CHAPTER 2

LITERATURE REVIEW

2.1 PREVIOUS STUDIES ON PAYA INDAH

A preliminary study on Paya Indah had been carried out by the Centre for Environmental Technologies (CETEC) (1996) to assess its existing hydrological condition and water quality. The hydrological study includes identification of inflowing and outflowing streams and drains, water level, water table, water movement between lakes, and effects from the proposed expressway project connecting from KLIA and Putrajaya to Bukit Cheeding (currently may known as NSECL), as well as from other planned development at that time. The water quality study was carried out in order to determine the source of acidification process onto Paya Indah water body.

Dr. Nik & Associates (DNA) (1999) had included Paya Indah in their study as part of the component in developments within the Kuala Langat Peat Basin, as water requirements for Paya Indah should be taken into account. Water requirement in their study is defined as the volume of water needed to sustain Paya Indah water table and water level (DNA, 1999). The requirement came about as a direct result of the recent forest fires within the peat forest vegetation raising concerns of a severe water shortage problem within Paya Indah (DNA, 1999). It should be noted that forest fires incident took place at Kuala Langat Peat Basin in 1998.

Dr. Nik & Associates Sdn. Bhd. (DNASB) (2001) had also carried out the study of water balance and water quality for Paya Indah as it was proposed to relocate the National Zoo at that time. The hydrological study on Paya Indah by DNASB (2001) was more comprehensive than the study by DNA (1999), when the numerical modelling had been used for the determination of Paya Indah hydrological regime. Moreover, from the numerical modelling results, they found that water balance and water quality of Paya Indah are highly dependent on the ability in sustaining the water table or water level in the peat basin as well as the ground water table (DNASB, 2001). They also observed that evapotranspiration is the main cause of major water loss (about 82%) compared to losses through canals and drainage systems (16%), and potable water abstraction (2%). Therefore, they concluded that the sustainability of Paya Indah was heavily dependent on the ability to sustain the water table on the peat basin and the groundwater table, as well as the water quality of the water bodies (DNASB, 2001).

CTI Engineering International Co., Ltd and OYO Corporation (CTI and OYO) carried out hydrological study on Paya Indah as part of study of Langat Basin. From their study, CTI and OYO (2001) observed that Paya Indah is part of the catchment area of the Langat Basin. Numerous studies had been carried out on Paya Indah including existing condition at that time, hydrological condition and water balance structures. Some of the potential pollution sources on Paya Indah had been identified, mainly from agricultural and industrial sources. Agricultural sources identified by CTI and OYO (2001) were namely palm oil estates and livestock rearing, while the industrial sources were namely industrial estates and mining activities.

DNASB et al. (2003) had carried out Paya Indah water management plan study as part of their study components. The study on Paya Indah was to determine the hydrological and ecological impact arising from the development of Cyberjaya and E-Village, which are located just to the east of Paya Indah. The impact study was done by developing an integrated hydrological model for Paya Indah water balance. As the results, to conclude the outcomes of the modelling exercise, the studies demonstrated that the development of Cyberjaya and E-Village, the North-South Expressway – Central Link and mega steel mill will have a substantial impact on the sustainability of Paya Indah Wetlands (DNASB et al., 2003) by causing both peat subsidence (loss of water) and increase risk of peat fire occurrence.

2.2 WATER QUALITY

2.2.1 Definition of Water Quality

The term "Water Quality" is a technical term that is based upon the characteristics of water body in relation to guideline values that determine its suitability for human consumption and for all usual domestic purposes, including personal hygiene, as well as suitability for other aquatic lives. Components of water quality measures/parameters include the microbial, biological, chemical and physical aspects.

The degree of water quality (good or poor) could be determined with its quantification by using hydrometry methods. The basic parameters measured are pH, dissolved oxygen, oxygen demands (biochemical and chemical), solids (suspended, dissolved, total) and turbidity for physical component, nitrogen compounds content and heavy metals for chemical component and coliform for microbial component. Other parameters such as hydrocarbons, pesticides etc. might be measured depending on the specific needs. For the biological component, biological indicator might be used.

When come to water pollution, it may refer to the changes of the water quality components that threaten health, survivals, or activities of human and other living organisms (Miller, 2004).

2.2.2 Water Quality Standards and Regulations

To control water pollution, water quality standards had been set up with the mandate of environmental legislations or regulations. According to the United States Environmental Protection Agency (US EPA), water quality standards define the goals for a water body by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. A water quality standards consists of four basic elements: 1. designated uses of water body (e.g. recreation, water supply, aquatic life, agriculture); 2. water quality criteria to protect designated uses (numeric pollutant concentrations and narrative requirements); 3. antidegradation policy to maintain and protect existing uses and high quality waters; and 4. general policies addressing implementation issues (e.g. low flows, variances, mixing zone). Therefore the water quality standards may vary according to the type of water (lakes, rivers, seawater) and type of usage of water.

2.2.2.1 Global water quality standards and regulations

The water quality standards are not uniform globally and each country has its own standards. In some cases, in a big country, each state or province under its jurisdiction has its own water quality standards. As an example, in the USA, each state has its own water quality standards mandated by Clean Water Act 1977. There are also water quality standards for Indian tribes, so called Tribal Water Quality Standards. The European Union (EU) had established its own water quality standard as it is applicable to its state members.

The water quality standards were established by taking into account of several factors such as geographical position, climate and the state's policy. Therefore, water quality standards at a temperate country may not suitable as the guidelines in a tropical country. Southeast Asian countries also have their own water quality standards, as example Indonesia and Thailand. Both countries have similar geographical conditions and climate like Malaysia. Surface water quality standards in Indonesia is governed by "*Peraturan Pemerintah Nomor 82 Tahun 2001 Tentang Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air"* (Government Regulations No. 82 Year 2001 for Water Quality Management and Water Pollution Control). This regulation includes limits of sewage discharge and water pollution control. In accordance to Section 8 (1) of this regulation, there are 4 classes of water quality, which are Class I, II, III and IV, as summarized in Table 2.1.

Ministry of Environment is mandated by this regulation to manage and monitor water quality, and to control water pollution. This regulation also delegate powers of managing water quality and control water pollutions to Chief of Provinces, Districts and Towns.

Table 2.1
Classification of Water Quality in Indonesia

Class	Details
Class I	Suitable for human consumption such as drinking or similar uses.
Class II	Suitable for recreation, freshwater fish aquaculture, livestock, irrigation or similar uses.
Class III	Suitable for freshwater fish aquaculture, livestock, irrigation or similar uses.
Class IV	Suitable for irrigation or similar uses.

Source: Section 8 (1), Government Regulations No. 82 Year 2001 for Water Quality Management and Water Pollution Control

In Thailand, the freshwater quality standard is called Surface Water Quality Standards and is regulated under an environmental law called "The Enhancement and Conservation of National Environmental Quality Act 1992". The Surface Water Quality Standards comprises 5 classes that are Class I to Class V. Classification of Class I to Class IV is similar to Indonesian Water Quality Standards. Additional Class V is for water that classified other than Class I to Class IV.

2.2.2.2 Water quality standards and regulations in Malaysia

Water quality in Malaysia is regulated by numerous regulations according to the type of water and its usage. In environmental aspects, Environmental Quality Act 1974 governs water quality for specific uses, such as Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977, Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978 and Environmental Quality (Sewage and Industrial Effluents) Regulations 1979. Malaysia also has water quality standards such as Interim National Water Quality Standards (INWQS) and Interim Standards for Marine Water Quality (ISMWQ), but these standards are not regulated directly under Environmental

Quality Act 1974. These standards have been as guidelines adopted by these concerned, especially in the implementation of environmental monitoring and management plan, and assessment in Environmental Impact Assessment (EIA), where they were enforced through. The obvious differences between INWQS and ISMWQ are addition of Salinity parameters in ISMWQ.

INWQS are classified into 5 major classes, which are Class I to Class V. Class I is mainly for environmental conservation and protection of very sensitive species. Class II is divided into two, which are Class IIA and Class IIB. Class IIA is mainly for water supply and Class IIB are suitable for recreation with body contact. Class III is for livestock drinking, suitable for moderately tolerate species of aquatic life and still can be used as water supply with extensive treatment. Class IV or Class V are polluted water, as Class IV is only suitable for irrigation.

2.3 WETLANDS

2.3.1 Definition

There are numerous versions and variations of wetlands definition.

The term ‘wetlands’ is a relatively new one to describe the landscape that many people knew before under different names (Williams, 1990). This term frequently refers to a vegetated landscape that is frequently inundated with water either stagnant or slow-moving.

Wetlands are defined by the Convention of Wetlands of International Importance (Ramsar Convention 1971) as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed 6 meters”.

From National Academy of Science, Ohio States University of the United States (Mitsch and Gosselink, 2000), “A wetland is an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features reflective of recurrent, sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physiochemical, biotic, or anthropogenic factors had removed them or prevented their development”.

U.S. Army Corps of Engineers define the wetland in accordance with 1977 Clean Water Act Amendment that ‘the term “wetlands” means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. (33 CFR 328.3(b); 1984) (Mitsch and Gosselink, 2000).

Food Security Act Definition (Mitsch and Gosselink, 2000) mentioned that ‘The term “wetland” except when such term in part of the term “converted wetland” means land that-

(a) has a predominance of hydric soils;

(b) is inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions; and

(c) under normal circumstances does support a prevalence of such vegetation.’

2.3.2 Classification of Wetlands

Ramsar Classification of Wetland Type is used here, which is coastal wetlands, inland wetlands and artificial wetlands, which simplified the complexity of wetlands classification according to certain factors such as soil type, hydrology, biology, geomorphology and chemical factors.

Five major divisions or systems, each of which share similar locational-geomorphological, hydrological and biological characteristics, were recognised (Williams, 1990). There are the coastal wetlands, which include (a) marine; and (b) estuarine wetlands, and the interior wetlands, which include (c) riverine; (d) lacustrine; and (e) palustrine wetlands (Williams, 1990).

2.3.3 Importance of Wetlands

Wetlands are one of the most important ecosystems on the earth due to the hydrologic conditions and their roles as ecotones between terrestrial and aquatic systems (Mistch and Gosselink, 2000). Williams (1990) had employed four broad categories of wetland functions, inter alia physical/hydrological, chemical, biological and socio-economic. However, none of these categories is exclusive and each can have a profound effect on the other such as chemical pollution will affect biological process and wildlife habitat, as quoted by Williams (1990) again.

2.3.3.1 Function of wetlands' characteristics

The hydrological of the wetland creates the unique physico-chemical conditions that make such an ecosystem different from both well-drained terrestrial system and deepwater aquatic system (Mistch and Gosselink, 2000). Therefore, the numerous hydrological functions played by the wetlands are water table regulation, flood mitigation, water quality improvement, climatic and atmospheric fluctuation, and possibly coastal protection.

Wetlands may regulate water table at its vicinity due to its capability to store and maintain water level at its basin or reserve. For inland wetlands, especially in tropical climates, this is essential because during dry season, evaporation rate may be higher, and water level at terrestrial area may be lowered. Thus the water from adjacent wetland basin will replenish the water table and water level. Apart from that wetlands also could be a water catchment where water from surface terrestrial area will be stored at its basin and groundwater table will be replenished, or drained into the tributaries.

Wetlands also are able to mitigate flood by temporarily storing run-off water and thereby protecting downstream localities (Williams, 1990) where the wetlands reduce run-off water velocity, then the run-off water will be maintained at its basin, and will be drained properly through tributaries, or sink into the ground. This at the same time will replenish groundwater table.

Water quality improvement by wetlands in this section refers to its function to improve water body's physical characteristics, namely suspended solids and turbidity. The other water quality components will be discussed in the subsequent section. Wetland's vegetations play important roles as natural filter to trap sediment and suspended solids from the water body that flows through this vegetation. This will enhance the clarity of outflowing water. It is proven by Lui (2003), where the construction of the Putrajaya Wetlands has improved the water quality of the Putrajaya Lake. There is a significant difference in the water quality of the lake before and after the construction of the wetlands. A similar difference is observed between upstream of Sg. Chua and Putrajaya Lake. While the presence of suspended sediments is detrimental to water quality, they have a strong tendency to absorb nutrients, pesticides, heavy metals and other toxins such as chlorinated and petroleum hydrocarbons (Williams, 1990), of which the details will be also discussed in the subsequent section. These substances could be removed by the vegetation itself or through slow decomposition once filtered and deposited. This process also may enrich the nutrients compositions in the wetlands through decomposition of the organic matter included in the trapped solids.

Wetlands soil can be as a net carbon sink and can absorb between 57 x 10^6 and 83 x 10^6 tons per year, as suggested by Armentato and Menges (1986) for temperate wetlands (Williams, 1990). However tropical wetlands can absorb more carbon than temperate wetlands. As example, peat swamp forests in Indonesia sequestered between 0.01 – 0.03 Gigatonnes of carbon annually in their original states, but this carbon sequestering system there had been reduced significantly due to reduction of peat swamp forests resulted from drainage, conversion to agricultural land and other activities in recent years (Sorensen, 1993). A study carried out by Mitsch et al. (2009) in a tropical wetland in Costa Rica shows that tropical wetlands could absorb carbon as much as 80 percents!

Wetlands' functions as a natural revetment for coastline and riverbanks are obvious. This is because the vegetation roots hold the soil from being washed away by strong currents or waves, as the roots will reduce the current speed or wave velocity. Tsunami events in 25th December 2005 that cost approximately 300 000 lives in the affected areas had given the lessons on the importance of coastal wetlands, where it can act as a natural defender from destructive storm or tsunami events.

2.3.3.2 Chemical functions of wetlands

As discussed in the previous section, wetlands play an important function in improving outflow water quality. In the chemical aspects, wetlands remove heavy metals, pollutants and pesticides through numerous processes. Removal of nitrogen and phosphorus are done through microbial process, where some vegetation and trapped sediments provide colonization for the bacteria that are involved in the microbial process. In much the same way, toxic residues from waste products, such as heavy metals, pesticides and herbicides, can be removed from the water by ion exchange and absorption in the organic and clay sediments (in effect they become buried in the sediments) and through uptake by plants, particularly the bullbrush (*Schoenoplectus lacustrus*), the common reed (*Phragmites australis*) and the water hyacinth (*Eichhornia crassipes*), which is an aggressive colonizer of warm still waters (Williams, 1990). Therefore, wetlands could act as efficient natural effluent treatment facilities for treating domestic effluents.

2.3.3.3 Biological functions of wetlands

Wetlands are well known as a landscape with rich biodiversity and very productive. They are amongst the most productive ecosystems in the world, rivalled only by some tropical rainforests and the most intensively cultivated areas of land (Williams, 1990) such as paddy fields, due to its nutrient richness provided by organic material decomposition.

Wetlands provide habitats for numerous invertebrates such as planktonic organisms, molluscs, crustaceans and insects, and cold-blooded vertebrates such as fishes. Apart from that, wetlands also provide breeding and nursing ground for fries, sheltering them from predation and harsh outside weather, beside offering foraging grounds, through its natural characteristic that is protected and inaccessibility by larger predators.

Some types of insects are solely dependent on these ecosystems. Fireflies are well-known as a kind of insects that are solely dependent on a tree species, namely Beremban (*Sonneratia* sp.). According to the information from an anonymous excerpt from

Malaysian Nature Society, this tree species can be found at the mangrove forest, or possibly at the area that has lower salinity, as low as 3 ppt. Fireflies frequently dwells at this tree species. Any disturbance of the Beremban trees may significantly affect the fireflies' populations.

According to the Malaysian Wetland Foundations, wetlands are also known as stations for migratory birds during migration seasons. In Malaysia, Kuala Gula in Perak is well-known as a sanctuary for birds, especially migratory birds and endangered species. Wetlands are utilised as their foraging ground, nursery and shelter. Most of the migratory birds' species encompassing species that are enlisted in IUCN as endangered. Paya Indah itself is an important ground for migratory bird species. As explained in the previous chapter, the wetland degradation in the earlier years had led to a decline in their number of birds visiting the location, but with the preventive measures taken by DWL later on, the number of bird species had increased again.

2.3.3.4 Roles of wetlands in socio-economy

Wetlands play important roles in numerous socio economic activities, namely natural resources production and aesthetic values (Williams, 1990; UNDP, 2006). In terms of natural resources production, inhabitants in interior wetlands, especially the indigenous people rely heavily on the resources from inhabited wetlands for their food, medicine, fuel and timber. Fish and certain aquatic vegetation such as Lotus (*Belumbo nucifera*) (Lim et al., 1998) are an important food sources for this community. Therefore, fishing activities are common in this type of wetlands.

According to UNDP (2006), wetlands also can be commercially utilised for timber, agriculture, fishing, peat extraction, and solid waste disposal. Commercial logging can be seen at mangrove swamps, where the timbers are utilised for construction material and charcoal production. Matang Mangrove Forest has demonstrated as the most successful forest conservation and sustainable logging, where conservation systems inherited from the colonial period are still implemented. Commercial aquacultures such as cockles (*Anadara granosa*), mussels (*Perna viridis*), mud crabs (*Scylla serrata*), shrimps and fishes in numerous forms are common at mangrove swamp and estuarine areas, besides coastal fishing activities.

In terms of aesthetic values, wetlands are becoming increasingly popular as eco-tourist destinations (Perbadanan Putrajaya, 1999). Their biodiversity, open space, aesthetics and the development of public amenities make them attractive prepositions for recreational activities and social pursuits (Perbadanan Putrajaya, 1999), such as recreational fishing, jungle trekking and educational activities, and bird watching for bird watchers. Therefore, several wetlands in Malaysia, especially Ramsar wetlands have become tourism destinations, for example Tanjung Piai in Johor, Tasik Bera in Pahang and Kuala Gula in Perak. Kuala Gula had been designated as a migratory birds and endangered birds sanctuary, and also as a bird-watching destination. Besides, a constructed wetlands, namely Putrajaya Wetlands is constructed not only for water quality management at Putrajaya vicinity, but also as a tourism attraction and as part of Putrajaya's landscape. Besides, wetlands also offer scientific and research opportunities for relevant institutions and individuals.

2.4 CONCLUSIONS

From Williams (1990), Paya Indah can be classified as an inland wetlands, but have combinations of both lacustrine and palustrine characteristics, as it comprises peat swamp at the north and ex-mining land for tin at the south and west. This combination forms a unique water quality feature of Paya Indah. Some of the wetlands characteristics are featured in Paya Indah, in terms of physical characteristics and biological function. The physical characteristics are water table regulations and flood mitigation of Langat Basin (CTI and OYO, 2000; DNASB et al., 2003), and maintaining peat soil to be kept inundated with water. As addressed in Chapter 1, the main biological function of Paya Indah is as habitat, foraging ground and reproduction for migratory birds. It should be noted that all available characteristics will be discussed in detail in a specific chapter for existing environment.

It was also advisable by the previous studies that any development within Kuala Langat Peat Swamp Forest generally and Paya Indah Wetlands especially must be carefully planned, by taking into account the adverse impact on Kuala Langat Peat Swamp forest caused by the development. The potential adverse impacts on Paya Indah were mainly reduction of water quality, peat subsidence and risk of peat fire. Thus a special development plan had been drafted by Selangor’s Jabatan Perancang Bandar dan Desa (JPBD) (1999), namely *Draf Rancangan Tempatan Kawasan Sekitar Paya Indah Wetlands Sanctuary 1999 – 2010*. The aim of this plan is to control and minimize the changes of land uses within Paya Indah vicinity, as well as to propose suitable type of development to ensure its sustainability.