THE IMPACT OF SEJINGKAT COAL – FIRED POWER PLANT ON FISH FAUNA AND FISHERIES IN SUNGAI SARAWAK

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ABSTRACT

Study on the impact of Sejingkat Coal-fired Power Plant on the fish fauna and fisheries of Sungai Sarawak was carried out in December 2005 until March 2006. Sejingkat Coal-Fired Power Plant is the first project of its type in Sarawak and is operated for electricity need of industries in Kuching. This study was carried out through sampling of fish fauna and survey based on questionnaires carried out on the local inhabitants of Kampung Senari, Kampung Goebilt and Kampung Muara Tebas. A total of 22 species of fish from 18 families and 4 species of crustacean from 2 families were recorded from Sungai Sarawak. A daily catch of 170 kg was reported for Kampung Senari, 785 kg for Kampung Goebilt and 870 kg for Kampung Muara Tebas. The result showed that there is minimal impact of Sejingkat Coal-Fired Power Plant on the fish fauna and fisheries of Sungai Sarawak. It could be postulated that the water used in the cooling of the turbine system and then discharged into Sungai Sarawak did not have significant impact on the aquatic life in Sungai Sarawak. Therefore, impacts, if any are localized to a small area closed to the discharge outlet. This may be due largely to the tidal influence of Sungai Sarawak whereby heated water discharge into the river is well diluted.
ABSTRAK

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CHAPTER 1
INTRODUCTION

According to Lloyd (1992), GESAMP defined marine pollution as the introduction by man, directly or indirectly, of substances or energy (e.g., heat) into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resource, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater and reduction of amenities.

1.1 Background of Sejingkat Coal-Fired Power Plant

Coal is one of the best alternative resources to generate electricity besides hydro power, wind energy, solar energy, wave energy and nuclear power. In Sarawak, Sejingkat coal-fired power plant is the pioneer project and sole power station that generate electricity using coal. Another coal-fired power station will soon be launched in Mukah, Sarawak (The Borneo Post, February 24, 2006).

The Sejingkat CFP is located about 27 kilometers from the state capital, Kuching and built on a 130 hectares land area at the bank of Sarawak River. Coal is supplied mainly from the coal mine in Merit Pila of Batang Rajang, Sarawak. The annual consumption of coal for phase 1 and phase 2 is estimated to be 744,000 tones (EIA Technical Reports, 2002). Three fishing villages are situated nearby this coal fired plant namely as Kampung Senari, Kampung Goebillt and Kampung Muara Tebas. Majority of the fishermen are Malays and some Chinese operate shrimp ponds at
Muara Tebas area.

Apart from the Sejingkat Coal-fired Power Plant, a lot of other industrial developments and shrimp farming activities have taken place along the Sungai Sarawak. Therefore, the river receives different type of pollutants from industries such as Steel Mills, Flour Mill, HTPE Product Factory, shrimp farming and Hardwood and Softboard industries. All these industries stated are located at Sejingkat area.

The coal-fired power station operates as a base load plant and the electricity produced is sold to Sarawak Electricity Supply Corporation (SESCO). The power station was designated to accommodate four units of steam turbine generators of 50 MW in phase I and 55 MW in phase II (EIA Technical Report, 2002). The electricity generated from phase I is then supplied to Kuching City and Sejingkat Industrial area. Meanwhile, electricity generated from phase II will go into the state grid to cater for the needs of the whole state.

There are several processes involved during the operation of fuel (coal) processing such as fuel combustion and by products, ash disposal system, turbines and generators, cooling water systems (condensation) and fresh water system (EIA Technical Report, 2002).

Generally, electricity is produced by the process of heating water in a boiler to produce steam. The superheated steam at 535 °C produced under tremendous pressure will
flow into turbines, which spins a generator to produce electricity. Basically, a large amount of water from Sarawak River is needed for the cooling system which are then discharged back into the river. This may increase the temperature of the receiving body from an original seawater temperature of 25 °C to a temperature of about 33 °C in a 20 meter radius. With the water temperature ranging between 25 °C, the increment was predicted to be 7.84 °C which is well within the Malaysian Standard. Furthermore, in order to prevent marine growth fouling (barnacles and other molluscs), the water will be treated by chlorine dosing (EIA Technical Report, 2002). Apart from that, as mentioned by Suh (2001) the cooling water discharges, also contained unwanted by-product that may cause harmful effects to the marine environment.

1.2 Scope of Study

This study focused on whether there are changes with the operation of phase I and phase II of the Sejingkat Coal-Fired Power Plant in fisheries and fish fauna in Sungai Sarawak.

1.3 Justification of Study

The demand for fish in every part of the world is reaching a stage where the resource should be managed properly in all aspects. In Sarawak, the coastal areas are being intensively developed in term of industrial as well agricultural. For instance, coal-fired power plants have to be built at the river estuarine in order to have surplus
supply of water for the system of cooling (Laws, 2000). Thus the impact of
development toward the natural habitat for those resources will be signified greatly in
future unless certain management have to be considered to minimize the situation.
Fish fauna communities in many major rivers in the world have also been affected by
the construction of dam primarily for the purpose of electricity generation. Apart from
dam construction, the increasing amount of power produced by fossil fuel and nuclear
power plants makes it pressing to establish the real impact of heated effluent
discharge from power stations on the aquatic environment and its organism (Crema
and Pagliai, 1981). However, much of the research that have been carried out on this
problem (Roessler, 1971; Verlaque et al., 1981; Crema and Bonvicini Pagliai, 1981;
Dinet et al., 1982; Saenger et al., 1982; Bamber and Spencer, 1984; Aleem, 1990 and
Suresh et al., 1993) have focused on benthic communities, which are considered a
suitable group for detecting the effects of different kinds of pollutant (Warwick, 1993).
Benthic species are susceptible to any effects of a thermal discharge, since they have
limited ability to escape. Many of them are sessile or sedentary and even many errant
species move little during their life-time (Bamber and Spencer, 1984). However, there
will be little loss of information if the data are analyzed at a higher taxonomic level

Agatha (2005), found that Coal-fired Power Plant have several impacts on community
structure of harpacticoid copepods at the study areas. The community of the
harpacticoid copepods were reported to be influenced by several physico-chemicals and
biological parameters. In addition, a study done by Juliana (2002), found that water temperature significantly affect the density of macrobenthos at the study area. The results of both studies were obtained during the operation of phase I of the power plant. Recently with the operation of phase II the cooling water effluent discharged from the power plant is 2.85 m$^3$s$^{-1}$. This cooling water will be pumped in from the Sarawak River from a distance of 100 m from the river bank and subsequently discharged to the river. There is concern as to the extent of the cooling water discharge plume in the river and its impact on aquatic life.

Harpaticiod copepods and macrobenthos are important to the fish fauna as they played a role as a source of food for fish. Agatha (2005) and Juliana (2002) have shown that these two taxa were affected as a result of the operation of the coal-fired power plant in Sejingkat. However, no studies have been carried out to determine the effect of the power plant on the fish fauna and fisheries.

1.3 Objectives

The objectives of this study were to:

1. record the fish fauna present in Sungai Sarawak;
2. record the fishing activities of the three villages located near Sejingkat Coal-fired Power Plant;
3. determine the impact of Sejingkat Coal-fired Power Plant on the fish fauna and fisheries in Sungai Sarawak.
CHAPTER 2
LITERATURE REVIEW

2.1 Coal Utilization

The usage of coal in generating electricity is later when compared to gas and oil. Botkin and Keller (2000) mentioned that coal is burned to produce nearly 60% of the electricity, and about 25% of the total energy consumed in the United States today. However, the giant power plants are also responsible for about 70% of the total emissions of air pollutants that arise from the combustion processes, or coal gasification or liquefaction plants.

Industrialization leads to the increase use of coal for generating electricity. Electricity has displaced the direct use of coal industry as oil-based electricity generation is uneconomical in comparison with coal. Hester (1983) mentioned that about 70% and 90% of the total quantity of coal is utilized for electricity generation. World wide this proportion range from 70% in the United States, 50% in the Western Europe and 15% in Japan (Chadwick et al., 1989). According to England (1980) about 75 and 80 millions tones of coal a year will be expected to be maintained in some years to come. The Industrial Revolution also leads to rapidly increasing of volume of water used in the cooling processes (Hester, 1983). Larger industries will proportionately discharge larger volumes of heated and noxious effluents to the nearest water body.
However, Laws (2000) pointed that the greatest disruption to aquatic systems from power plant effluents may be caused by the continual exposure of the organism to sublethal stresses rather than the occasional killing of large number of organisms due to thermal shock, chlorination, or gas bubble disease.

Khalanski and Bordet (1980) mentioned that chlorine is widely used to treat fouling organism in both freshwater and marine cooling system because it act quickly and chlorine is also relatively inexpensive. However, chlorine is highly toxic to the aquatic organisms.

A case study at Turkey Point, Biscayne Bay in East Florida showed an adverse impact on aquatic fauna when Florida Power and Light Company (FPL) built an oil-fired generator in 1964 and followed by nuclear-powered generators in 1971. This study found that a total area of 2.7 km² was affected. A massive fish killed was entirely caused by elevated temperature resulting from nuclear plants cooling waters discharges (Laws, 2000).

2.2 Daily Operation of Coal Power Plant in Sejingkat

According to the EIA Technical Report (2002), several processes involved during the operation of the coal-fired power plant are fuel (coal) processing, fuel combustion and by products, ash disposal system, turbines and generators, cooling water systems (condensation) and fresh water system. The brief descriptions of each component are as follows:
2.2.1 Fuel processing

Firstly, coal needs to be dried and milled to the correct size. The processed coal will be carried out by air stream through the separator and distributor. Coarser material is regrounded and the impurities (e.g., shale, etc.) falls into the reject box.

2.2.2 Fuel combustion and by products

The coal will then be channelled to the furnace through 4 corner burners. The coal dust will be combusted to 540 °C to enable the generation of superheated steam to power the turbines. In the process of combustion, various by products are produced and these include water vapour, carbon dioxide, sulphur oxides, nitrogen oxides and particulate.

2.2.3 Ash disposal system

The bottom and fly ash are to be pumped into the ash disposal area by a system of slurry pumps and settled in the ash pond. Hydraulic ash disposal piping will be adopted using Dg 194 × 7 mm thick steel pipes and will be internal-lined with cast basalt pipes. Treatment technologies to reduce airborne particulate emissions from coal-fired power plants have reached a high level of efficiency, sometimes achieving in excess of 99.5% removal. Huge volumes of seleniferous fly ash (50 to 300 µg Se/g) and other combustion wastes are generated in the process. Selenium-laden seepage (50 to 200 µg Se/L) can be transported off-site, where it may ultimately reach streams or other surface water, bioaccumulate, and threaten the health of fish populations. The
design specifications for fly-ash landfills acknowledge that even under the best conditions, some contaminated leachate will result (Murtha et al., 1983).

2.2.4 Turbines and generators

The superheated steam produced will pass to the turbines at 535 °C. The steam will be passed through sets of turbines blades resulting in turning the turbine shaft at a speed of 3000 rpm. The turbine is coupled to a generator, which generates 55 MW of electricity. The primary open circuit seawater cooling system will channel the spent to the condenser where it will be cooled. The condensate will then be pumped back to the boiler drums to be heated back to steam as before. Any reduction of the boiler will be topped up with demineralised fresh water.

2.2.5 Cooling water system

Seawater is used to cool the condenser and then discharged back into the river downstream of the intake head. The distance is chosen to ensure that there is minimum possible occurrence of warm water reticulation. With the water temperature ranging between 25 °C, the temperature increment was predicted to be 7.84 °C, which is well within the Malaysian standards. In order to prevent marine growth fouling (barnacles and other molluscs) biocide such as chlorine were added into the water (EIA Technical Report, 2002).
2.2.6 Fresh water system

Fresh water is mainly used in the coal-fired power station for the boiler make up water only after demineralisation. This process is used in the secondary cooling circuit for air coolers, lube oil coolers, oil coolers, generator stator coolers and other equipments in the power station.

2.3 Effluent Discharge from Coal-Fired Power Plant

Markham (1994) stated that the most intractable problem is water pollution as a result of water discharges from coal-fired power plant cooling system. For example, the heated water that was discharged from a coal-fired power plant will affect the environment. However, Baumgartner (1996) reported that heated water or water containing some contaminants might not be a problem provided it is well mixed with a large volume of surface water and of that diluted material does not accumulate over time.

Cooling water discharges from the electricity generating stations including coal-fired power plant are the main sources of pollution by heat. The increase in temperature results in altering of physical environment, in term of both a reduction in the density of water and its oxygen concentration. The impact on fish may be due to reduced resistant to disease, reduced metabolism efficiency and changes in competitive advantage.
Laws (2000) stated that aquatic organisms may also be killed by the discharge of chlorine used to prevent fouling in the turbine system. The toxicity of chlorine plays an important role in the impact of the entrainment on the other types of organism such as zooplankton. Clark and Brownell (1973) reported the decline in numbers of menhaden at Cap Pod Canal Plant in Massachusetts in 1968 and the killing of 40,000 blue crab at the Chalk Point Plant in Maryland.

2.4 Fish Fauna and Benthic Organism

2.4.1 Fish fauna

The potential significant impacts of the Sejingkat Coal-fired Power Plant to the fish community at Sarawak River can be divided into the construction phase and during the operation of the power plant.

During the construction phase, the most likely potential impact is the increase in total suspended solids at an area near to the construction site. An increase in sediment load would give negative effects to the fish community. Sediments, especially fine mud particles can get easily stuck to the gills of fish and crustacean and this will reduce the ability of the gills to absorb oxygen from the water, reduce growth rate, more susceptible to diseases and affecting the development of eggs and larvae (Gaber and Gaber, 1992). Excessive sedimentation could potentially produce fatal effects on fish and crustaceans communities. However, the fish communities in Sarawak River are non permanent resident of specific area due to the generally homogenous nature of the
river and tidal influences. These non permanent resident fishes will move away or avoid an area that is high in sediment load.

During the operation phase, the most likely potential impacts are due to the increase in river water temperature and discharge of amine resulting from the use of Drewsperse 767 as anti fouling into the river. Seawater which will be used mainly to cool the condenser will be discharged back into the river downstream of the intake head. The increase in water temperature at the effluent discharge point is predicted to be 7.84 °C above the ambient water temperature (25 °C).

Fish are sensitive to a large increase in water temperature. A large increased in water temperature above the normal ambient temperature in a short period of time could be fatal for most fish. Water temperature influences physiological processes such as respiration rates, efficiency of feeding and assimilation, growth, behaviour, and reproduction (Meade, 1989; Tucker and Robinson, 1990). A temperature increase of 10 °C will cause rates of chemical and biological reactions to double or triple, that is doubling the amount of oxygen consumed.

However, the above scenario is more likely for fish confined to a specific site (e.g., in the case of cage culture). For fishes that are in the natural environment, they are able to sense an increase in water temperature and would avoid such area. The increase in water temperature at Sarawak River would be localized to a distance of about 50 to 150 m (area of approximately 100 to 1,500 m²) from the effluent discharge point,
depending on the tide level and current. Therefore, the area of the river that could not be utilized by the fish community would be insignificant to the total area.

Fish are sensitive to diamine derivatives and the effects are normally species dependant. The volume of effluence discharge would be doubled with the operation of phase II. Assuming that the concentration of amine within 50 m from the discharge point would also be doubled, the concentration with the operation of both phases would be < 2.0 mg/l.

The effects of amine to tropical fish species have not been studied. However, data obtained for rainbow trout, *Salmo gairdneri*, a temperate species showed that the LC50 for 24 hours exposure is 1.3 mg/l and the LC50 for 96 hours exposure is 0.68 mg/l (MSDS, 1998; Jorgensen et al., 1991). However, in the case of fish communities of Sarawak River, exposure time to this chemical would be minimal because all the fish recorded from the area are not site or habitat specific. Therefore, there are no fish species that would stay put in one site for longer period of time. Fishes would immediately swim away from the effluent discharge site once they detected the presence of amine. Negative effects would be significant if there are aquaculture activities in the immediate vicinity of the effluent discharge point. However, the nearest aquaculture farm is about 6 km from the effluent discharge point and at this location the concentration of amine would have been significantly diluted by the large volume of waters in Sarawak River.
In Malaysia, demands for river fish have resulted in overfishing in streams that have not been dammed (e.g. Tembling River and Pahang River system) (Tan and Hamza, undated). Semi-sanctuary status provided to the upper Tembling River and its principal tributaries as a result of being in the National Park has protected fish stocks primarily for recreational fisheries and to support demands for fish by tourist restaurants near the national park headquarters. In many other rivers in Malaysia, pollution and sedimentation impact riverine fisheries, especially during the rainy season when runoff increased (Ho, 1995).

Alterations brought about in the marine environment by discharge of heated effluents may vary greatly as a function of the quantity of heat discharged and the climatic condition, hydrological and biological features of the study environments. For this reason it is very difficult to predict *a priori* the effect of a coastal power station discharging heated effluent into the water body, so predictions also largely depend on the knowledge of the widest possible range of site specific reports (Crema and Bonvicini Pagliai, 1981; Cironi *et al.*, 1995). However, improved procedures for the reliable detection and interpretation of environmental impacts are needed (Underwood, 1994).