that can affect any

[16]See: Lee, Lik Meng. (1991). "Town Planning Law in Malaysia: Politics, Rights and Jealousies," *Habitat International, vol. 15, no. 4* for elaboration on this subject matter.

[17]Attempts have also been made by other prolific writers to examine the roles of the Malaysian Town and Country Planning Act 1976 in relation to environmental management and pollution control. For more details see: Mansor Ibrahim et al. (1989). *Town Planning and Pollution Control*, University Technology Malaysia Johor, 1988; M.Zainuddin. (1994). "Key Issues in Environmental Planning in Malaysia: A Town planner Perspective," in *Environmental and Urban Management in Southeast Asia*, edited by Azman Awang et al., (Johor: Institute Sultan Iskandar Urban Habitat and Highrise); Mokhtar; Long Idris, *Planning Decision-Making in Kuala Lumpur and DBKL's Planning and Development Policies,* (1996). For general reading, see: Wood, C., *Town Planning and Pollution Control*, (Manchester: Manchester University Press, 1976).

[18]See: Act 3 of the Land Conservation, 1960.

[19]For the historical development of regulatory policy on land-use and its environmental protection in Malaysia, see: Mohideen Abdul Kader and Shahridan Faiez, "Land-use Law and Policies on Environmental Degradation," in CAP (1996), *op. cit.*; also see: Fee, Wan Leong, *Land Resource Utilization and Land Use Controls in West Malaysia*, (PhD thesis,: University of Wisconsin, 1976); and Soong, Ngin Kwi et al., *Soil Erosion and Conservation in Peninsular Malaysia*, (Kuala Lumpur: Rubber Research Institute of Malaysia, 1980).

[20]See: *Enactment 110 (Silt Control) of the State of Kedah* (Kedah 110); *the Prevention of Soil Erosion Enactment 1940 of the State of Kelantan* (Kelantan 23 of 1940); the *Hill Lands Enactment 1951 of the State of Pahang* (Pahang 4 of 1951; and Section 26 of *the Land Conservation Act 1960.*

[21]Environmental Quality Act, 1974 and Regulations: All Amendments up to November 2001, (Kuala Lumpur: MDC Publisher Printers SDN BHD, 2001), at 79–92.

environmental resource, particularly water.[22] This was later followed by the Prohibition on the Use of Controlled Substance in soap, Synthetic Detergent and Other Cleaning Agents Order passed in 1995. These had been strictly emphasized in the EIA, 1987.[23]

3.2 Implementation of Water-protection Policies: An Overview with Respect to Sources

The operational tasks of policy enforcements have been shouldered by the Department of Environment (DOE). In other words, since 15th September 1975 there emerged a small core government institution formerly known as the Division of Environment (i.e., Department of Environment-DOE now) at the national level dealing with environmental policy questions and the implementation of the Environmental Quality Act, 1974.[24]

In 1981, the Department of the Environment (DOE) directed its efforts towards controlling water pollution from *point and non-point sources.* The point source of water pollution policy control focuses on discharges from industrial effluents and sewage from the domestic or household sector. For effective control, point sources of water pollution were classified into three broad groups namely: agro-based inventory sources, which comprise palm oil mill effluent, natural rubber processing effluent, sewage and effluents from other manufacturing industries. The non-point sources include major activities in land and resource development, which affect water catchments in the country as a whole and Peninsular Malaysia in particular.[25]

3.2.1 Enforcement of Water Pollution Control Policy on Crude Palm Oil Industry

The activities of the DOE focused increasingly more on prevention rather than curative measures. It could be noted that the enforcement of the policy instruments via regulations were further strengthened by escalating the degree of stringency of measures, particularly against repeat offenders. Through the enforcement visits conducted by DOE State Offices, the status of compliance for Crude Palm Oil industry amounted to 62.1%. However, 16 Crude Palm Oil factories were taken to court for offences under the relevant water pollution policy's instruments and regulations. Lack of adequate maintenance of their effluent treatment systems was the principal offence for the non-compliance cases. By this, DOE has intensified its enforcement activity and focused on problematic sources of water pollution. In other words, steps were taken to enhance accreditation in an effluent scheme known as *Skim Akreditasi Makmal Malaysia* (SAMM) [translated as *Malaysian Laboratories Accreditation Scheme*]. There were many cases of violations of water pollution regulations taken to court, within the period. Perak, Selangor and Pulau Penang accounted for 58% of the offences charged in Peninsular Malaysia. About 69% of the offences committed involved the discharge of effluent exceeding the stipulated standards. In

[22]Lim Poh Eng; Leong Yueh Kwong and Evelyn Teng, "Environmental Impacts of Industries in Malaysia: With Special Reference to the Industrial Estates in Penang," in CAP: *State of Environment in Malaysia: A Compilation of Selected Papers, SAM National Conference*, 5–9 January 1996, (Penang Malaysia, 1997), 332.

[23]Ibid., 333.

[24]Ong Kee Hui., "Department of Environment Conception, Birth and Maturity," in *20 Years Environmental Management Excellence in Malaysia (1975–95)* edited by Patrick Tan Hock Chuan, Roshadan Hashim, Zainab Zubir and Norzan Mohd Nazir, (DOE, 1999), 11. See also the Opening Address by E. Mansul in CAP, (1982), o*p. cit*., 8.

[25]Low, KS (1993) Industrial development and urban growth in Malaysia: issues, problems and prospects in relation to the environment. University Malaya, Kuala Lumpur, 60

its policy implementation effort against effluent discharge violations of the standard, DOE prosecuted 113 cases in 1993, which was a 13% decrease from 1992.[26] Between 1994 and 1996, DOE has intensified its policy implementation efforts against the Crude Palm Oil industry. Water pollution control and abatement remained the principal thrusts of the body, and enforcement activities continued to be given high priority. This was reflected in a number of ways, for example, out of the total 275 Crude Palm Oil mills licensed in 1994, 15 mills were taken to court for various offences not much different from those mentioned earlier. As in the previous year, the lack of maintenance of effluent treatment systems was found by DOE to be the principal reason for non-compliance with the policy regulation instrument and standard.[27]

In 1995, DOE found that some of the Crude Palm Oil mills in Peninsula Malaysia were lax in complying with the legal policy requirement and 12 were taken to court for repeated violations of the standard. To intensify its enforcement programs, DOE organized a workshop on Environmental Quality Management in Plantation industries at the Palm Oil Research Institute of Malaysia (PORIM) Headquarters, in Bangi on July 24, 1995. The main agenda under discussion was the government's concern for water pollution by Palm Oil mills and non-compliance to the stipulated effluent discharge standards. One of the resolutions of the workshop was the need to form a joint Working Group comprising DOE, PORIM, Rubber Research Institute of Malaysia (RRIM), Standard and Industrial Research Institute of Malaysia (SIRIM) and Federation of Rubber Trade Association of Malaysia (FRTAM) to review and monitor a new generation of watercourse discharge standards for the plantation industry.[28] Among other tangible issues discussed was the proposed waiver on the effluent-related fee for land application or partly treated effluent. On this issue, DOE made it clear that it could consider waving of such fees only if the industry could prepare specific guidelines on land application methods including the Contingency Plan. More importantly, all mills should at all time be able to comply with these guidelines.[29] In the following year, 1996, 282 Crude Palm Oil mills were licensed, out of which 185 were allowed to discharge their effluents into water courses, 185 onto land and 12 to both water courses and land. However, in the pursuit of water pollution abatement, four Crude Palm Oil industries had their licences temporarily suspended for not complying fully with the limits of effluent discharges as stipulated in the license by DOE. The suspensions were lifted only after the problem had been rectified.[30]

From year 1998 to 2005, DOE reinforced its various efforts to abate water pollution from Palm Oil point sources in Peninsular Malaysia. 229 mills were licensed for 1 year, 70 for 2 years and 27 for 3 years of operation effective from July 1998. To tighten the aggregate of licences issued, DOE made two types of fees payable for obtaining a licence. These were processing fees and effluent-related fees, which were estimated on the basis of effluent discharge and mode of disposal into water courses in accordance with the "Polluter Pay Principle." In this period, 477 enforcement inspections were carried out by DOE state

[26]Department of Environment (1993) Environmental Quality Report, 1993, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 31–33

[27]Department of Environment (1994) Environmental Quality Report, 1993, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 22

[28]Department of Environment (1995) Environmental Quality Report, 1994, Malaysia, Ministry of Science, Technology and Environment, Kuala Lumpur, 20

[29]Ibid.

[30]Department Space of Environment (1996) Environmental Quality Report, 1995, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 27

offices. More than 30 Crude Palm Oil mills from various states of the peninsular were taken to court. In line with the Malaysian Incorporated concept that was actively promoted by the Mahathir administration, a Consultative Committee comprising prescribed premises operators, palm oil, rubber association and DOE was established. The principal objective was to review and exchange information on the latest available environmental pollution control technology. In addition, the establishment of the committee was to enhance the level of compliance among the operators of the prescribed premises with the effluent standards and licensing conditions of their operation.[31]

3.2.2 Enforcement of Pollution Control Policy on Raw Natural Rubber Factories

In the case of rubber industry, the policy related to the Raw Natural Rubber regulations was enforced to control water pollution from this source. The approach was quite similar to the one applied to palm oil except that compliance with the standard was made mandatory right from the inception without the option of payment of effluent-related fees as in palm oil. However, since the numbers of rubber factories kept increasing in the 1990s, the rate of prosecuted rubber industries increased between 1993 and 1996.

In 1998, DOE had identified that many rubber mills had expanded their production outputs without a corresponding increase in the capacity of their effluent treatment plants. As a result, the effluents being discharged exceeded the prescribed standards stipulated by the policy regulatory instrument. In 1995, legal actions were taken against eight Raw Natural Rubber industries for repeated violations of the standards. In its efforts to strengthen the water pollution control programs, DOE held a dialogue with the Federation of Rubber Trade Associations of Malaysia (FRTAM) on June 23, 1995 about the issues related to odour control, improper siting and the need for relocation of some smelly factories. One of the Resolutions that came up within the dialogue was that industries were allowed to send samples for analysis at laboratories not accredited with the Malaysian Laboratories Accreditation Scheme (SAMM) due to the lack of sufficient capacity of those under SAMM.[32] In 1996, four rubber mills had their licences temporarily suspended, while 30 of them were taken to court for not fully complying with the limits of effluent discharges as stipulated in the licences.[33] From 1998 to 2004, vigorous inspections by DOE earmarked a significant era in the efforts to achieve success in water pollution control from the point sources such as rubber factories in Peninsular Malaysia. During the inspection visits, the main foci included factory identification, location and immediate surrounding land use with the aid of map; terms and conditions in the schedule of compliance attached to DOE "prescribed premises" license issued under section 18 of the EQA; status of the effluent discharges for at least two preceding quarters based on the Quarterly Return Forms from the factory and findings of previous inspection visits and recommendations if any. Other areas of the inspection activities included the factory production process to see capacity and by-products, chemical and quantity used as well as waste management systems. In addition, DOE also carried out treatment plant inspection and observed adequacy of basic design,

[31]Department of Environment, *Environmental Quality Report, 1997, Malaysia*, (Kuala Lumpur: Ministry of Science, Technology and Environment, 1998), 23. See EQR of 1999 and 2000, 2001, 2002, 2003 2004/05 for further details.

[32]Department of Environment (1995) Environmental Quality Report, 1994, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 20–23

[33]Department of Environment (1996) Environmental Quality Report, 1995, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 27

status of operation and maintenance, regulatory of the sludge removal and sludge return if any, and specific features of improved design operation. A total of 477 enforcement inspections were carried out by DOE State Offices in Peninsular Malaysia.[34] It appears that the implementation of policy, at this particular point in time, was very stringent and quagmire in nature as the closing down of factories or firms or suspending them would affect a strategic industry and the lives of many families as well as the country's economy. Whereas allowing them to pollute the environment is harmful for health. Hence, it is a trade-off that needs to be balanced.

4 Enforcement of Water Pollution Control Policy on Pig Wastes

In Peninsular Malaysia, water pollutions arising from the pig industry are significantly peculiar with states such as Negeri Sembilan, Melaka, Selangor, Penang and Johor where the pig industries are concentrated. Wastes from the pig industry include urine, faeces and the amount discharge relatively proportional to the age, weight of the pig and the quantity/ quality of food and water consumed by the pig itself. Therefore, the volume of daily wastewater discharged per pig varies according to frequency of wash and amount of waste produced. In the 1980s, the control of effluents from pig farming in Peninsular Malaysia has been very difficult due to lack of adequate technology and expertise to operate treatment plants, and inadequate land for building a treatment plant for some pig farms. These aforementioned factors had made it difficult for DOE to enforce the Sewage and Industrial Effluent policy-related Regulations against the concerned pig industries. However, the Department of Environment adopted another strategic approach to control the pollution problems of the pig factories during the period.

A task force was established by DOE to overcome problems including using technology for treatment and disposal of pig wastes. This task force comprised personnel from DOE, Standards & Industrial Research Institute of Malaysia (SIRIM), University Pertanian Malaysia (UPM), Department of Veterinary Services, the Chemistry Department, Ministry of Agriculture and Ministry of Health and chaired by the Secretary General of the Ministry of Science, Technology and Environment. Surveys were carried out in Penang, Selangor and Melaka States with pig waste problems to obtain data with respect to the size of the pig farm, weight, water course discharged and other tangible information. The task force also came up with pilot scale plants for pig waste treatment. In these periods, two plants suitable for pig farms with 100–1,000 and 1,000–5,000 pigs were designed. The plant for 100–1,000 pigs was already in operation at the Government Veterinary Department farm at Sungai Buloh in Selangor.[35] To further intensify the enforcement control of water pollution in pig farms in the Peninsular, the Ministry of Agriculture in collaboration with DOE also initiated some preventive steps for the Government to introduce a uniform Federal Law to harmonize the control of pig farm wastes in various states namely: Johor, Terengganu Melaka and Negeri Sembilan had introduced their own enactments for the control of the problem.[36]

[34] Department of Environment, "Industrial Processes & the Environment: Raw Natural Rubber Industry," *Handbook No. 2*, (Kuala Lumpur: Government Printer, 1998), 63–70, also see: *Environmental Quality Reports 1999–2005*.

[35] Department of Environment (1984) Environmental Quality Report, 1981–84, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 27

[36] Ibid.

In the period of 1990–2005, the Department of Veterinary Services and DOE continued their collaborative enforcement efforts to initiate a number of projects in addressing water pollution from Piggery wastes and animal husbandry. A task force was initiated on Piggery Waste Management to draft guidelines and practical design criteria to assist farmers in upgrading their existing treatment facilities and constructing of new ones. Recognizing the fact that such piecemeal approach might not be efficient in solving the problem, DOE highlighted that only larger pig industries, located in non-sensitive areas, and capable of installing the effluent treatment system, were to be permitted to carry out operation. So, throughout 1990s up to the 2002/05 period, vigorous enforcement efforts by DOE have been in operation to control water pollution arising from this source.[37]

4.1 Enforcement of Water Pollution Control Policy on Manufacturing Industries

The water pollution problems arising from the manufacturing industries continued to be regulated under the environmental policy-related to the Regulation for Sewage and Industrial Effluents. Among the focuses of DOE were premises engaged in food and beverage productions, palm oil refineries, textile factories, paper recycling mills, metal finishing works and rubber product factories. In its efforts to intensify the policy enforcement, DOE carried out a thorough inspection in 1985–1986. In terms of waste treatment, it was found that palm oil refineries lagged far behind when compared to the crude palm oil mills. Of the tangible reasons associated with the problem was the lack of a feasibility study of efficient technology equipment. A feasibility study was then carried out by PORIM to assist the industry in treatment technologies for the various processes employed in refining activities. The study was concluded with substantial recommendations for the industries to follow. In the case of rubber products manufacturing industry, DOE enforcement sampling on some existing premises in 1990s showed excessive levels of pollutants such as zinc, oil and grease, and COD. From this, the policy of upgrading the treatment system was initiated.[38]

Other enforcement actions had to deal with contravention licences. Licences were only granted to small scale industries facing genuine reasons in disposing wastes that were left behind after various efforts had been made. It was also issued to those manufacturing industries facing the problem of repairing and constructing their incinerators or facilities to reduce pollution. In addition, suggestions have been offered to wood-based industries on recycling and reutilizing of their wood wastes in order to conserve water resources of the country. The granting of contravention licences to manufacturing industries underwent stricter scrutiny to strengthen the enforcement actions. Industries were also required "to be accompanied by operations and discharge data and evidence of previous effort made in meeting compliance"[39] before their application can be endorsed.

As the world demand for rubber gloves and condoms increased, the industry continued to mushroom. The DOE took policy actions to promote the installation of appropriate effluent treatment to cutback pollutants such as zinc and COD and other loads. However, from the efforts taken, DOE noted that some industries had abused the accommodating standards stipulated in the policy regulation. In addition, inadequate references to the DOE

[37]Department of Environment (2005) Environmental Quality Report, 2002–2005, Malaysia. Ministry of Science, Technology and Environment, Putrajaya

[38]Department of Environment (1987) Environmental Quality Report, 1986, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 33–4

[39]Ibid., 36.

prior to project approval also led to substandard operational discharge. Upon realizing this problem, the waste discharge standard was comparatively made more stringent than for the case of rubber processing mills discussed under agro-based earlier. For the newly-emerged industry such as coconut-based product factory, affordable and suitable treatment technology was lacking. However, enormous assistance was rendered by DOE to farmers via directives and advices about the way forward for progress and meeting the required standards. Subsequently, while majorities of the palm oil refineries have complied with the discharge standards, the compliance progress of others are being closely monitored by DOE.[40]

Likewise, the schedules of the DOE inspection were also revised to be more cost effective. Upon detection of violation of the compliance with the conditions, warning letters were issued to the concerned industries, while gross negligence cases were subjected to imposition of fine and prosecution in court. According to a DOE report, a number of the food industries were unable to meet the required discharge standards mainly due to improper maintenance of existing treatment plants and gross negligence in the operation of the treatment plants. As part of the policy enforcement actions, contravention licences were issued under Section 25 (1), Environmental Quality Act, to those industries with genuine reasons in order to give them time to upgrade their treatment plants to meet the effluent standards required by the National Policy. In 1990, it was noted that the rubber-based industry continued to pose severe problems in relation to the disposal of vulcanized rubber wastes. An interim measure was employed via contravention pending the development of a long-term solution.

During the inspections carried out by DOE, it was discovered that many textile industries were still without proper effluent treatment systems resulting in water pollution problems in states such as Perak, Johor, Selangor, Kelantan and Terengganu where these industries were located. A stipulated period of adjustment and improvement was issued to those industries by DOE to build up appropriate and workable plant systems. In the mean time the operations of such industries were required to improve their housekeeping in order to reduce oil and grease in the discharged effluents.[41]

A close examination of DOE implementation efforts from 1992 to 2005 shows that metal-based industry – especially electroplating – was unable to install sufficient facilities to treat its effluents containing heavy metal such as cyanide, iron and chromium. The DOE as an enforcement body, held a series of discussions with Electroplating Association on establishing central effluent treatment systems. A series of dialogue was also held in 1993 between DOE and the food/beverage industries to facilitate compliance with the existing water pollution policies in meeting the standards of their effluents discharge into the water catchments. As in the case of 1990, similar problems of some rubber-based and textile industries, associated with the lack of proper treatment systems (especially stipulated COD and BOD standards) were found in 1993 and 1994, respectively. The metal finishing industry and some other small and medium scale industries were found without any forms of treatment system for their discharges to meet the specified effluent standards in the policy regulations. Out of 49 licence applications applied under Section 25(1) of the EQA, 34 were rejected by DOE due to the lack of adequate required information in 1994.[42] In 1995, the contravention

[40]Department of Environment (1991) Environmental Quality Report, 1991, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 91

[41]Ibid, p. 118

[42]Department of Environment, *Environmental Quality Report, 1992, Malaysia*. (Kuala Lumpur: Ministry of Science, Technology and Environment, 1993), 21; see also *Malaysia Environmental Quality Report*, 1994, 20, and 1995, 24–6.

licences issued by DOE were the highest so far. Of the 60 approved licences under Section 25 (1) policy related regulation, "53% were to enable industries to upgrade their effluent treatment plants, 35% to construct effluent treatment, while the remaining 12% were issued to industries that were still unable to obtain appropriate treatment technology or in the process of relocation."[43] A total of 1,283 licences were granted to Indah Water Konsortium Sdn. Bhd. (IWK), the company operating sewerage treatment facilities in the country, to enable it to upgrade the existing facilities. In the same period, the Use of Controlled Substances in Soap, Synthetic Detergent Order 1995 was promulgated by DOE. For example, two licences were granted to the concerned industries to enable them to clean up Branched Alkyl Benzene Sulphonates by November 30, 1995. However, applications for contravention under Section 25 (1) decreased to 40 in 1996. Despite this decrease, DOE rejected 15 applications due to inadequate evidence received from the industries. Of the remaining approved licences, metal finishing manufacturing industry, textile and food industries comprised the biggest number.[44]

The period of 1997–2003 sought to strengthen the efforts utilized by DOE in water pollution abatement. In 1997 and 1998, a total of 3,889 manufacturing industries were inspected with vigorous enforcement of Sewage and Industrial Effluents Regulation. However, up to the year 2005, many small and medium scale industries such as metal finishing and electroplating premises had difficulty in complying with the stipulated effluent standard for BOD, COD, SS, Oil and Grease as well as heavy metals like nickel, copper and lead in their waste water discharges. In other words, the majority of them were operating without efficient and appropriate treatment plants. To enable them to comply with the policy's requirements, contravention licences were issued to seven industries, while 24 applications were rejected due to the lack of sufficient data and genuine information about the contravening conditions expected by DOE.[45]

4.2 Enforcement of Water Pollution Control Policy on Sewage Disposal

Water pollution control via treatment of sewage discharges depends on the waterborne sewerage systems available in the country. As of the year 1981, DOE recognized the need to increase the sewerage system projects in Peninsular Malaysia. Over this period, sewerage systems were only available in a few places such as Georgetown, Shah Alam and Kuala Lumpur. These sewerages had to be extended to serve all households within these urban areas. In the period of 1981–1984, Master Plan studies were completed for a number of major urban cities like Alor Star, Ipoh, Klang, Seremban, Kuatan, Kuala Terengganu, Melaka and Johor Baru in Peninsular Malaysia.[46] From 1985 to 1986, enforcement actions were carried out by DOE at some identified sources of sewage discharges into water resources such as holiday resorts, hotels and housing estates. In 1990s, environmental inputs were also provided to the Steering and Technical Committee for Urban Sewerage

[43]Department of Environment (1996) Environmental Quality Report, 1995, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 24

[44]Department of Environment (1997) Environmental Quality Report, 1996, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 29, see interview result in p. 347 of this study.

[45]Department of Environment, *Environmental Quality Report, 1998, Malaysia*, (Kuala Lumpur: Ministry of Science, Technology and Environment, 1999), 36; see also *Environmental Quality Report* for 2000–2005, respectively.

[46]Department of Environment (1981–84) Environmental Quality Report, 1981–84, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 2

Projects set up by the Ministry of Health, and Committee for Solid Wastes Management formed by the Ministry of Housing and Local Government.[47] Within the trends of 1991–1996, DOE incorporated dialogues into its enforcement actions and operations for resolving water pollution and abatement. To enhance compliance with policy requirements of water protection, a number of dialogue sessions between the DOE and industries concerned were conducted in 1993. The participating industries included: the food and beverage industry, the textile associations, Malaysian Oleochemical Manufacturers Group and the Malaysian Rubber Glove Manufacturers Association through the Tripartite Consultative Committee.[48]

DOE signed an agreement with Indah Water Konsortium Sdn. Bhd. (IWK) under privatization modality as a company working for the government to operate and maintain sewerage treatment facilities throughout the country. The Technical Working Group, which comprised the DOE, the Sewerage Services Department (SSD), and IWK, was established in July 1996 to discuss various operational issues faced by IWK. The main objective was to facilitate compliance with regulatory policy instrument of Sewerage Services Act, 1993. The outcomes of the agreement of the Working Group include: adoption of guidelines on Sludge Disposal Sites Selection Criteria for use by the state DOE and SSD; and the procedure for the application of written approval for disposal of sludge.[49] Other enforcement actions carried out by DOE during the period of 1997–2005 include: operational inspections and surprise visits relating to industrial effluent discharges.[50] Assessment of the current status of sewerage facilities has shown that between 1990s until the present time, "Malaysia has 8,000 sewage plants and approximately 7,500 km length of sewers, mostly situated in urban areas, serving more than 12 million populations."[51]

5 Technology Employed

Waste from Piggeries, Palm oil waste, Rubber waste (latex) and waste from Food manufacturing industries are considered as the wastes that have BOD greater than 500 mg/l and treatments can be technologically divided into two main stages. In the first stage, the treatment technologies include *anaerobic systems* such as Upflow Anaerobic Sludge, Hybrid, and Anaerobic Filter systems. The second stage of these wastes treatments uses *aerobic systems* technologies such as Activated Sludge, Sequencing Batch Reactor, and Trickling Filter systems. Treatment process is therefore made up of Primary and Secondary only. Since Tertiary or Advanced Treatment is not employed in the country, it therefore implies that effluent from such treatment plants will be very high in nutrient loads such as ammoniacal nitrogen, phosphorus etc, which may lead to eutrophication of the water courses.

As for municipal wastewater (sewage), Table 6 reflects most of the treatment plants used in different states of Malaysia. As can be inferred from Table 6, about 55% of the 8,000

[47]Department of Environment (1990) Environmental Quality Report, 1990, Malaysia. Ministry of Science, Technology and Environment, Kuala Lumpur, 155

[48]Low, Kwai Sim, "Industrial Development and Urban Growth in Malaysia: Issues, Problems and Prospects," (1993), o*p. cit*., 64; see also: Department of Environment, (1993), o*p. cit*., 20.

[49]Department of Environment, (1996), o*p. cit*., 30

[50]Department of Environment, (1997–2003), *op*. c*it*.

[51]Mohamed Haniffa, A. Hamid and Muhammed Zuki Muda: "Advanced Wastewater Treatment Kuala Lumpur," *A Short Course on Current Status of Sewrage Services in Malaysia and Challenges Ahead*, by University of Technology Malaysia in collaboration with Danced, Ensearch & IWK,1999, p.13

Table 6 Distribution of sewerage treatment facilities by type and state

State	Sewer (km)	Plant type					Total
		CST	IT	OP/AL	MP	NPS	
Johor	363	422	56	91	49	28	646
Kedah	217	432	39	32	153	4	658
Melaka	281	302	35	16	168	4	525
N/Sembilan	498	336	94	91	139	10	668
Pahang	81	256	63	28	80	1	426
Perak	903	614	115	137	134	52	1,052
Perlis	3	22	6	0	7	0	35
P/Pinang	1,412	203	138	20	237	36	632
Selangor	1,698	909	207	195	446	59	1,814
Terengganu	42	246	38	35	36	1	354
P/Kuala Lumpur	2,034	109	134	76	93	54	465
WP/Labuan	23	11	5	2	10	4	32
Total	7,554	3,862	928	723	1,552	253	7,318

Source: University of Technology Malaysia in collaboration with Danced, Ensearch & IWK, Current Status of Sewerage Services in Malaysia, 1999, p.13

plants is *communal septic tank* (CST) types 15% is *imhoff tank (IT)*, 10% is *oxidation pond/ aerated lagoons* (OP/AL) types and 20% is *mechanical treatment plant* (MT) type that provides secondary treatment.

In addition, there are other types of sanitation systems such as *pour flush*, serving more than six million of the population and one *marine outfall* in Penang state (not a treatment plant) serving about 30,000 of the population.

A critical examination of these technologies in treating municipal wastewater, especially imhoff tank, septic thank and pour flush, can be mostly considered as Primary Treatment only. As a result, sludge is taken out for treatment periodically and effluents are therefore discharged into the soil which may lead to serious surface and groundwater pollution. Since the final tributary of these effluents through the soil is nearby river, this in turn will lead to increase in water pollution.

5.1 Financial Constrain on Sewerage Systems

The cost of developing a modern and efficient sewerage system is too expensive to be borne by the government. Currently, the major constrain of building up the new sewerage systems is solely depended on Sewerage Capital Contribution (SCC). The Consortium body IWK has estimated that about RM28 billion would be needed to build up new systems such as sewer reticulation and pumping stations; a centralized sewerage treatment plants catering for sewerage and sludge treatment within the next 28 years concession period. As such, a new sewerage tariff of at least 70% higher than the existing rates would be required to fund these additional works. The government has seriously reviewed this and finally approved a sewerage capital contribution rate of up to 1.65% of the property value to be levied on all properties, except low cost houses.[52]

[52]University of Technology Malaysia in collaboration with Danced, Ensearch & IWK, *Current Status of Sewerage Services in Malaysia*, 1999, p.24

6 Relationship between Development Indicators and Pollution Trends

In order to test whether there is a relationship between development and water pollution, the paper hypothesizes that: *Higher degree of development activities does not necessitate high degree of water pollution* (using technology and policy control as moderators).

6.1 Procedures and Approaches

A multiple regression analysis method was used to find out whether there is a relationship between development indicators and pollution trends over a period of 12 years consecutively. The indicators were chosen based on the three identified major sources of water pollution in peninsular Malaysia. The alpha level of significance set in the paper for obtaining the relationship between dependent variable and its predictors is: α=0.05, while *t*-test of significance will therefore be equal to $\alpha/2=0.05/2$. The expected *F*-Statistics value for test of hypothesis must be greater than the *standard value* +2 for single tailed-hypothesis put forward in the paper at the said alpha level. Any predictive variable that fails to fulfil these requirements was removed from the model developed.

6.2 Definition and Operationalization of Variables

Operationally, there are two competing variables in this hypothesis, which are economic development activities and the rate of water pollution. For the independent variable (economic development activities), the focus of this paper is on (1) industrial growth with special reference to manufacturing industries, (2) population/urbanization, and (3) economic growth (GDP). These are the *three key indicators* for assessing the rate at which the independent variable affects the dependent variable (water pollution). The yardstick for measuring the effect of the first indicator is the *index of industrial production* for manufacturing industries. The justifications for using this yardstick is that: (1) the index of industrial production for any manufacturing industry reflects the rate of production growth of the industry per year. It is argued that as the rate of the production increases so also are the emissions of organic water pollutants, (2) as the rate of production increases so also are the shares in national GDP contribution.

The yardstick for measuring the second indicator of the independent variable (urbanization/population) is the population growth of the country. The justification for using this yardstick lies in the correlation between industrial growth and increases in population of industrial cities and states. The fact is that as the industrial activities increase the rate of population also increases especially in industrial states. Thus, it is argued that the establishment of more industries serves as a *pull factor* for bringing more people from rural areas to urban cities and states. This makes the population in urban agglomerations increase yearly. Thus, the more the population grows in urban cities the more the rate of waste products of their consumptions and sewages discharged. These sewages being discharged significantly add to the water pollution load. The yardstick for measuring the third indicator of independent variable is GDP per capita. The justification for using it is that it reflects the rate of the people's consumption and their purchasing power parity, which is determined by the general economic growth of a country.

The dependent variable in this hypothesis is water pollution as mentioned above. Water pollution is defined as the introduction of deleterious substance into water that changes its composition and beneficial usage. When the concentration of acids and other chemicals or suspended solids or oil or animal/domestic wastes is increased to the extent that can affect its users, the water has been polluted. The yardstick that would be used to measure dependent variable is the Water Pollution Index (*WPI*) that is measured via the following parameters for organic pollutants or loads as laid down by Department of Environment (DOE) Malaysia, namely: level of Biochemical Oxygen Demand (BOD), level of Chemical Oxygen Demand (COD), level of Ammoniacal Nitrogen (NH_3–N), level of Suspended Solids (SS) and pH value. All these actually bear some severe effects on the physical health of the people as they drink water from polluted sources directly or indirectly. The statistical tool that was used here is *Multiple Regression Analysis*. It is given by the following equation to show the interactive effects of all independent variables indicators on the dependent variable:

$$\log Y = a + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_1X_2 + \beta_5 \log X_1X_3 + \beta_6 \log X_2X_3 + \beta_7 \log X_1X_2X_3 \ldots + \in \quad (1)$$

Where Y is the variance in the dependent variable (WPI) and X_1, X_2, X_3, are the single indicator of development (i.e., independent multivariate variables) and log means logarithm throughout the paper. X_1 represents the GDP per capita; X_2 represents population variable; and X_3 represents industrial production index for manufacturing industries. X_1X_2 represents the product of GDP per capita and population; X_1X_3 represents the product of GDP per capita and industrial production index; X_2X_3 represents the product of population and industrial production index; while $X_1X_2X_3$ represents the interactive product effects between the three predictors on polluted rivers. β_1, β_2, β_3, β_4, β_5, β_6, β_7 are the unit changes in the independent variables and their interactive products that account for the variances in the dependent variable (Y). The symbol a is an intercept that denotes the point where the gradient of the slope cuts the Y-axis when X is zero and the symbol "a" is the residual**.** The justification of using this statistical method is that it allows us to see how the dependent variable (water pollution) is affected by a unit change in the independent variable (economic development activities) measured by these indicators. In addition, the method helps us find out the interactive effects of the independent variables' indicators and the exact effect of each of them on the dependent variable. Hence, it shows the relationship between the dependent variable and the independent variables.

The predictors highly correlated with the *total water pollution variable*. The value for GDP per capita reached the highest value of 0.898, 0.861 for population variable and 0.887 for index of industrial production (Table 7). The high magnitude for the value of *correlation* in the result of the output for each predictor indicates the strength of the association between each of the predictors and water quality status for polluted rivers. In other words, the results show that as the value of each predictor increases or decreases the value for the

Table 7 Correlation matrix results

		logTWPI
Pearson correlation sig (1-tail)	logWPI	1.00
	logGdp	0.898
	logPop	0.861
	logIndex	0.887

log (Logarithm); *TWPI* (total water pollution index); *Gdp* (GDP per capita), *Pop* (population); *Index* (index of industrial production)

Table 8 Regression results

Independent variables	Dependent variable (TWPI)
GDP per capita	R-sq=81%; Adj. R-sq=78.7; *P*=0.000; *t*=6.46
Population	R-sq=74.2%; Adj. R-sq=71.6; *P*=0.000; *t*=5.36
Index of industrial production	R-sq 78.6%; Adj. R-sq=71.5; *P*=0.000; *t*=6.07

dependent variable equally also increases or decreases. Hence the strength of association is positive with a higher value of Pearson's correlation coefficient. Having observed the association between dependent and independent variables, each and the collective effects of the predictors on the level of river pollution (based on DOE categorizations) are discussed in the following sections.

6.3 Principal Factor Effect of Each Predictor on Total Water Pollution Index

6.3.1 Analysis of Results

As shown in the Table 8, GDP per capita variable accounted for 81% variances in rivers' pollution episode, over the period under consideration, in the country with an alpha level of significance less than 0.005. The second predictor variable (population) also accounted for 74% of total polluted rivers with *R*-sq of 74.2 and *p*-value less than 0.005. According to regression result (Table 8), the third predictor (industrial production) accounted for 78% of the yearly variances in level of river pollution. This was highly significant at a *p*-value less than 0.005.

Generally, the results obtained showed that each predicting variable has a clear effect on the level of polluted rivers per year. Thus, the resultant model equation for effect of each predictor on the river pollution is summarized in the Table 9.

6.4 Regression Results of Multiple Factor Interactive Effects of Predictors on Total Water Pollution Index

6.4.1 Analysis of Results

A co-effect of the three predictors on trend of river pollution was examined. The co-effect of GDP-population (X_1X_2) was examined. As shown in the Table 10, the interactive effect of X_1X_2 accounted 87% (*R*-sq=87.3) of river pollution, which is higher than the effect of individual variable alone. In addition, when the product of GDP-industrial production (X_1X_3) was stepwisely regressed against polluted rivers, the value of R-sq increased further to 97.18 due to interactive effects of both predictors on polluted rivers. However, when products of X_2X_3 and $X_1X_2X_3$ were stepwisely added there was no change in R-sq value. This indicates that R-sq has

Table 9 Model equations for effect of each predictor on total water pollution index

Single predictor	Model equations
Predictor-GDP	$\log T.WPI = -1.82 + 0.913\ \log gdp$ eq (2)
Predictor-pop	$\log T.WPI = -10.5 + 2.85\ \log pop$ eq (3)
Predictor-index	$\log T.WPI = 0.392 + 0.696\ \log index$ eq (4)

Table 10 Regression results

Independent variables	Dependent variable (total water pollution)
X_1X_2	R-sq=87.30% Adj. R-sq=80.04
X_1X_3	R-sq=97.18% Adj. R-sq=94.84 F=51.35

reached a saturated point and therefore cannot increase further. As such, the final model equation obtained due to interactive effects of the three predictors on pollution trends is:

$$> \log T.\text{pollu} = -3.80 - 6.62 \log \text{gdp} + 48.3 \log \text{pop} + 61.2 \log \text{index} + 11.8 \times \log X_1X_2 - 0.721 \log X_1X_3 \tag{5}$$

R^2=97.2%

7 Test of Hypothesis

1.1 High Level of Development Activities does not Necessitate High Degree of River Pollution in the Presence of Effective Technologies and Policy Measures

The F-statistic is a ratio between and within the variances of the predictors (independent variables) in relation to total polluted rivers (dependent variable) in this paper. The F-statistics was used to test for null hypothesis. In terms of each single predictor, the output result of F-value estimated was highly significant. After being moderated by the multiple factor interaction effects of the product for the three predictors, the value of F-statistics changed to 51.35 at a p-value less than 0.05. It is obvious that the value of estimated F-statistics found in the outputs due to each predictor is far greater than the critical standard value of F(2.55), a degree of freedom (df=$N-1$) at a level of significance of 0.05 alpha value set.

It must be recalled that a sharp increment in the value of F-statistics during the stepwise addition of each predictor and their interactive products symbolizes three significant points that must be noted about the model and hypothesis: (1) there is a clear relationship between the dependent variable and the three predictor variables chosen; (2) the model can be used to predict the futuristic nature of the dependent variable (level of water pollution) in relation to changes in independent variables (predictors); and (3) that the claim of a null hypothesis, *which denies the relationship between technology, policy measures and reduction in water pollution* must be accepted. Therefore, it shows that the presence of technology and policy measures do not imply that pollution trend will reduce. All the reduction in water pollution depends on type of technologies used, effectiveness of policy measures and the nature of the instruments used for implementing such policy actions.

1.2 Concluding Findings and Recommendation

The result obtained from the relationship between the predictors and dependent variable shows that development in terms of industrialization, urbanization and population growth accounts for various changes in yearly level of pollution in rivers in Malaysia. As such, the trends of water pollution tend to be sporadic in nature until the current situation despite all the policy measures and actions taken by DOE as well as technologies for waste treatments. The paper has considered technology and policy measures as moderator of the trade-off between development activities and the water pollution.

Although, there is no solid fact to attribute the root of the water pollution problem to one particular area, however, the findings of the paper have pinpointed many implications for policy-makers to ponder about. Firstly, the result of the interactive effects of predictors on polluted water implies that policy actions that might be taken against the individual sources of water pollution would be ineffective when the actions are concentrated to control only one source of water pollution. In other words, it implies that co-policy instruments and actions must be very stringent; working together against all the identified sources of water pollutants. Secondly, policy measures against water pollution may be appropriate and effective, but lack of coordinative actions and holistic actions in implementing the policies might lead to non-improvement in the level of river pollution in the country. Third, the problem also in part may be associated with the financial constraints to invest in appropriate technology especially sewerage systems for controlling human source of water pollution in the country. As for the case of waste treatments, most of the technologies currently are only based on primary and secondary treatments. Since Tertiary or Advanced Treatment is not employed in the country, it therefore implies that effluent from such treatment plants will be very high in nutrient loads. Fourth, the problem might be associated with lack of cooperation between government and private business firms to comply with regulatory policies for water pollution. Fifth, availability of technologies in industries does not necessitate reduction in water pollution rather it depends on the appropriateness of those technologies in terms of capacity and up dates; and the compliance of concerned firm industries to install these technologies. In addition, most of these technologies are only capable of primary and secondary operations. There is need for advanced and tertiary operation of waste treatments if water pollution is to be reduced. Sixth another central location of the problem is the policy issue of *contravention licence* granted to some firm industries as well as its renewals.

As noted in this study, the clause "contravention licence" provided in the Environmental Quality Act seems to be an unconscious issue in the management and control of water pollution and abatement in the country as a whole. The fact is that the said acceptable conditions may be contravened deliberately in a situation where the estimated cost of compliance by the concerned polluters seems to be prohibitive to the operation cost of the factory. Although the aim of granting contravention licences to manufacturing industries is to give them sufficient time to install technology equipments that would make these industries comply with policy requirements, the polluter industries might take this liberty for granted especially if a longer period is given for the use of contravention licence. In other words, the polluter industries might see the cost of obtaining a permission or licence to contravene the effluent-limit requirement by the policy cheaper than to set up pollution control technology. Hence, it is recommended that the cost of contravention should be made higher than the cost of compliance with "acceptable condition" stipulated in the policy instrument for water pollution control. There is need to re-examine this issue by the government, as it embodies many trade-offs between "the dos and the don'ts." The same problem goes with "Polluter Pay Principle" used as policy instrument to reduce water pollution. Many firms would prefer to pay polluter-fines than to equip the industry with technology since the amount of fine is lower than cost of technology for controlling pollution. In fact, this is perhaps weakening the policy effectiveness to control the source of water pollution. Hence, the cost of violating policy compliance should be made higher than cost of compliance by the government, if 'polluter pay principle' is to be effective.

Again, as a form of recommendation, the policy approach that would probably be most successful in achieving clean water and maintaining a vibrant economy is one that allows for experimentation and encourages cooperation among business, government and environmentalists. The complied industries with policy requirements for reducing water pollution should be given more incentives. Finally, the assimilative capacity of each river catchments must be considered in setting the effluent standards for industrial emissions. Finally, the government can provide loan incentives to small scale industries to purchase appropriate pollution control technologies rather than issuing contravention licences to them.