Reducing Effluent While Raising Affluence: Water Pollution Abatement in Malaysia

How did Malaysia manage to nearly eliminate its leading water pollution problem, without simultaneously blocking growth of the industry generating the pollution?

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Introduction

Production of crude palm oil (CPO) in Malaysia more than tripled between 1975 and 1985 (Figure 1; p.21). This expansion solidified the industry's ranking as the largest in the world — it accounted for half of world production and three-fourths of world exports in 1980[1] — and made it the country's second largest earner of foreign exchange by 1984[2] (Figure 2; p.22).

In 1975, the CPO industry also held another, more dubious, distinction: it was the country's worst source of water pollution.[3] Pollution caused by the organic wastes from CPO mills was equivalent to pollution generated by a population of more than 10 million people (Figure 3; p.23). This was nearly as large as the entire population of the country. No proven treatment technology for palm oil effluent (POME) existed. Extrapolating from 1975 pollution loads, the industrial expansion that occurred between 1975 and 1985 should have increased the population-equivalent of the industry's pollution load to 33 million people.

In 1985, however, the population-equivalent pollution load actually *fell* to 0.08 million people (Figure 3; p.23). Professor Khalid of the Universiti Pertanian Malaysia has remarked, "Malaysia is one of the few trade-dependent industrializing nations to move decisively against pollution in a key export industry."[4] How did Malaysia manage to nearly eliminate its leading water pollution problem without simultaneously blocking growth of the industry generating the pollution? What lessons does Malaysia's experience hold for other industries and other countries? Is it a unique case, or does it illustrate general principles for designing policies to improve environmental quality without sacrificing economic growth?

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The Palm Oil Industry in the Malaysian Socioeconomic Context

The federation of Malaysia is a multiethnic nation of 18 million people in peninsular and insular Southeast Asia. It was formed in 1963 by the union of the former British colonies of Malaya (which had gained its independence in 1957 and is now termed Peninsular Malaysia), British North Borneo (renamed Sabah), Sarawak, and Singapore (which withdrew from the federation in 1965). Oil palm plantations and the palm oil processing industry are concentrated in Peninsular Malaysia. The rest of this case refers primarily to this part of the country.

At independence Malaysia was a quintessential primary commodity exporter. It was the world's leading producer of natural rubber and tin. These two commodities accounted for 39 percent and 23 percent, respectively, of its export earnings in 1965.[5] A World Bank team that visited Malaya in the mid-1950s recommended that the country diversify its economy, particularly through diversification of the agricultural sector.[6] Oil palm was one of the crops it recommended. During the 1950s, however, rubber prices were relatively stable, so only limited diversification occurred.[7] Instead, estate-owners and smallholders concentrated on replanting rubber and in other ways upgrading their plantations. Rubber remained the preferred crop when new land was opened.

The shift to oil palm came in the 1960s, when rubber prices began a prolonged decline. Evidence that palm oil prices moved counter-cyclically compared to rubber prices offered the prospect of more stable aggregate export earnings. In 1962, the government announced that it would permit estates and smallholders to use rubber replanting grants, which were financed out of export duties on rubber, to establish oil palm.[8] A Ford Foundation report in 1963 reiterated the World Bank's call for diversification, and again recommended oil palm.[9] Now, the response was dramatic (Figure 4; p.24): the area of private oil palm estates in Peninsular Malaysia increased more than six-fold between 1960 and 1975, and by 1975 it was two-thirds as large as the area of private rubber estates.

The government itself got directly involved in oil palm plantations. Since the establishment of the rubber industry in Malaysia, there had been a persistent gap between rubber yields on estates and smallholdings. This and related factors, such as small land parcels, contributed to a general problem of low incomes in rural areas. To deal with these problems, in the 1950s the government established various agencies to assist smallholders. Chief among them was the Federal Land Development Authority, or FELDA, which was established in 1956. Unlike many other developing countries in Asia, Malaysia was relatively land rich. FELDA's mission was to develop new land and to provide settlers with the infrastructure, land holdings, and technical assistance they needed to raise their crop yields and their incomes.

FELDA's initial land development schemes were based on rubber. Its first oil palm scheme was not established until 1961. Between 1965 and 1975, however, three-fourths of the area developed by FELDA was planted with oil palm. FELDA's oil palm schemes represented fully two-fifths of the land converted to agriculture in Peninsular Malaysia between 1965 and 1975. Settlers in FELDA oil palm schemes enjoyed incomes that were 16 percent higher than in rubber schemes.[10]

Most of the settlers in FELDA schemes were ethnic Malays, who constituted half of Peninsular Malaysia's population in 1970. Historically, Malays have had a lower economic status than ethnic Chinese Malaysians, the country's second largest ethnic group (a third of the population in 1970). This was partially a consequence of the traditional rural basis of Malays' economic activities — rice growing, fishing, rubber and coconut smallholding — while the Chinese were typically engaged in retailing, commerce, manufacturing, and other more modern sectors centered in cities and towns.

Many in the Malay community felt that the economic gulf separating them from other Malaysians widened in the decade following independence. Rural-to-urban migration increased, but Malays frequently found it difficult to obtain jobs after they moved. When they did, the jobs were typically low skill and low paying. Squatter areas, lacking in public services and with squalid conditions atypical of the bucolic *kampungs* that the Malays had left behind, sprouted around Kuala Lumpur and other urban centers.

In May 1969, these conditions, kindled by fears that the Chinese were adding political clout to their economic dominance, exploded into racial riots that left hundreds dead. This experience fortified the government's resolve to attack rural and urban poverty and to reduce income disparities between ethnic groups. These two objectives formed the twin prongs of the government's controversial New Economic Policy (NEP). The NEP guided economic development between 1971 and 1990 and was arguably the most ambitious affirmative action program in the world. It granted various preferences — government hiring, scholarships for higher education, and share-holding requirements for new investments — to the *bumiputera* (Malays and other indigenous ethnic groups).

Land development schemes by FELDA and other agencies became a chief tool for fighting Malay rural poverty and providing economic options other than migration to cities. The schemes increased Malays' economic assets, as the settlers received title to the land after repaying a portion of the development costs at favorable interest rates. The agencies set up to develop and administer the schemes and assist the settlers provided professional employment for Malay civil servants.

These agencies and the schemes became prominent not only because of their role in advancing the government's socioeconomic engineering objectives, but also because they were well run. FELDA schemes have their critics

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— for example, those who argue that the schemes failed to tap settlers' initiative fully — but benefit/cost analyses have by and large shown that they earned positive rates of return and succeeded in raising smallholder incomes.[11] The authors of a book on environmental problems caused by development in Peninsular Malaysia have conceded that the schemes were "one of the most successful forms of rural land development in the Third World."[12] The land development program was a high profile government effort, integral to the government's economic and social development policies, and increasingly its fortunes depended on the performance of the palm oil industry.

Palm Oil Processing and POME Pollution

Like most of Malaysia's leading crops, the oil palm, *Elaeis guineensis*, is an exotic. It is native to Africa and was first planted commercially in Malaysia in 1917.[13] Due to high returns to rubber, only minor expansion of the crop occurred during the next five decades. Nevertheless, during this time estates gained valuable experience growing the crop, so when the World Bank and the Ford Foundation recommended it they were convinced it was viable.

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Malaysia's soils are nutrient poor, like soils in much of the humid tropics. They have good physical properties, however, and decades of research on rubber and estates' experimentation with oil palm had generated a good deal of knowledge on how to grow perennial tree crops on them. The combination of ideal climate, suitable soils, and sound management created conditions for oil palm to thrive in Malaysia. In fact, Malaysia is the only country apart from the Congo where oil palm produces fruits year round.[14]

Oil palm fruits yield two commercially valuable oils. The middle layer of the fruit produces palm oil, an all-purpose vegetable oil. The nut or kernel yields palm kernel oil. Quantitatively, palm oil is the more important product. A fruit cluster, or fresh fruit bunch (FFB), yields about eight times as much palm oil as palm kernel oil, by weight.[15]

FFBs must be harvested and processed as soon as they are ripe. If left on the tree, they are devoured by rodents, birds, and other predators; if harvested but not processed the same day, the oil is spoiled by the formation of free fatty acids.[16] CPO mills must therefore be located on or adjacent to oil palm plantations. The processing needs of the plantations thus led to the establishment of a large number of moderate-sized mills scattered around the countryside, rather than a small number of large mills concentrated near export points.

CPO mills' processing technology is relatively simple.[17] It is primarily a physical process, and has its origins in the technology used aboard whale ships in the 1800s. Figure 5 (p.25) shows the major steps. Mills require about one tonne of water to process one tonne of FFB, and therefore they tend to be located on watercourses.[18] FFBs are sterilized using steam to loosen the fruit and to arrest the formation of free fatty acids. The fruit is then stripped from the bunches by rotary drum threshing and pressed to release oil liquor. The oil liquor is sent to a clarification tank, where palm oil is decanted. The underflow or sludge from this tank is processed through a separator to recover residual oil. Oil from the clarification tank and the separator is purified through centrifugation and finally vacuum dried. Nuts are recovered during the pressing operation, cracked, and processed using a hydrocyclone to yield palm kernel. POME is a mixture of the wastes generated by sterilization, clarification, and hydrocycloning. Mills generate 2.5 tonnes of POME for every tonne of CPO produced.[19]

Like their whaler ancestors, CPO mills in Malaysia in the early 1970s disposed of their waste by dumping it, untreated, into the nearest body of water.[20] When there were only a handful of mills in the country the environmental impacts of this disposal method were minor. POME consists mainly of dissolved organic compounds, which at low concentrations are readily decomposed by naturally occurring microbes.

Between 1965 and 1975, however, the output of CPO grew at a literally exponential rate, as oil palm plantations in converted rubber estates and land development schemes began reaching maturity. The area of mature oil palm plantations and the output of CPO doubled between 1971 and 1975 alone (Figures 6,1; pp. 26, 21). The environmental impact of the rising POME discharge was worsened by the fact that most of Peninsular Malaysia is drained by a relatively small number of major rivers. Although the mills were dispersed, many were on one of these rivers or their tributaries. Virtually overnight, CPO mills became the major source of water pollution in almost every major river basin in the peninsula.

Pollution problems caused by POME relate mainly to its oxygen-depleting effects. Tonne for tonne, the oxygen-depleting potential of POME is one hundred times as great as that of domestic sewage.[21] When dumped into previously unpolluted watercourses, POME is initially decomposed by aerobic (oxygen-requiring) bacteria. As decomposition proceeds, oxygen is depleted. If POME discharge continues, the population of aerobic bacteria eventually crashes. So do the populations of other organisms that require oxygen, such as the fish, prawns, and other aquatic animals that provided a significant share of the protein in the diets of riverine Malay villagers in the 1960s and 1970s.[22] By mid-1977, 42 rivers in Malaysia were so severely polluted that freshwater fish could no longer survive in them.[23] Oxygen depletion also affected mangroves near river mouths, which provided vital spawning and feeding grounds for marine organisms caught by traditional Malay fishermen.[24]

When the oxygen concentration in freshwater falls below 2 parts per million, most aerobic life cannot survive.[25] Decomposition of POME

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continues, but now by anaerobic bacteria that release hydrogen sulfide, ammonia, and other malodorous compounds.[26] These compounds are toxic to fish,[27] and their odor is not merely a nuisance. In the 1970s, some villagers were forced to leave their homes and set up new villages because the stench from CPO mills was so overpowering.[28]

Rivers and streams provided the major source of drinking water for rural Malaysians in the 1970s.[29] Water from anaerobic, POME-choked rivers was unsuitable for human consumption, forcing villagers in some areas to dig wells.[30] Rivers were also the site of intakes for municipal water supplies for most cities and towns. POME pollution raised the cost of treating water to meet municipal standards.[31] While most CPO mills are not located in the northern rice-growing region of the peninsula, some farmers suspected that POME pollution was hurting their yields,[32] although one study failed to confirm this.[33] Finally, local people worried that POME clogging was creating stagnant pools that were breeding grounds for disease-bearing mosquitoes.[34]

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Between 1974 and 1978, CPO mills were the major source of water pollution complaints to the government.[35] The communist insurgency, which was still present in Malaysia into the late 1980s, used the pollution of the country's rivers and streams in its antigovernment propaganda. It seemed inevitable that the problem would only get worse. The total area of newly cleared or immature plantations was nearly as large as the mature area in 1975 (Figure 6; p. 26). Worse, no technology for treating POME existed.[36] Malaysia's success in developing the largest palm oil industry in the world made it the first country to confront a severe POME pollution problem. Unlike the 19th-century whalers, mills were not discharging their waste into a vast ocean miles from home, but into their country's own limited freshwater resources.

The Government's Policy Response, I: Prescribing a Remedy

The POME pollution problem put the government between a rock and a hard place. On the one hand, the government could not ignore the problem. POME discharge and the problems associated with it were already large, and they were growing. The well-being of the rural poor, most of them Malay, was particularly affected. On the other hand, the government could not shut down the palm oil industry. The government realized that it could not alleviate poverty without economic growth, and the palm oil industry was a principal engine of the economy's growth. Land development schemes were a principal means by which the government was attempting to raise the economic status of rural Malays.

The government therefore proceeded firmly but cautiously. Its first step was to pass the Environmental Quality Act (EQA) in 1974. POME pollution was not the sole factor motivating the passage of the EQA (for example, rubber mills were also a major source of water pollution), but it was arguably the most important one. The EQA called for the establishment of a Division (later Department) of the Environment (DOE). It authorized the DOE to "prescribe" particular classes of industrial premises and to require them to obtain a license before they could operate. The EQA authorized the DOE to attach license conditions related to pollution control. In determining the conditions, the EQA directed the DOE to consider factors related to the economic cost of pollution control:[37]

(a) *whether it would be practical to adapt the existing equipment, control equipment, or industrial plant to conform with the varied or new condition;*
(b) *the economic life of the existing equipment, control equipment, or industrial plant;*
(d) *the estimated cost to be incurred by the licensee to comply with the varied or new condition.*

The EQA did not similarly require the DOE to consider the economic benefits of pollution control, but it did direct the DOE to "consider the quantity or degree of cutback of emission . . . to be achieved by the varied or new condition."

A novel feature of the licensing provisions was the authorization to vary the size of the license fee according to:[38]

(a) *the class of premises;*
(b) *the location of such premises;*
(c) *the quantity of wastes discharged;*
(d) *the pollutant or class of pollutants discharged;*
(e) *the existing level of pollution.*

Provision (c) gave the DOE latitude to make the license fee equivalent to a pollution tax: mills that polluted more would be taxed more via the higher license fee.

The DOE was established in April 1975, within the Ministry of Science, Technology, and Environment.[39] Its most urgent task was to formulate license conditions for CPO mills. In the year that had elapsed between the passage of the EQA and the formation of the DOE, the population-equivalent of the CPO industry's pollution load had increased from 8 to 10 million people (Figure 3; p. 23).

The government realized that it could not alleviate poverty without economic growth, and the palm oil industry was a principal engine of the economy's growth.

Suppose it is 1975 and you are the first head of the DOE. The EQA authorizes you to deal with the POME problem by attaching conditions to licenses for CPO mills. How do you determine the conditions to attach to the licenses? Bear in mind the lack of a proven technology for treating POME.

Suppose it is 1975 and you are the Director-General of Malaysia's Economic Planning Unit. The Director of the newly formed DOE asks for your input on license conditions for CPO mills. What advice do you give him? Bear in mind the importance of the palm oil industry to economic diversification and the NEP's goals.

The Government's Policy Response, II: Making Polluters Pay

The DOE began the process of formulating license conditions by forming an expert committee with representatives from both industry and government.[40] The committee's assignment was to investigate possible treatment technologies and to advise the DOE on regulations that were "not only environmentally sound but also sensible within the framework of economic feasibility and available technology."[41]

The passage of the EQA, the establishment of the DOE, and the formation of the committee convinced the industry that the government was intent on reducing POME pollution. The industry began exploring treatment technologies and, through the committee and other channels, sharing information on promising leads and dead ends. Although no off-the-shelf treatment system for POME existed, systems for treating other types of organic waste had been developed in industrialized countries.[42] These systems typically involved a series of ponds that provided proper conditions for growing bacteria that could feed on the waste. Water containing the waste got cleaner and cleaner as it proceeded from one pond to the next. The industry hoped it could adapt one of these systems and avoid the higher R&D costs involved in designing a treatment system from scratch.

The industry conducted laboratory experiments to hunt for sufficiently voracious bacteria and constructed pilot ponds and tanks to test ways to grow the microbes in the field. It consulted foreign as well as local experts.[43] The fact that foreign (mainly British) interests controlled much of the industry made it easier to tap into foreign expertise.

Within two years the industry's efforts were bearing sufficient fruit to convince the DOE that it need not wait much longer to exercise its licensing authority. The environmental costs of waiting were escalating. The population-equivalent of the pollution load from POME rose by another 4 million people between 1975 and 1977 (Figure 3; p.23).

On July 7, 1977, the DOE announced the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations.[44] The regulations imposed standards on eight parameters of POME: BOD (biological oxygen demand, a measure of oxygen-depleting potential), COD (chemical oxygen demand, another measure of oxygen-depleting potential), total solids, suspended solids, oil and grease, ammoniacal nitrogen, organic nitrogen, and pH (Table 1; p. 18). The regulations required CPO mills to apply for an operating license every year. In their applications, mills needed to describe their system for treating and discharging POME. The DOE could reject a mill's license application if it disapproved of the proposed treatment system. Every three months mills also needed to file "quarterly returns" in which they reported the amount of POME discharged and its composition, based on tests by independent laboratories.

The DOE also announced that it would make the standards increasingly stringent each year over four years. The first generation of standards would take effect on July 1, 1978. BOD was the key parameter in the standards. From the first to fourth generations, mills would be required to reduce the BOD concentration in their effluent from 5000 parts per million (ppm) — one-fifth the level in untreated POME[45] — to 500 ppm. The DOE warned the industry that the fourth generation of standards would not be the final ones.[46]

The license conditions did not come as a surprise to the industry — through the committee, the industry had been consulted as they were developed — but this did not mean that they were pleased. Some companies claimed that the DOE had not sufficiently heeded the EQA's directive to "take into consideration, before attaching conditions to licenses . . . whether it would be practical to adapt the existing equipment, control equipment, or industrial plant to conform with the varied or new condition."[47] Following the DOE's announcement of the regulations, an engineer with one of the largest plantation companies claimed that "The standards proposed appear harsh against the technology available."[48] He continued,

> What is quite clear at this stage is that there is no single generally applicable solution that is proven on a large scale, over an acceptable period of time. . . . there can be little doubt that the limits for discharge will be very difficult to meet, except at a cost incompatible with the economics of operating a mill, unless there are unforeseen advances in technology.[49]

Other industry representatives concurred.[50]

The DOE stood its ground, despite the industry's complaints. It countered by pointing to several provisions that eased the burden of complying with the regulations. First, in phasing in the standards over four years, the DOE recognized that the industry needed time to construct treatment facilities, to gain experience operating them, and in other ways to move from experiment to practice. Informally, at least, the DOE weighed the environmental benefits of more rapidly implementing the standards against the industry's cost of meeting the standards more quickly, and it found that the latter exceeded the former.

Second, the DOE used the flexibility in the licensing provisions to relate the size of the annual license fee to a mill's POME discharge. It recognized that mills that discharged less pollution degraded the environment less and therefore should, according to the "polluter pays principle," be obliged to pay less to operate. The license fee consisted of two parts — a flat processing fee of M$100 and a variable effluent-related fee.[51] If a mill discharged POME into a watercourse, the effluent-related fee was linked to the BOD load in the effluent, with the mill required to pay M$10/tonne of BOD load discharged. If the mill discharged POME onto land, the fee was linked simply to the quantity of POME discharged, with the mill required to pay M$0.05/tonne. Table 2 (p.19) shows the basic license fee that a mill was required to pay for watercourse or land disposal, for various amounts of

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POME and various BOD concentrations. Higher POME discharge (for both watercourse and land disposal) and higher BOD concentrations (for watercourse disposal only) resulted in higher fees.

The DOE did not set the fees by estimating that M$10 was the value of the environmental damage caused by an additional tonne of BOD discharged into a watercourse (e.g., the loss of fish production or increased cost of treating drinking water), and that M$0.05 was the value of the damage caused by an additional tonne of POME discharged onto land (e.g., waterlogging). The DOE's officers, none of whom were economists, were more uncertain about the level of the fees than any other part of the regulations. In the end, the DOE set the fees at levels that it guessed would provide some inducement for the industry to reduce its pollution emissions without being onerous. If actual environmental costs were greater than the fees, then the fees did not induce a large enough reduction in pollution emissions — lower emissions would have generated environmental benefits that more than offset the additional treatment costs incurred by mills. On the other hand, if actual environment costs were less than the fees, then the fees induced *too much* reduction — higher emissions would have caused additional environmental damage, but the value of the damage would have been less than the treatment costs saved by mills.

Third, the DOE recognized that mills could substantially reduce their pollution discharge even if they fell short of achieving the standard. Hence, it did not make the first-generation BOD standard mandatory. For example, a mill that reduced the BOD concentration of its POME from the 25,000 ppm typical of untreated POME to 10,000 ppm would have reduced the BOD load it discharged by 60 percent. Given the time needed to install treatment facilities and to get them up and running, such a mill could well be on its way to full compliance with the standard. The short-run environmental benefits from cancelling the mill's license could be less than the long-run costs to the economy of losing the mill's output.

Mills could choose the least-cost option: either paying the direct cost of treating the POME to meet the standard, or paying the excess fee to discharge POME with a BOD concentration exceeding the standard.

The DOE permitted mills to pay an excess license fee in lieu of meeting the standard. The fee was linked to the BOD load in the POME and was identical for watercourse and land disposal, M$100/tonne of BOD load above the standard of 5,000 ppm. Table 2 (p.19) shows the fee for various POME and BOD levels. Mills could choose the least-cost option: either paying the direct cost of treating the POME to meet the standard, or paying the excess fee to discharge POME with a BOD concentration exceeding the standard. As in the case of the basic license fees, the DOE did not calculate the level of the excess fee by analyzing incremental treatment costs and incremental environmental damages. Instead, it set the excess fee much higher than the basic license fee to induce mills to meet the standard.

Fourth, and finally, the DOE recognized that ongoing R&D was necessary for addressing the POME disposal problem. Therefore, it included in the regulations a provision authorizing it to grant a partial or full waiver of effluent-related license fees to mills conducting research on

POME treatment. The industry had expressed its doubts about the effectiveness of proposed treatment systems at an operational scale; what if these doubts were confirmed? The DOE warned the industry that it was not satisfied with even the fourth-generation standard; could systems be developed to reduce the BOD in POME to even lower levels? Following site visits in 1976, a Japanese consulting firm pessimistically concluded, "Both initial and running costs for [a] mill waste treatment plant . . . which can reduce the level of BOD in treated water below 500 ppm [the fourth-generation standard] will be extremely high and the mill will be impossible to afford such high expenses."[52]

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To create an incentive for the industry to maintain its POME-related R&D programs, Section 17 of the regulations stated:

> *If the Director-General [of the DOE] is satisfied that research on effluent disposal or treatment of a kind or scale that is likely to benefit the cause of environmental protection is being or to be carried out at any prescribed premises, he may, with the approval of the Minister, completely or partially waive any effluent-related amount payable by virtue of [the license-fee] regulation.*

Even without the waiver, the effluent related fees created an incentive for research, as mills that succeeded in developing technologies for reducing the BOD in POME were rewarded by being charged lower license fees. For mills that had R&D programs, the waiver replaced this incentive with one more explicitly tied to R&D activities.

When the regulations took effect on July 1, 1978, the population-equivalent of the POME pollution load had increased by more than another million people (Figure 3; p. 23). Since 1974, when the EQA was passed, the population-equivalent had doubled. The DOE had not been fiddling while Rome burned, but it could not yet claim any tangible success in reducing the country's number-one pollution problem.

Should the Malaysian government have acted more rapidly to reduce pollution from CPO mills? Bear in mind that the pollution-equivalent of the BOD load discharged by the mills rose from 8 million people in 1974, when the EQA was passed, to 16 million people in 1978, when regulations promulgated under the EQA were finally implemented.

The excess-fee provision enabled the industry to avoid undue treatment costs.

Should the DOE have maintained the excess fees on the BOD load discharged by mills instead of making the standards mandatory? Bear in mind that during the first year of the regulations, when the excess fees were employed, the average mill reduced the BOD load it discharged daily by only half the amount the DOE expected.

Performance of the Regulations

The DOE was somewhat disappointed with the performance of the regulations during the first year. On the positive side, the DOE collected a substantial amount of revenue from license fees (Table 3; p. 20). Many mills chose to pay the excess fee rather than treat their effluent to meet the 5,000 ppm standard, which indicates that the excess-fee provision enabled the industry to avoid undue treatment costs. Forty-six mills (out of 130) paid license fees of more than M$10,000; seven paid more than M$100,000.[53] Most important to the DOE, the average mill reduced its daily discharge of BOD from about 220 to 125 tonnes.

Although this was an impressive reduction, it was less than the DOE had expected, based on a calculation of what was theoretically possible (Figure 7; p.27). The DOE had expected the average mill to reduce its daily discharge to 25 tonnes. The DOE's high expectations were not met because so many mills opted to pay the excess fees.[54] The DOE continued to receive complaints about water pollution caused by CPO mills. In 1979, mills caused 17 incidents that "affected or temporarily disrupted the use of . . . water bodies . . . for drinking, fishing, agricultural irrigation and aesthetic uses."[55]

The DOE could have responded by raising the basic and excess license fees, since these fees were apparently too low to induce compliance with the BOD standard. (The impact of the fees was perhaps not as weak as it appeared; many mills had simply not yet begun operating treatment systems they were constructing). Instead, from the second year onward the DOE made the standards not only more stringent but mandatory. It could now fine and ultimately cancel the license of any mill that violated the BOD standard.

The DOE's resolve was soon tested. It learned that a mill in the state of Penang was discharging effluent with a BOD concentration exceeding the second-generation standard of 2,000 ppm. The DOE threatened to suspend the mill's license if it did not comply within two months. The mill did, and no further action was taken.[56]

Just a few months later, a violation by a second mill, coupled with a headline-grabbing accident, pushed the DOE to take harsher action.[57] The mill, on the Sungai (River) Langat in the state of Selangor, had built huge holding ponds for its effluent instead of building a treatment system with sufficient capacity. The mill ignored repeated warnings by the DOE, apparently confident that the DOE would not suspend its license. In late October, 1979, the dike around one of the holding ponds burst, flooding a nearby village with tonnes of partially decomposed effluent. Although no villagers were killed, many lost their homes, livestock, and other possessions. National newspapers reported the accident. Backed by the public's outrage, the DOE suspended the mill's license on November 2. Between 1981 and 1984, the DOE was to take legal action against an additional 27 mills.[58]

During the second year, the average mill reduced its daily discharge of BOD to 60 tonnes, half the level during the first year. Although this still did not match the DOE's expectation, the discrepancy between performance and expectation was much less than in the first year (Figure 7; p.7). The anaerobic ponding treatment system was proving to be more successful, and more affordable, than expected, at an operational scale. Mills had encountered some problems, such as a buildup of sludge in the ponds[59] or insufficient land (which prevented a quarter of the mills from constructing adequate systems before the third year of the regulations),[60] but they had also devised means of overcoming these problems. For example, land-short mills developed systems based on agitated tank digesters rather than ponds.[61] In just two years the regulations had reduced the population-equivalent of the pollution load from 15.9 to 2.6 million people (Figure 3; p.23), despite increases in the number of CPO mills from 131 to 147 and the output of CPO from 1.8 to 2.6 million tonnes (Figure 1; p.21).

The BOD load continued to decrease in succeeding years. The industry's efforts to develop even better treatment technologies were given a boost in 1980 when the government established the Palm Oil Research Institute of Malaysia (PORIM). A survey conducted by PORIM and the Rubber Research Institute of Malaysia in 1980-81 found that 90 percent of the 40 mills surveyed were discharging POME with a BOD concentration below the fourth-generation standard (500 ppm), and that 40 percent were discharging POME with a BOD concentration below 100 ppm.[62] These findings and other evidence of ongoing improvements in treatment technology led the DOE to announce fifth- and sixth-generation BOD standards that called for even lower BOD levels (Table 1; p.18). In a concession to the industry, the DOE eliminated the standards on COD, total solids, and organic nitrogen, which the survey revealed had proved difficult for the industry to meet. In 1991, three-quarters of CPO mills complied with the sixth-generation BOD standard, and more than four-fifths complied with the other standards.[63] In 1989, the population-equivalent was less than one percent of its level at the inception of the regulations (Figure 3; p.23), even though CPO production reached an all-time high (Figure 1; p.21).

The industry's ability to reduce its BOD discharge has been facilitated by not only improvements in treatment technology but also by the development of various commercial byproducts made from POME.

The industry's ability to reduce its BOD discharge has been facilitated by not only improvements in treatment technology but also by the development, by it and by PORIM, of various commercial byproducts made from POME.[64] As early as 1977, a Danish company saw in the forthcoming regulations a market opportunity and began marketing to mills a process to convert separator sludge into animal feed.[65] By 1982, ten large pig and poultry farms were using POME meal in their feed mixes.[66] Mills that discharged POME onto land found that it had a fertilizing effect.[67] This enabled many plantations to eliminate their purchase of fertilizers,[68] which saved one company an estimated M$390,000 per year.[69] In 1992, three mills with tank digesters were recovering methane, which constitutes 60 to 70 percent of the gas generated during anaerobic digestion, and using it to generate electricity for mill use.[70] The industry has discussed selling electricity generated from biogas to the National Electricity Board.[71] One analysis found that the payback period for the investment required to build an integrated fertilizer/biogas recovery system was only 3.1 years.[72] In 1984, four mills found uses for all their POME and consequently had zero discharge.[73]

No study has analyzed which features of the regulations deserve the most credit for the massive reduction in the industry's pollution discharge. Were the innovative economic incentives in the regulations, such as the effluent-related license fees, the excess fees (in the first year), and the waivers for research expenditures, the key features? Or were the key features the more traditional, command-and-control aspects of the regulations, such as the mandatory standards (after the first year) and the DOE's authority, and demonstrated willingness, to suspend or cancel licenses? Or was the key the combination of these features, a carrot-and-stick approach?

Was the key to the program's success its 'carrot-and-stick' approach?

What *is* clear is that over time the regulations have taken on more of a command-and-control flavor. An obvious change is the switch from excess fees to mandatory standards. Less obvious is the erosion of the economic incentives due to inflation. The DOE has never revised the effluent-related license fees in the 1977 regulations. The fees of M$10/tonne of BOD (for watercourse disposal) and M$0.05/tonne of POME (for land disposal) legislated in 1978 were worth only M$6.37 and M$0.03, respectively, in real terms in 1992. Due to their much higher incomes — Malaysia had the tenth fastest growing economy in the world during the last twenty years — Malaysians undoubtedly place higher values on environmental quality than they did 15 years ago.

In spite of the fact that the industry grew even while it was facing the regulations, the regulations did impose costs on it. By 1984, mills other than those owned by FELDA had spent an estimated M$100 million to construct and operate treatment systems.[74] In the end, who actually paid these costs? By 1985, Malaysia exported mainly refined rather than crude palm oil. Both products are sold in an extremely competitive world market for fats and oils. This prevented the industry from passing the costs of treating POME onto consumers in importing countries. Instead, most of the costs were ultimately borne by oil palm growers, who have no outlet for FFBs aside from sales to CPO mills.[75] The regulations made FFB prices lower than they would have been otherwise. Professor Khalid concludes,[76]

Most of the costs were ultimately borne by oil palm growers.

> These findings serve notice to other trade-dependent industrializing nations that environmental protection need not impair overall competitiveness. However, [it] may significantly change the distribution of returns to trade.

Although estates and land development agencies footed most of the bill for the regulations, they did not protest vociferously. Why not? Although the effect of the regulations on FFB prices was discernible through economic analysis, it was not obvious in the marketplace. Moreover, in the 1980s estates and land development agencies faced a more obvious source of economic difficulties: labor shortages caused by the country's successful industrialization. Lack of settlers forced the government to slow the rate of land development (Figure 4; p. 24) and to reformulate FELDA schemes as essentially government-run estates. Private-sector jobs created by industrialization lessened the need for state-sponsored agricultural development to achieve the government's socioeconomic goals. Rapid growth of other sectors explains why palm oil's share of the country's export earnings declined in the 1980s, even through the value of exports continued rising in absolute terms (Figure 2; p. 22). One wonders what would have been the fate of the regulations if their negative impact on oil palm growers had been more obvious, and if the country had failed to diversify its economy into more industrialized sectors.

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Table 1
Palm Oil Mill Wastewater Standards

PARAMETER	STANDARD A 1.7.78	STANDARD B 1.7.79	STANDARD C 1.7.80	STANDARD D 1.7.81	STANDARD E 1.7.82	STANDARD F 1.7.84
Biochemical Oxygen Demand (BOD), 3-DAY, 30°C: MG/L	5,000	2,000	1,000	500	250	100
Chemical Oxygen Demand (COD): MG/L	10,000	4,000	2,000	1,000	-----	-----
Total Solids: MG/L	4,000	2,500	2,000	1,500	-----	-----
Suspended Solids: MG/L	1,200	800	600	400	400	400
Oil & Grease: MG/L	150	100	75	50	50	50
Ammoniacal-Nitrogen: MG/L	25	15	15	10	100*	150*
Organic Nitrogen: MG/L	200	100	75	50	-----	-----
Total Nitrogen: MG/L	-----	-----	-----	-----	300*	200*
pH	5.0-9.0	5.0-9.0	5.0-9.0	5.0-9.0	5.0-9.0	5.0-9.0
Temperature, °C						

Source: Department of the Environment, *Environmental Quality Report* 1981-84.

*Value of filtered sample

Table 2
License Fees for CPO Mills, 1978 Standards

Pollution Discharge		License fees (ringgit) — by mode of discharge						
POME output (tonnes/day)	BOD Concentration (ppm)	Processing fee	Basic license fee: Water[a]	Basic license fee: Land[b]	Excess fee[c]: Water	Excess fee[c]: Land	Total fee[d]: Water	Total fee[d]: Land
I. Increasing POME output								
45,000	5,000	100	2,250	2,250	0	0	2,350	2,350
90,000	5,000	100	4,500	4,500	0	0	4,600	4,600
135,000	5,000	100	6,750	6,750	0	0	6,850	6,850
II. Increasing BOD concentration								
90,000	2,000	100	1,800	4,500	0	0	1,900	4,600
90,000	5,000	100	4,500	4,500	0	0	4,600	4,600
90,000	10,000	100	9,000	4,500	45,000	45,000	54,100	49,600
90,000	25,000	100	22,500	4,500	180,000	180,000	202,600	184,600

a. POME output times BOD concentration (divided by one million) times M$10.
b. POME output times M$0.05.
c. Applies only if BOD concentration exceeds 5,000 ppm: POME output times difference between BOD concentration and 5,000 ppm (divided by one million) times M$100.
d. Processing fee plus basic licence fee plus excess fee.

Table 3
License fees collected by the DOE

Year	1000 M$[a]
1978	2,768
1979	714
1980	714
1981	40
1982	219
1983	271
1984	254
1985	158
1986	281
1987	310
1988	335
1989	362

a. M$ = Malaysian dollar (ringgit) = US $.040 in 1992

Source: Department of the Environment, Malaysia, *Environmental Quality Reports.*

Figure 1
Growth of the Palm Oil Industry in Malaysia

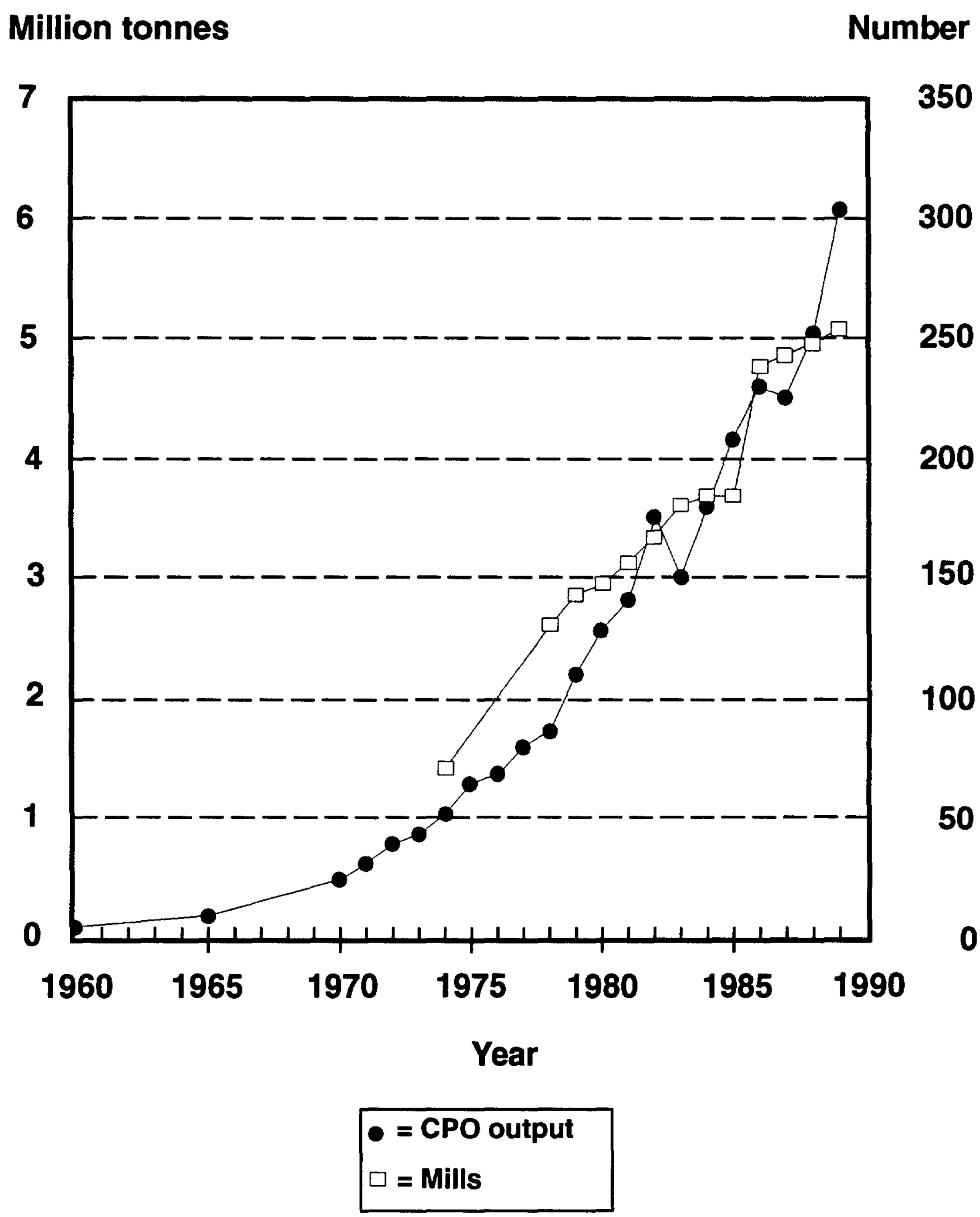
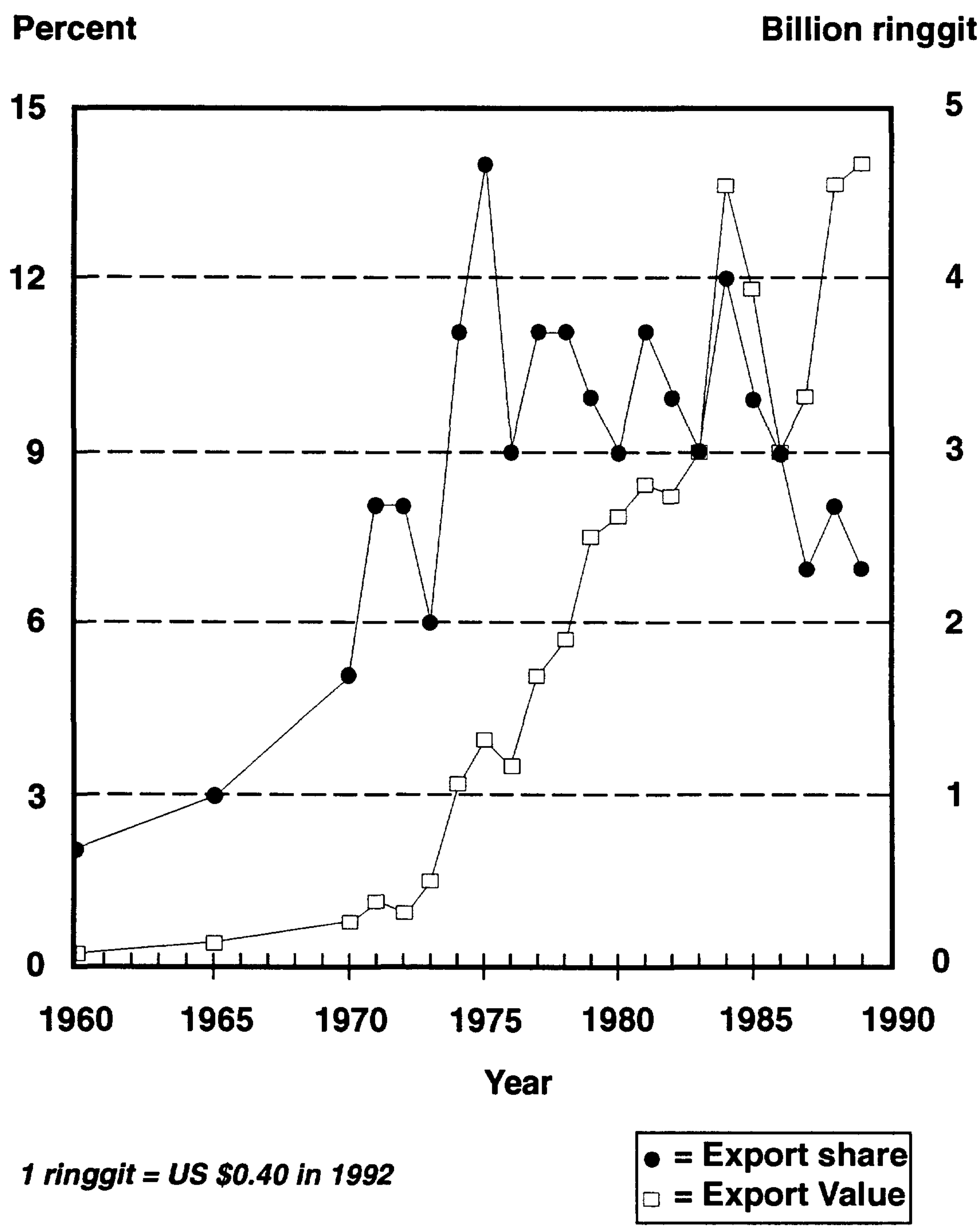
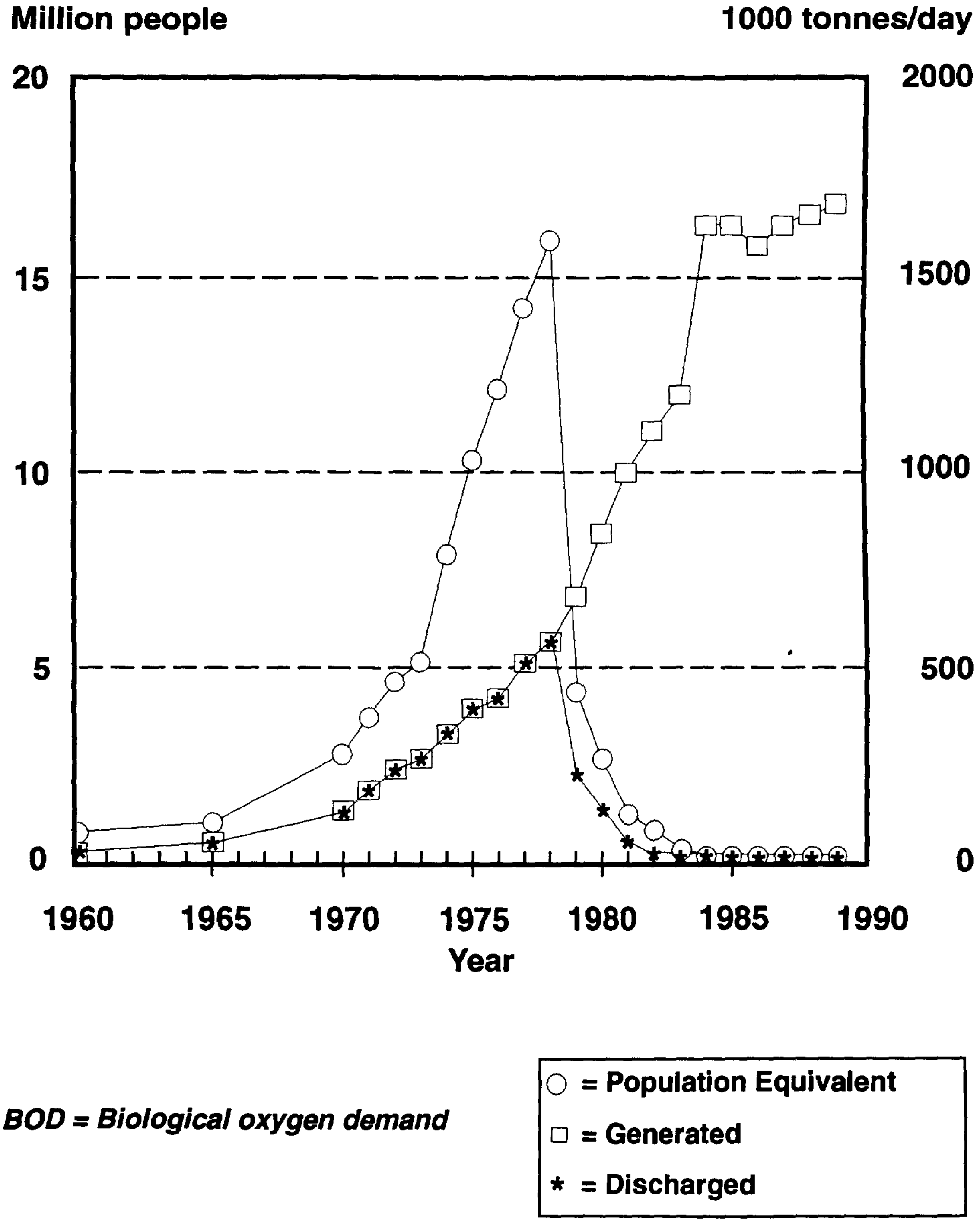


Figure 2
Crude and Refined Palm Oil Exports by Malaysia



1 ringgit = US $0.40 in 1992

Figure 3
BOD Load from CPO Mills in Malaysia



BOD = Biological oxygen demand

Figure 4
Ownership of Oil Palm Plantations in Peninsular Malaysia

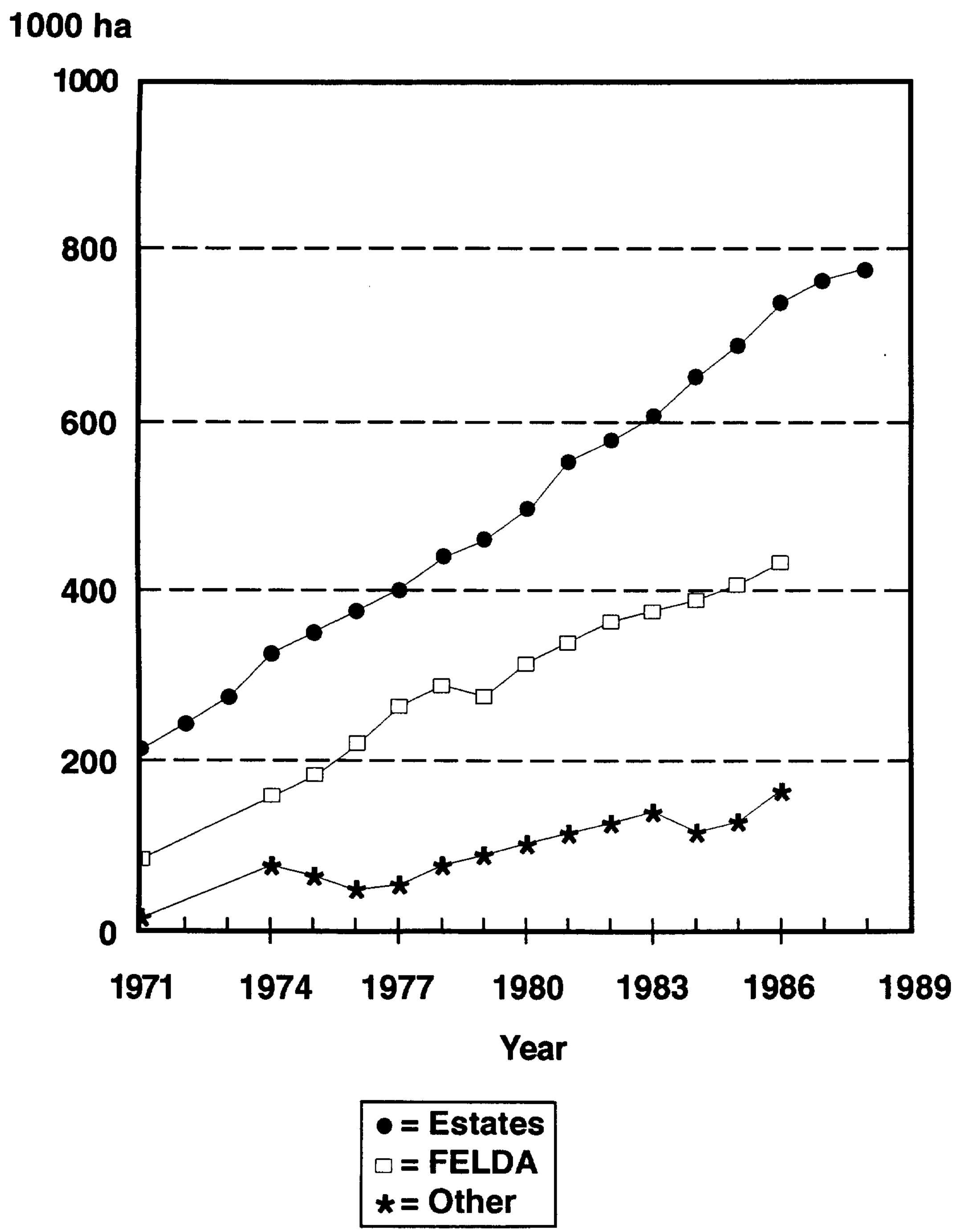


Figure 5
Palm Oil Extraction Process

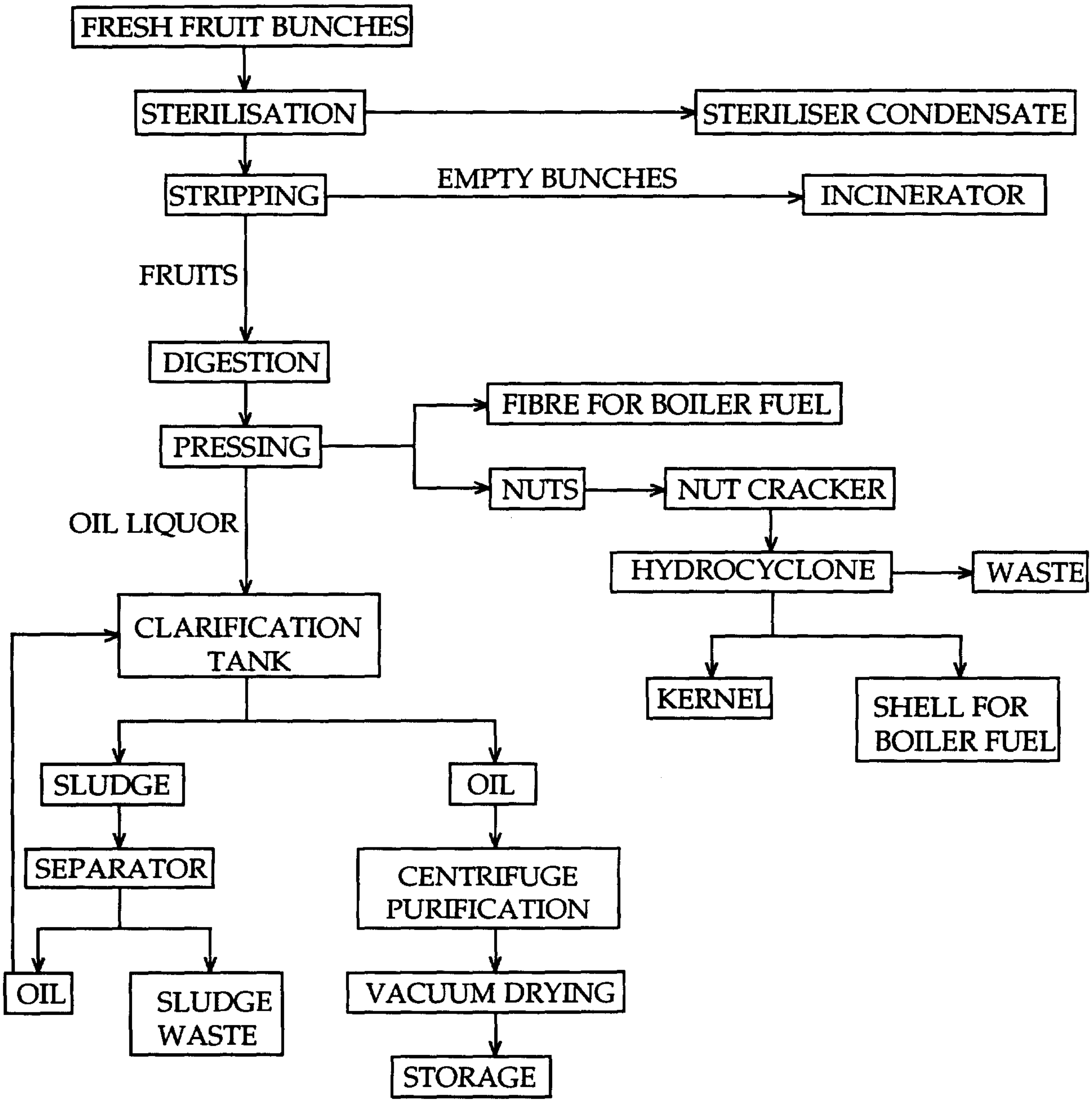


Figure 6
Status of Oil Palm Plantations in Peninsular Malaysia

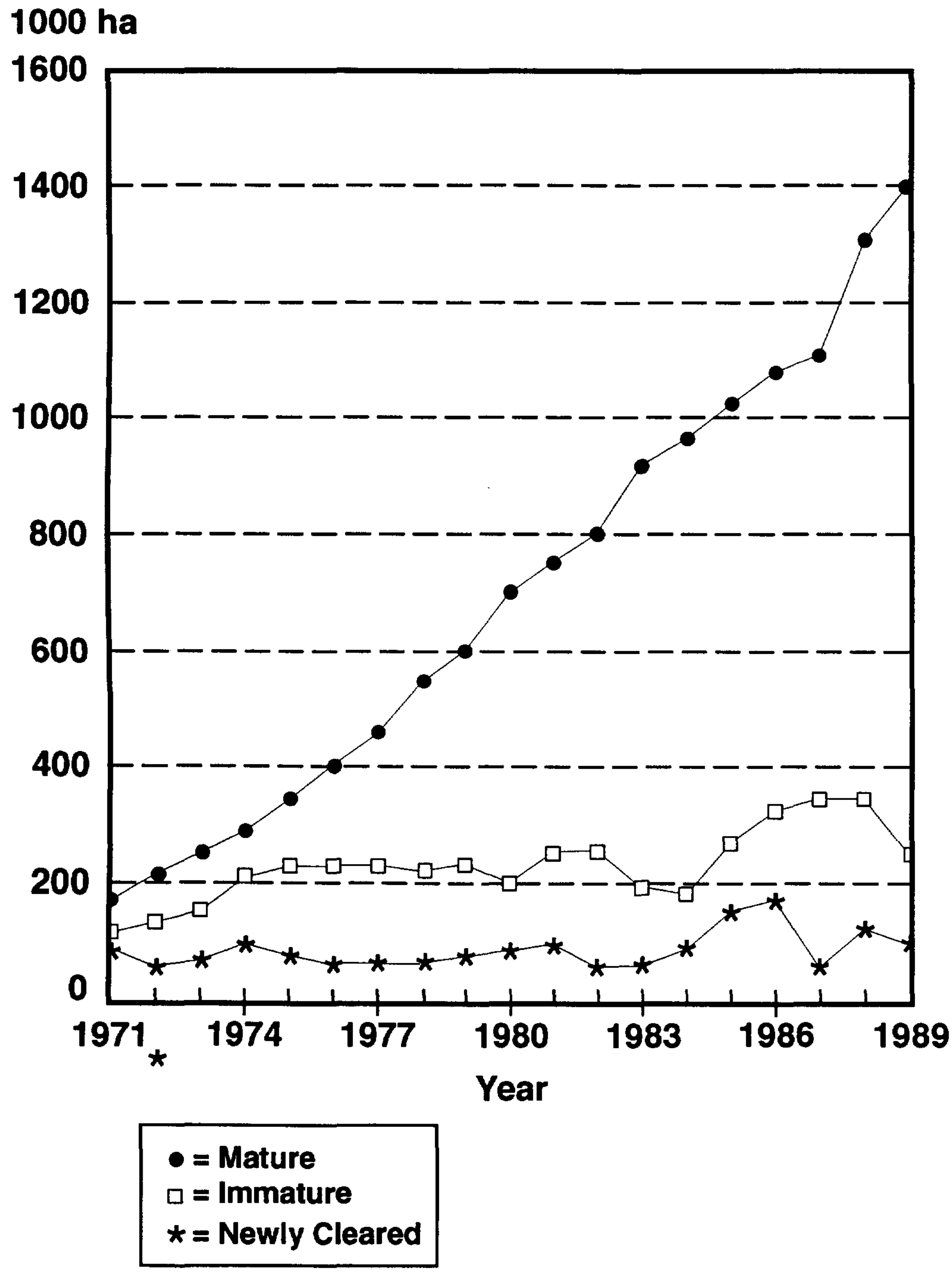
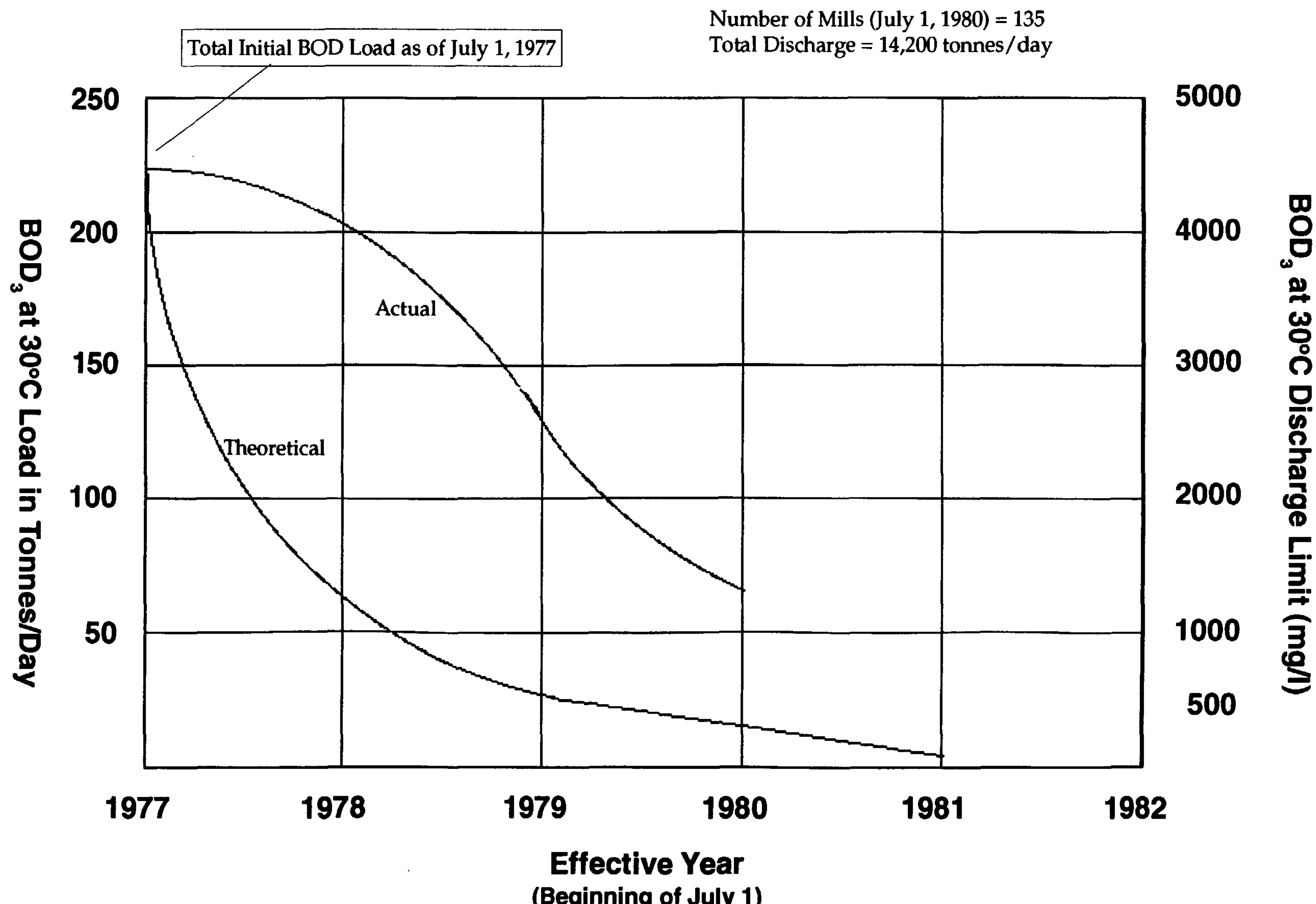


Figure 7
Expected and Actual BOD Load Reductions in The Palm Oil Industry



Source: Maheswaran, Abu Bakar, and Singh, op. cit.