

THE IMPACT OF URBANIZATION AND INDUSTRIALIZATION ON RIVER WATER QUALITY: A CASE STUDY OF SUNGAI KLUANG, BAYAN LEPAS, PULAU PINANG

Ab. Latif Ibrahim

INTRODUCTION

Increasing population, rapid urbanization and rapidly intensifying human activities have exerted immense pressures on water quality. Whenever human and industrial wastes are not properly managed, surface waters as well as ground waters become the sink for receiving such wastes. When effluents from industries are discharged into river channels, the river water will be polluted physically, biologically and chemically. This is due to the increased concentration of dissolved solids, toxic chemicals, BOD loadings, heavy metals and other pollutants. Pesticides and weedicides from agricultural areas add to the increasingly polluted water sources.

Penang is one of the most developed states in Malaysia, all set and moving ahead to become an industrial state by the year 2020. Hence in the foreseeable future, rapid industrialization is unavoidable. With further rapid industrialization, water contaminations from industrial chemicals, trace metals and organic compounds could accelerate as well, unless appropriate environmental safeguards are ensured, and relevant legislation is strictly enforced. Lim (1994) also found that the impacts of industries on the environment have been severe, particularly with reference to pollution.

BACKGROUND OF INDUSTRIAL AND URBAN DEVELOPMENT IN PENANG

In terms of industrial development in Penang, the Free Industrial Zone (FIZ) has expanded and there are now hundreds of factories located in the Bayan Lepas-Bayan Baru region. Electronics and electrical sectors dominate the industrial scene with most industries producing semiconductors, computers and peripherals. This is followed by the fabricated metals sector engaged in the manufacturing of jigs and fixtures, stamped metal parts, injection steel moulds and wire harness. Other types of industries are the plastic sector, food processing sector and basic metal sector.

Important effects on water quality may also accompany urban development. Hill slope clearance for urban development can cause soil erosion that have contributed to increased sediment yields in the rivers, causing an increase in the suspended solids. In 1991, the state of Penang has 75% of its population residing in areas defined as urban. During the period of 1980-1991, and using the 1991 definition of urban areas for both censuses, the urban population of Penang grew at a rate of 3.5%. A comparison with the urban growth rate during the 1970 and 1980 censuses period shows that the tempo of urbanization has increased significantly.

The urban population of Penang was estimated to be around 81% at the end of 1995 and is set to be more than 90% by the year 2010. The Water Quality Technical Report on the Penang GIS (PEGIS) Pilot Project has shown that the majority of river basins on the island are already badly polluted (Lim, 1994). Major contributors to river pollution were silt due to soil erosion and organic loadings from sewage and animal waste as indicated by SS and $\text{NH}_4\text{-N}$. Hill development activities in the Paya Terubong hills (through housing and infrastructure development), the Penang Hill area (through illegal farming and squatting), Bukit Gambier (through housing developments) and Teluk Bahang hills (through the construction of Teluk Bahang Dam), have resulted in the degradation of water catchments and the pollution of water quality.

MATERIALS AND METHODS

Study area

This study was carried out in the Kluang River, which is located in the south eastern part of Penang Island. The lower part of the river flows directly through the middle of the Bayan Baru Industrial estate while in the upper part of the river are major housing and urban development, that is in the Sungai Ara and Relau areas.

For the purpose of this study, a significant number of sampling stations were chosen along the entire selected river stretch but four prominent sampling sites have been chosen for extensive study. These four points were selected based on accessibility, location in the vicinity of the polluting sources, or and at the junction of the two water courses. The first station was located in the upper part of Sungai Relau where no development activities is taking place, the second station was located at the course of Sungai Relau and Sungai Ara, the third station was in the Bayan Baru commercial and residential area and the fourth station was in the industrial area. Stations were selected and visited in order to determine parameters such as dissolved oxygen, pH, salinity, and toxic trace metals like; lead (Pb), Nickel (Ni), and Zinc (Zn). Water samples from all the station were collected twice a week for a period of four months from September to December 1996. Samples were collected using thoroughly clean

plastic bottles in the midstream of the river. All the samples were analyzed for pH, temperature, turbidity, DO and various heavy metals such as, lead (Pb), Zinc (Zn) and Nickel (Ni).

Results and Analysis

Results of the study showed that the quality of water in the Kluang River was badly polluted. Analysis of water samples taken from all the four station clearly showed that water samples taken from the station in the industrial sites, housing estates and commercial areas were badly polluted by organic wastes, suspended solids, and trace metals such as Zn, Ni and Pb.

Dissolved Oxygen

Dissolved oxygen is one of the most important constituents describing the water quality. It is required by fish and other aquatic animals. The level of dissolved oxygen (DO) was found to be low ranging from 0.9–5.9 mg/L. The average level of DO for all stations are less than 6 mg/L that is the level set by the Malaysian Government for a clean river (Goh et al., 1986). Low levels of DO are indicative of greater pollution in this river.

pH

pH value of samples taken from all stations showed that the value is decreasing from upper to the lower part of the river. The average value for station 1 is about 7.6, station 3 is about 7.3 and station 4 is about 6.1. The main factor that has contributed to the decreasing trend in the pH value is the decomposition of organic matters found in the river (Bishop, 1973). For station 3, most of the organic matters in the rivers are due to human waste from housing and commercial areas. In the case of station 4, most of the organic matters are from waste discharged from factories.

Temperature

Temperatures were high ranging from 24–39°C especially for station four. This is probably due to hot water discharged from industries. The average temperature of water at station 4 is about 33°C. High temperature recorded at this station was due to paper and plastics factories located near this station. A lot of water used in these two factories to keep the machines cool. The water that has been used was then released as hot water into the river.

Heavy Metals

Trace metals are released into the aquatic environment from numerous natural and anthropogenic sources. However, discharge from domestic and industrial operation is the principal source of metal pollution for river water. The level for heavy metal for lead value was 0–0.7 mg/L, nickel was 0–23 mg/L and zinc was lower than 1 which were higher than the national standard.

CONCLUSION

The water quality problem consists of many aspects: social, economic, physical, biological, as well as political. In the case of the causes of water quality degradation in the study area, it can be categorized in two ways; (i) it is caused by the growth of population, and subsequently rapid development of industrialization and urbanization. This in turn results in a corresponding increase of waste from both sources, and (ii) it is affected by the neglect of the intrinsic value of the environment. It is apparent that the quality of water in Sungai Kluang is greatly affected by uncontrolled human activities. Serious attempt must be made to ensure progress in monitoring, analyzing, studying and perhaps most important of all, enforcing legislation relating to environmental and water quality protection.

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