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Siltation in Zoo Negara Lake

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Key Words: Siltation; Turbidity; Total Residues.

RINGKASAN

Kajian di Tasik Zoo Negara telah menunjukkan bahawa turbiditi dan jumlah bahan-bahan sisa adalah lebih tinggi di dalam tasik dari stesen di ulu sungai di mana tidak terdapat kesan hakisan tanah. Kemasukan bahan-bahan hakisan yang banyak telah menyebabkan pertukaran warna air dan pengurangan pada kedalaman tasik. Kesan-kesan kekelodakan seperti pengurangan organisma-organisma akuatik dan penembusan cahaya telah dibincangkan.

SUMMARY

In a study of Zoo Negara Lake, it was found that the turbidity and total residues were higher in the lake than in the upstream station where there is no effect of soil erosion. The immediate results of massive flows of erosion silt were the change of water colour and reduction in the depth of the lake. Effects of siltation such as the reduction in light penetration and aquatic organisms are discussed.

INTRODUCTION

Siltation is regarded as one of the most important factors in aquatic pollution. Aquatic resources which depend upon the natural ecosystems are threatened by erosion and siltation. The drastic modifications of aquatic environment by siltation have changed the fish fauna from a community dominated by fishes requiring clear water to rough fishes tolerant to high turbidity (Trautman, 1957). As a result of deposition and accumulation of sediment, the aquatic insects typical of clean rubble bottom such as larvae of caddisflies, stoneflies and mayflies are replaced by sediment-burrowing organisms such as Chironomidae (Eustin and Hillen, 1954). Chutter (1969) in his study of invertebrate fauna of Vaal River System, South Africa, concluded that an increased amount of sand and silt leads to the instability of the sediment, which adversely affects the fauna. High mortality of fish in highly silted Kelang River, Malaysia, is mainly due to the accumulation of silt particles in the gills (Mohsin and Law, 1980).

Turbidity decreases light penetration and thereby reduces the rate of photosynthesis (Corfitzen, 1939; Tarzwell and Gaufin, 1953). The rate of photosynthesis also could be reduced by sedimentation, since sediment acts as a physical barrier preventing free exchange of gas necessary for survival of autotrophic organisms (Phinney, 1959). Cordone and Pennoyer (1960) found that a population of algae *Nostoc* was virtually destroyed by sediment discharged into the Truckee River, California.

In Malaysia, there has been an increase in the silt load in its aquatic systems resulting from accelerated erosion caused by improper land use practices (Goh, 1982; Prowse, 1968). In spite of many reports on the denudation processes in Malaysia. (Berry, 1956; Hartley, 1949; Liew, 1974; Sandhu *et al.* 1980), very little work has been done to assess the siltation and increased turbidity in the aquatic systems and their effects on the organisms.

Zoo Negara Lake was chosen as a study area because there has been an increase of erosion silt in the lake due to the housing project in the watershed area. Located approximately 8 km northeast of the city of Kuala Lumpur (3° 13′ N, 101° 47′ E), the lake occupies an area of about 2.17 ha and has an average depth of 1.0 m and a maximum depth of 5 m. This paper describes the resultant increase in water turbidities and residues, and their effects on the fauna.

MATERIALS AND METHODS

Samples were collected from May to October 1981 at the intervals of about 11 to 14 days. Collections were made in duplicates using a Van Dorn sampler from the upper stream (S_1), deep basin of the lake (S_{II}) in the littoral zone (S_{III}), in the outflow (S_{IV}) and in the inflows (S_V and S_{VI}) *(Fig. 1)*. Turbidity was analysed using a Monitek Model 151 Laboratory Turbidimeter. Values for total residues were obtained by drying 150 ml water sample to a constant weight at 150°C (Wetzel and Likens, 1979). Water samples were filtered through a 0.45μ membrane filter for total dissolved residues analysis. The turbidity and the total residues of water samples from the lake were compared with those collected from the upper stream where there was no man-made disturbance. Transparency of the water was also determined using Secchi disk. Underwater light penetration was measured using a LI-888 Integrating Quatum Photometer. A total of 80 fishes comprising *Tilapia mossambica* (Peters), *Hampala macrolepidota* (Van Has), *Osteocheilus hasselti* (C. & V.) and *Cyclocheilichthys apogon* (C. & V.) were caught and processed for routine histopathological studies of the gill tissue. Histological sections were made from tissue fixed in 10% buffered formalin, embedded in paraplast, cut to 5μ thickness and stained with Haematoxylin and Eosin. Plankton samples were taken four times during the study period to survey the planktonic organisms.

RESULTS AND DISCUSSIONS

The turbidity in the upperstream is 18.09 mg/1 but increases as much as 23 times in the lake (Table 1). Besides being low in concentration, the turbidity in the upperstream is more or less constant throughout the season. In the lake, however, turbidity fluctuates rather drastically varying from 140 mg/l on a dry and calm day to as much as 814 mg/1 on a wet and windy day *(Fig. 2)*. The turbidity of the lake is due to the erosion materials introduced by the inflows from the feeding stream and also to the wind-induced turbulence which keeps the silt materials in suspension. During rainy season in August for example, the turbidity of the incoming water at stations V and VI amounted to 2250 mg/1 and 2650 mg/1 respectively *(Figs. 2 and 4)*.

Parallel to turbidity, the lake also has high values of total residues with an average of 168.06

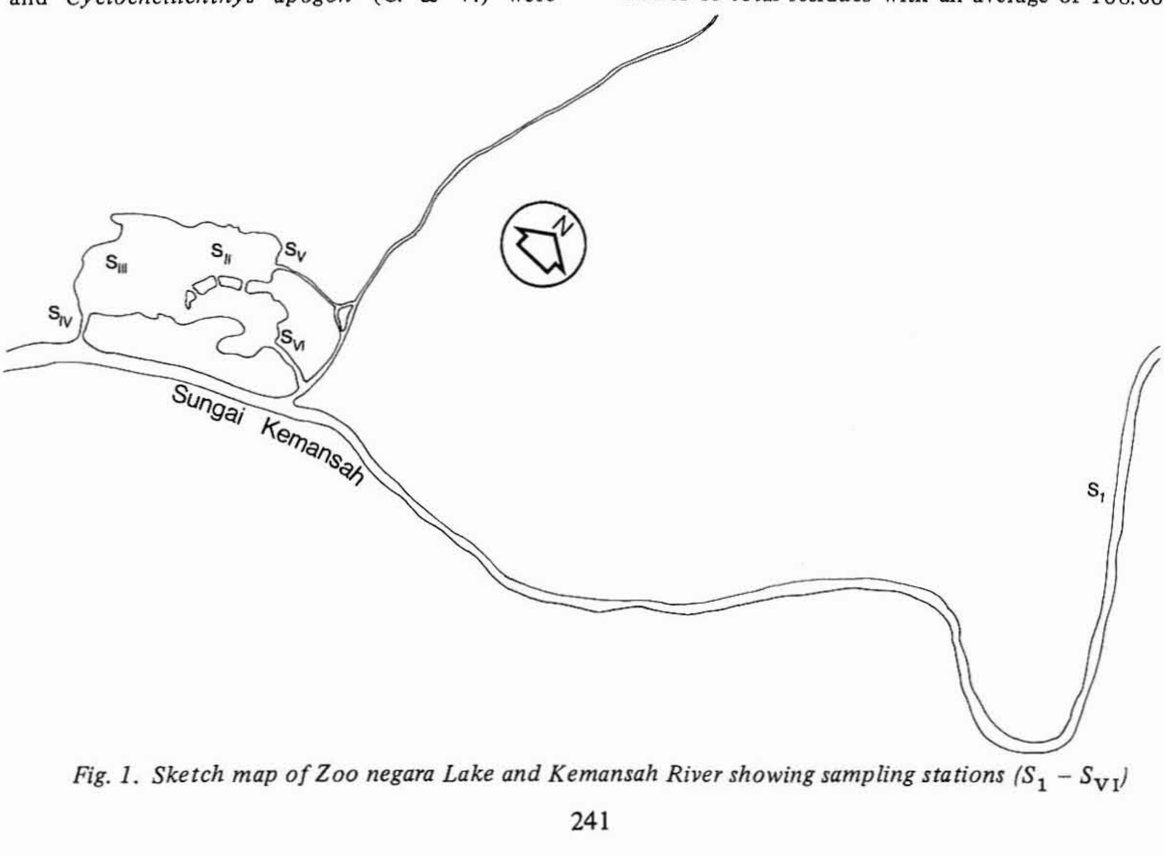

Fig. 1. Sketch map of Zoo negara Lake and Kemansah River showing sampling stations (S_1 – S_{VI})

TABLE 1

Mean values (in mg/1 unless and otherwise stated) of some water quality parameters at different sampling stations. Values given are the mean ± one standard error of the mean estimate.

	STATION I	STATION II	STATION III	STATION IV	STATION V	STATION VI
Turbidity	18.09 ± 1.33	416.58 ± 67.77	330.08 ± 79.57	260.60 ± 26.32	527.84 ± 26.84	501.10 ± 36.28
Total Residues	43.04 ± 5.99	168.06 ± 23.06	130.83 ± 28.13	97.70 ± 8.16	268.66 ± 13.07	259.19 ± 14.29
Total Dissolved Solids	24.55 ± 4.62	53.94 ± 11.34	31.94 ± 5.87	39.81 ± 8.59	44.63 ± 8.97	30.60 ± 5.09
Temperature °C	25.81 ± 0.37	27.50 ± 0.18	28.75 ± 0.29	30.45 ± 0.48	27.78 ± 0.30	28.03 ± 0.38
Secchi disk m	–	0.25	0.25	–	–	–

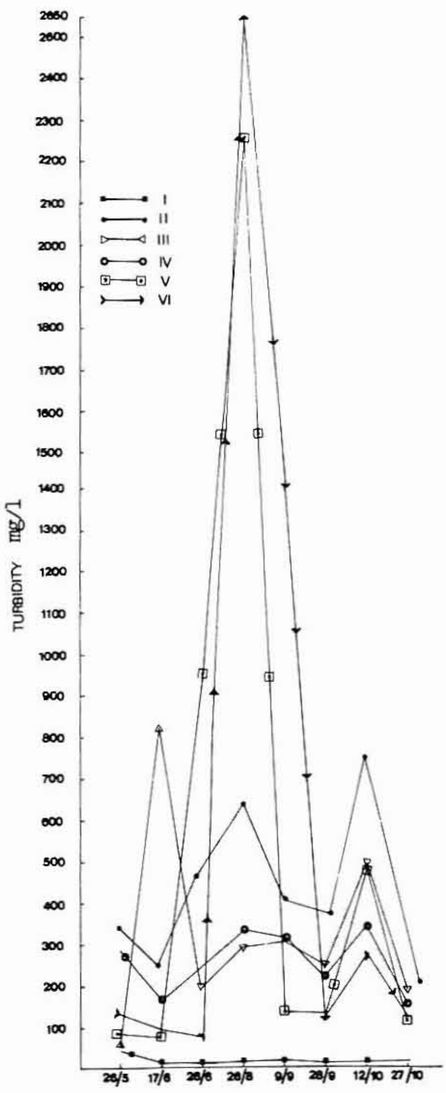

Fig. 2. Turbidity in mg/1 at the sampling stations from May-October, 1981.

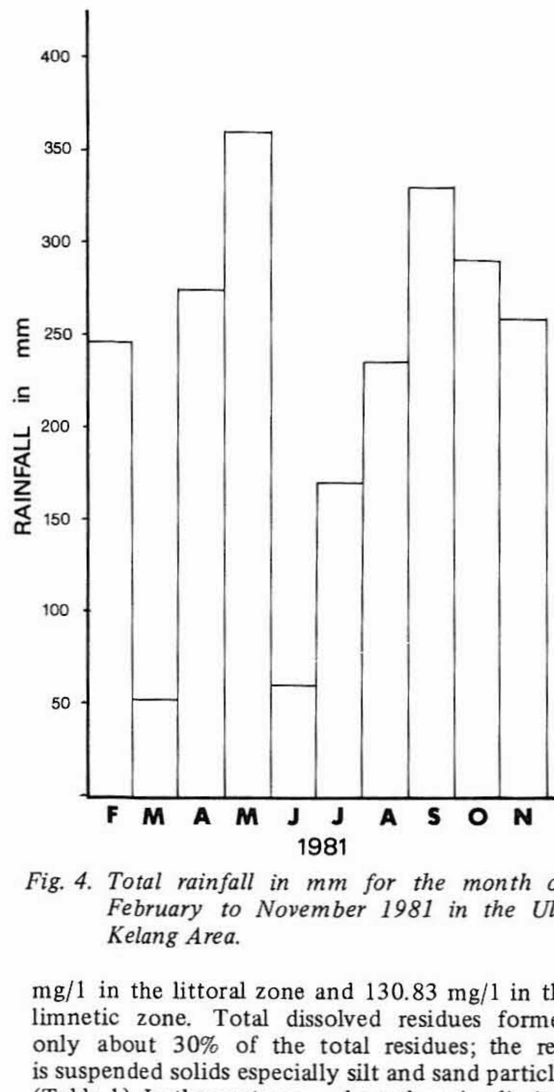

Fig. 4. Total rainfall in mm for the month of February to November 1981 in the Ulu Kelang Area.

mg/1 in the littoral zone and 130.83 mg/1 in the limnetic zone. Total dissolved residues formed only about 30% of the total residues; the rest is suspended solids especially silt and sand particles (Table 1). In the upstream, where there is a limited influence of land use activities, the total residues is relatively low with an average value of 43.04 mg/1; 60% of which is total dissolved solids.

Figure 3 shows that in late August when there was a heavy rain, the inflow water brought in a large load of total residues amounting to as much as 1250 mg/1.

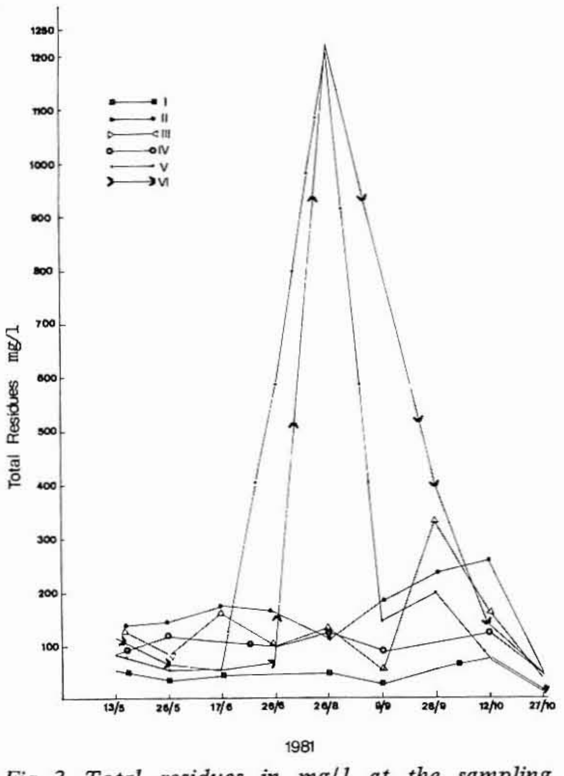

Fig. 3. Total residues in mg/l at the sampling stations from May-October, 1981.

The high turbidity and total residues in the lake are mainly due to the surface runoff from the housing projects area which carries a large amount of soil materials into the Kemansah river and eventually into the lake. In this way, the lake serves as a massive trap for the silt and sand. It was also observed that the color of the water changed from clear blue to muddy yellow. Since the start of the housing project in 1977 which contributed silt and sand to the lake, the depth of the lake has been reduced from 6 m to 4.5 m in the limnetic zone and from 1.5 m to 0.5 m in the littoral zone (Zoo Negara authority, personal communication). Probably due to the shallowness of the lake the water remains permanently turbid even during the dry periods.

The effects of turbidity are often widespread and permanent. The presence of suspended solids in water reduces the light penetration and thereby limits the growth of primary producers which are of outstanding importance as food source for aquatic organisms. In Zoo Negara Lake, aquatic macrophyte vegetation is limited to a few small patches of Lotus, *Nelumbo nucifera* Gaertn., which occur in the sheltered areas of the lake. No submerged macrophyte communities were observed despite the shallowness of the lake. It is therefore possible that the general increase in silt loads has caused a major decline in the abundance of aquatic macrophytes (Edward, 1969). High silt loads in Zoo Negara Lake greatly reduce the amount of the light penetrating into this aquatic environment. Secchi disk measurement is only 0.25 m. Light penetration (photosynthetically active radiation, 400–700 nm) in the month of May and June was reduced to 0.55% and 0.27% at one meter depth respectively. Probably due to this limited light energy the phytoplankton in this system are limited. The phytoplankton in this system are limited to a few species of Euglenaceae, especially *Euglena, Trachelomonas* and *Phacus,* and a small number of diatoms.

Many studies have been done on the effects of erosion materials on the animal communities. Campbell (1954) pointed out that eyed-fish eggs died within a six-day period where turbidity ranged from 1000 to 2500 ppm. Ellis (1936) studied the effect of very silty water on mussels in the laboratory and found silt interfered with their feeding and respiration. Trautman (1933) pointed out that gravel pit washings can clog or cover the gills of fishes and so prevent respiration that results in death. In Zoo Negara Lake, the gills of most specimen were found to be clogged with mud. Aizam (1982), found that the stomach contents of *Hampala macrolepidota* from this lake were made up of about 60% sand particles. On examining the histopathological slides of fish gills made from the fish of this lake, it was found that all the fish gills show inflamatory responses and hyperplasia. Plates 1 and 2 illustrate

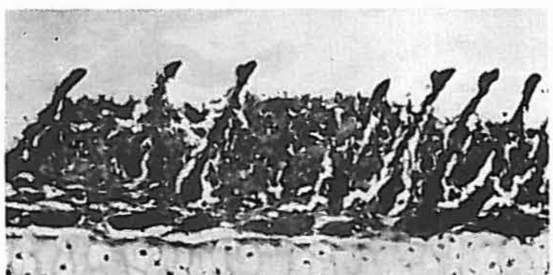

Plate 1. Presence of leukocytes in the hyperplastic tissue seen between the secondary lamellae of Tilapia mossambica *(3250 x).*

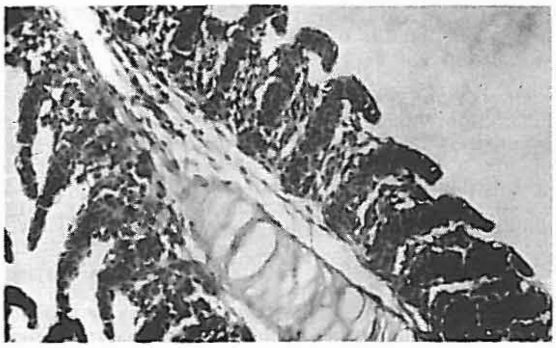

Plate 2. Congestion along the secondary lamellae of Tilapiamossambica *resulting in the thickening of the artery, indicating early inflammatory response against pathogens. Hyperplasia is also noted in between the secondary lamellae (3250 x).*

the presence of leukocytes in the hyperplastic tissue and congestion which results in the thickening of the artery along the secondary lamellae in *Tilapia mossambica.* The gills also show infection by monogenetic trematode and cysts of unidentified protozoans *(Plates 3 and 4).* However, the results do not directly indicate that high turbidity and residues cause the infections of the fish gills. On the other hand, high turbidity and residues might act as environmental stress which causes the fish to be more susceptible to diseases.

In most cases, indirect damage to fish and other aquatic organisms through destruction of food supply, eggs or changes in the habitat probably occur long before the adult organisms are directly damaged (Cordone and Kelly, 1961). Most of the literature concerned with effects of silt and sand on the aquatic life have shown that the density of the organisms is considerably reduced

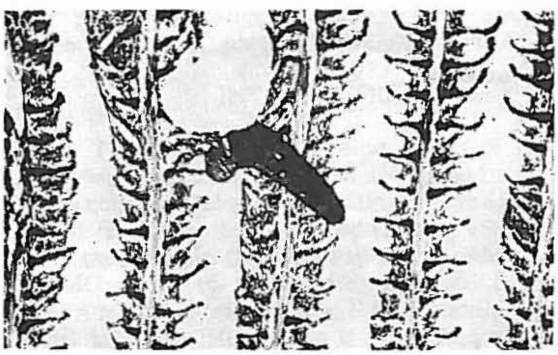

Plate 3. Presence of monogenetic trematode in the gill filaments of Tilapia mossambica *(1300 x).*

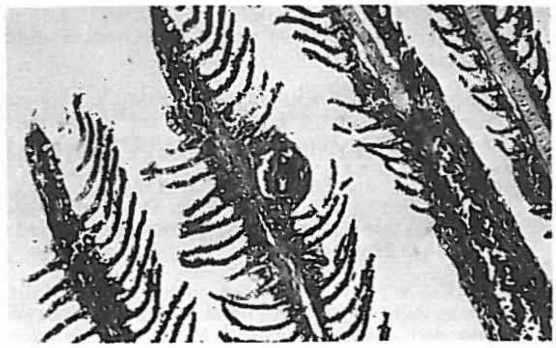

Plate 4. Presence of unidentified protozoan parasite encysted between the secondary lamellae of Hampala macrolepidota *(1300 x).*

where there is heavy sedimentation (Wu, 1931; Bartsch, 1960; Hamilton, 1961). Probably because of this, the fish population in Zoo Negara Lake has steadily decreased since the siltation started in 1977 (Zoo Negara authority, personal communication).

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