

## Biochemical Oxygen Demand Concentration of Two River Basins in Selangor

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Key words: B.O.D.; probability; variability; classification

### RINGKASAN

*Kertas kerja ini memberi nota-nota interpretasi ke atas keperluan oksigen biokimia (B.O.D.) terhadap tadahan Sungai Kelang dan Sungai Selangor yang terletak di negeri Selangor, Semenanjung Malaysia. Analisa statistik telah dijalankan untuk interpretasi kualiti air dengan menggunakan keperluan oksigen biokimia sebagai petunjuk pencemaran. Keputusan yang diperolehi menunjukkan bahawa proses perbandaran telah mengakibatkan kemerosotan kualiti air yang tetap. Terdapat juga satu tanda di mana variasi B.O.D. adalah tinggi di semua stesyen sampel dalam jangka masa yang pendek.*

### SUMMARY

*This paper presents some interpretive notes on biochemical oxygen demand (B.O.D.) of Sungai Kelang and Sungai Selangor river basins located in the State of Selangor, Peninsular Malaysia. Simple statistical analysis was carried out to interpret the water quality using B.O.D. as an indicator of pollution level. Results showed steady deterioration of water quality with the level of urban development. There is also an important indication that short term variations of B.O.D. levels is high in all sampling stations.*

### INTRODUCTION

The increasing rates of development and population growth in affected river basins give rise to growing concern about river pollution. The increasing awareness of this problem is well indicated by a good number of studies such as those documented by Chan *et al.*, (1978), Law and Mohsin (1980), Law (1980), Tan and Ng (1980) and Ho (1982).

The activities within a river basin, such as forest clearing, intensive and extensive agricultural practices, and urbanisation alter the ambient chemistry of river water. All these factors contribute significantly to the increase in concentration downstream.

Biochemical oxygen demand (B.O.D.) data have found wide applications not only in sanitary and engineering practices but also in river pollution control where organic loading must be limited to maintain desired dissolved oxygen level. High B.O.D. levels have been frequently reported in urbanised river basins due to direct effluent discharge from industrial premises and sewage effluent from domestic homes while natural streams in general maintain low B.O.D. levels.

However, the regime characteristics within the river basin framework have been little studied. This paper presents those characteristics and some interpretive notes of two important river basins in Selangor, Sungai Kelang at Puchong Weir (hitherto referred to as Sungai Kelang basin) and Sungai Selangor at Rantau Panjang (hitherto referred to as Sungai Selangor basin).

### MATERIALS AND METHOD

#### *Study Area*

The two river basins in this study are drained generally in a southwest direction and their catchment areas form about 25% of the State of Selangor: Sungai Kelang basin - 712 km<sup>2</sup> and; Sungai Selangor basin - 1450 km<sup>2</sup>. Their respective locations are shown in *Fig. 1*. Seven sampling points were examined for Sungai Kelang basin (*Fig. 2*) while two were investigated in the Sungai Selangor basin (*Fig. 3*).

The type of distribution of land use in these two river basins was measured from published Land Use Maps (1976). A summary of the breakdown is listed in Table 1: 51% of the Sungai Kelang basin is altered with 19% of the catch-

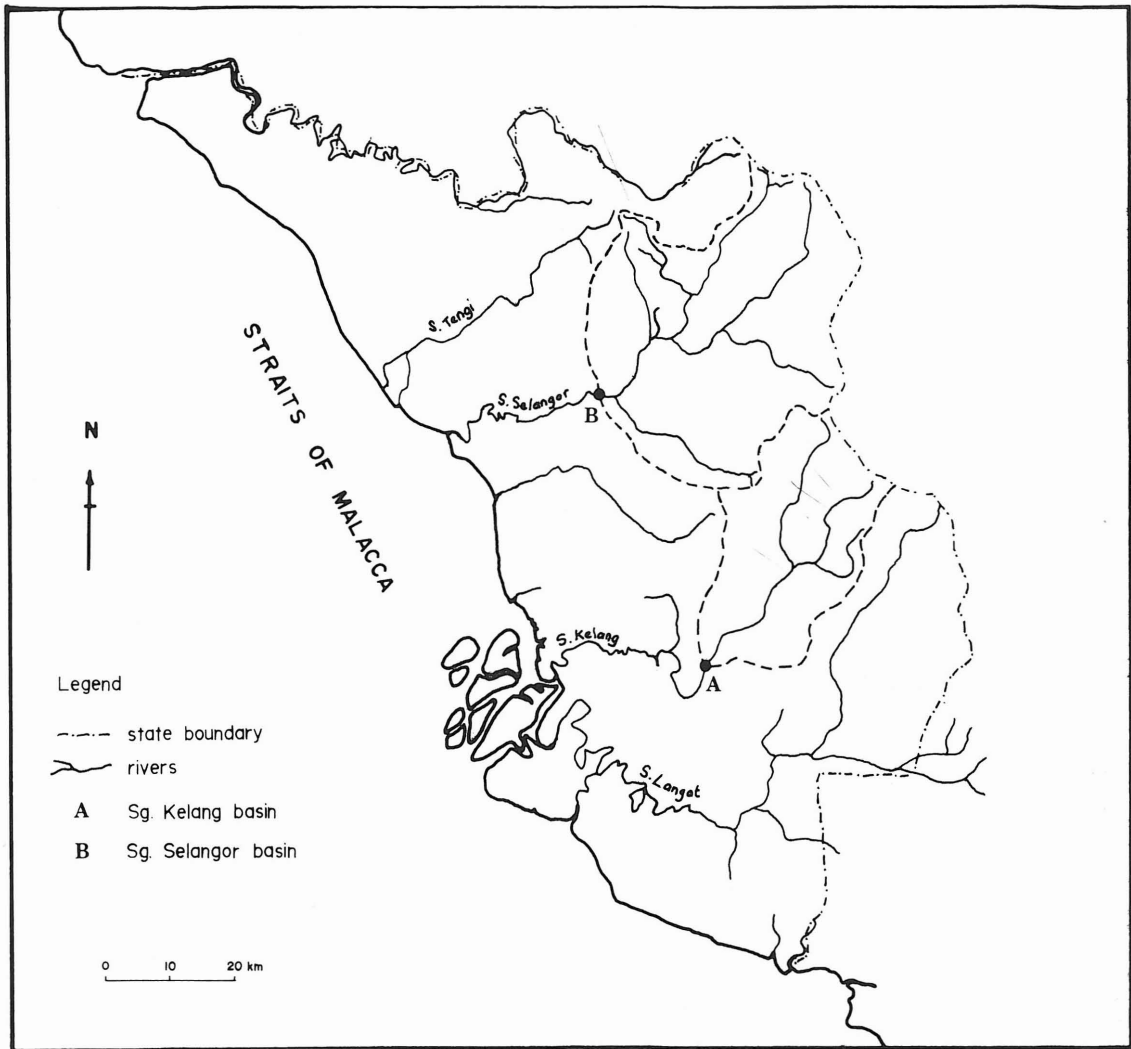


Fig. 1. Location of study area.

ment area urbanised compared to 41% and 1% respectively in the Sungai Selangor basin.

#### Data

20°C B.O.D.<sub>5</sub> data were obtained from the annually published water quality records which were routinely taken by the Drainage and Irrigation Department. Sampling in their regular monitoring programme is done on a fortnightly basis. Records spanning three to five years between 1974 and 1978 were analysed.

### RESULTS AND DISCUSSION

Table 2 summarises some of the measures of dispersion of data obtained. Mean B.O.D. values

are higher at the Puchong Weir outlet of the Sungai Kelang basin than the upper reaches. An examination of data obtained from the sampling stations shows a steady deterioration of the water quality (Fig. 4). The maximum B.O.D. value recorded for Sungai Batu at Kampong Tua, for example, is only 3.8 mg/l compared to a high 50.1 mg/l at Puchong Weir. This can be attributed mostly to urbanisation, especially when Sungai Kelang flows through the nucleus of Kuala Lumpur, a capital city, that is developing at a phenomenal rate. This has also been reported by Law (1980), Law and Mohsin (1980) who attributed the high pollution levels of Sungai Kelang to domestic effluents, industrial wastes and siltation.

## B.O.D. CONCENTRATION OF TWO RIVER BASINS IN SELANGOR

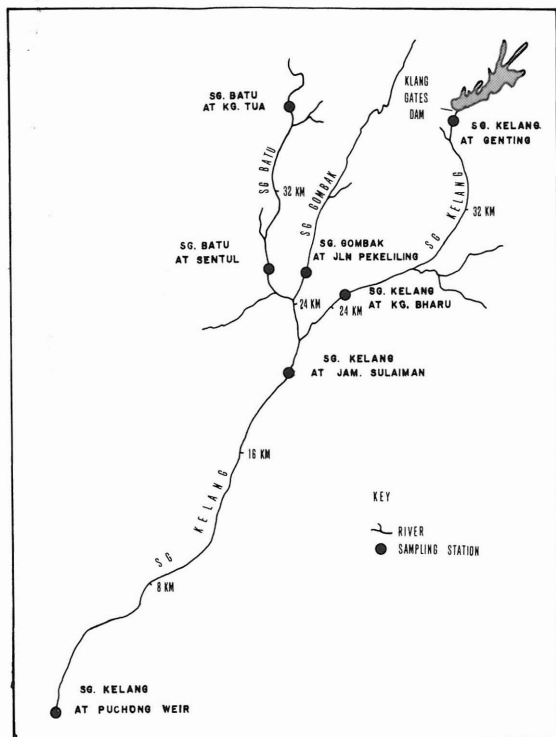


Fig. 2. Location of sampling stations of Sg. Kelang basin.

By comparison, Sungai Selangor at Rantau Panjang has a mean B.O.D. concentration almost equal (Table 2) to Rasa, a sampling point about

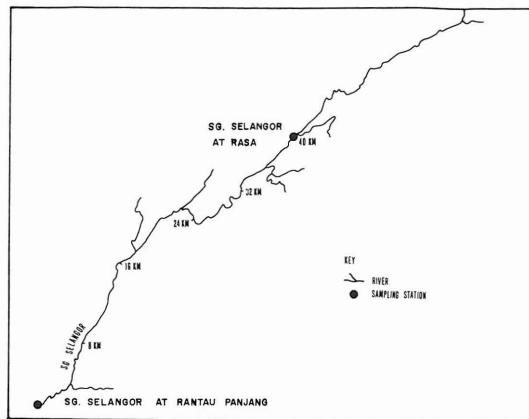


Fig. 3. Location of sampling stations of Sg. Selangor basin.

40 km upstream (Fig. 4). Although small urban centres like Rasa and Kuala Kubu Bharu lie close to this river, the effect on B.O.D. by domestic sewage and possibly light industrial wastes appear to be negligible. The maxima registered by both stations were 3.7 mg/l and 4.1 mg/l respectively. The negligible effect on B.O.D. concentrations can be attributed to the size of the river, which has a higher 'carrying capacity'<sup>1</sup> and a lesser sewerage load compared to Sungai Kelang. Although a large portion (35%) of this basin is cultivated, the results suggest that these activities do not deteriorate water quality as quickly as urbanisation does insofar as B.O.D. is concerned.

TABLE 1  
Land use of area

River basin	Land use (%)							
	Forest	Rubber	Oil Palm	Padi	Other agricultural and cleared lands	Tin mining	Urban and associated lands	Total
Sg. Kelang at Pucong Weir	49	20	1	negligible	5	6	19	100
Sg. Selangor at Rantau Panjang	59	25	3	negligible	7	5	1	100

<sup>1</sup> The mean annual flow obtained from unpublished records (Drainage and Irrigation Department) for the period 1975–1978 for Sg. Selangor basin was 51 m<sup>3</sup>/s. However, since no streamflow records were available for Sg. Kelang basin for this period, it is reasonable to assume that the mean annual flow is approximately half that of Sg. Selangor taking into consideration the catchment sizes: the direct relationship between streamflow and catchment area has long been in general use (Strahler, 1964, cited in Chow, 1964; Hack 1957). It is important to note that the existing Klang Gates dam lies in one of the headwaters of the Sg. Kelang basin (Fig. 2).

TABLE 2  
B.O.D. properties of the rivers

Station name	B.O.D. (mg/l)				Years of record
	Mean	Maximum	Minimum	S. Dev	
A. <i>Sg. Kelang at Pucong Weir basin</i>					
a. Sg. Batu at Kg. Tua	1.3	3.8	0.1	1.4	1974-1978
b. Sg. Batu at Sentul	4.8	16.5	0.2	2.9	1974-1978
c. Sg. Gombak at Genting Klang	1.8	8.4	0.2	1.3	1975-1978
d. Sg. Klang at Kg. Bharu	2.7	6.2	0.5	1.3	1974-1978
e. Sg. Gombak at Pekeliling	5.0	18.1	0.2	3.6	1974-1978
f. Sg. Kelang at Jambatan Sulaiman	5.1	15.7	0.8	3.4	1976-1978
g. Sg. Kelang at Pucong Weir	8.2	50.1	0.7	7.3	1974-1978
B. <i>Sg. Selangor at Rantau Panjang basin</i>					
a. Sg. Selangor at Rasa	1.2	3.7	0.1	0.6	1975-1978
b. Sg. Selangor at Rantau Panjang	1.3	4.1	0.3	0.9	1975-1978

The data are further interpreted using simple probability frequency analyses (*Fig. 5*). The results demonstrate 'clustering' of 0.1 to 0.2 mg/l cases for stations Sungai Batu at Kampong Tua and Sungai Klang at Genting Klang, the two most distant stations from Puchong Weir, the outlet point of interest. Further downstream, from the former two points the B.O.D. concentration distribution is much 'flatter'. It was found that river water in less developed environments which have not been exposed to much urbanisation and industrialisation will tend to have higher concentrations of low B.O.D. level. This is illustrated in *Fig 6* which shows 'clustering' of 0.1 to 2 mg/l B.O.D. concentrations for Sungai Selangor at both stations.

Additionally, from cumulative probability analysis, there is a 14 percent chance, for example,

that B.O.D. will be less than 3 mg/l at Puchong Weir (*Fig. 5* and *Table 3*) compared to 98 percent at Rantau Panjang (*Fig. 6* and *Table 3*). Conversely; the chances that B.O.D. will exceed these values are 86 and 2 percent at the two points respectively. These statements on relative concentration distribution should be useful for planning purposes with respect to river water quality. *Table 3* provides a quick reference of probability values for stations in the upper reaches of both basins.

Another important feature from the analysis is that the B.O.D. levels display high concentrations over a short period of time in all stations in Sungai Kelang and Sungai Selangor. The concentration diagrams (*Figs. 7 and 8*) illustrate a high and almost random degree of variability with time. This can be due to point source effluent additions; sporadic effluent discharge or storm events.

B.O.D. CONCENTRATION OF TWO RIVER BASINS IN SELANGOR

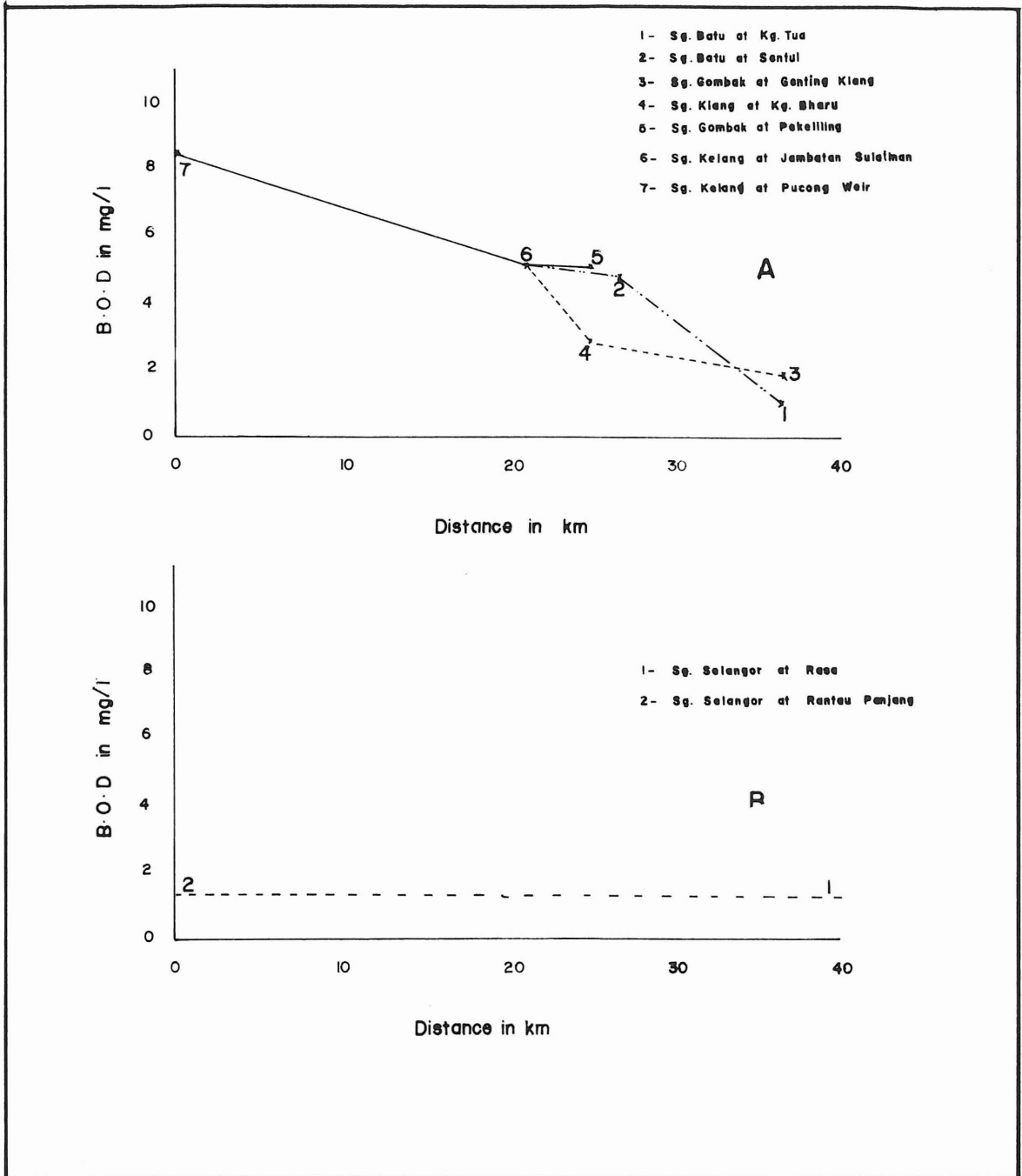


Fig. 4. Diagram illustrating mean B.O.D. concentration along reaches of Sg. Kelang basin (A) and Sg. Selangor basin (B).

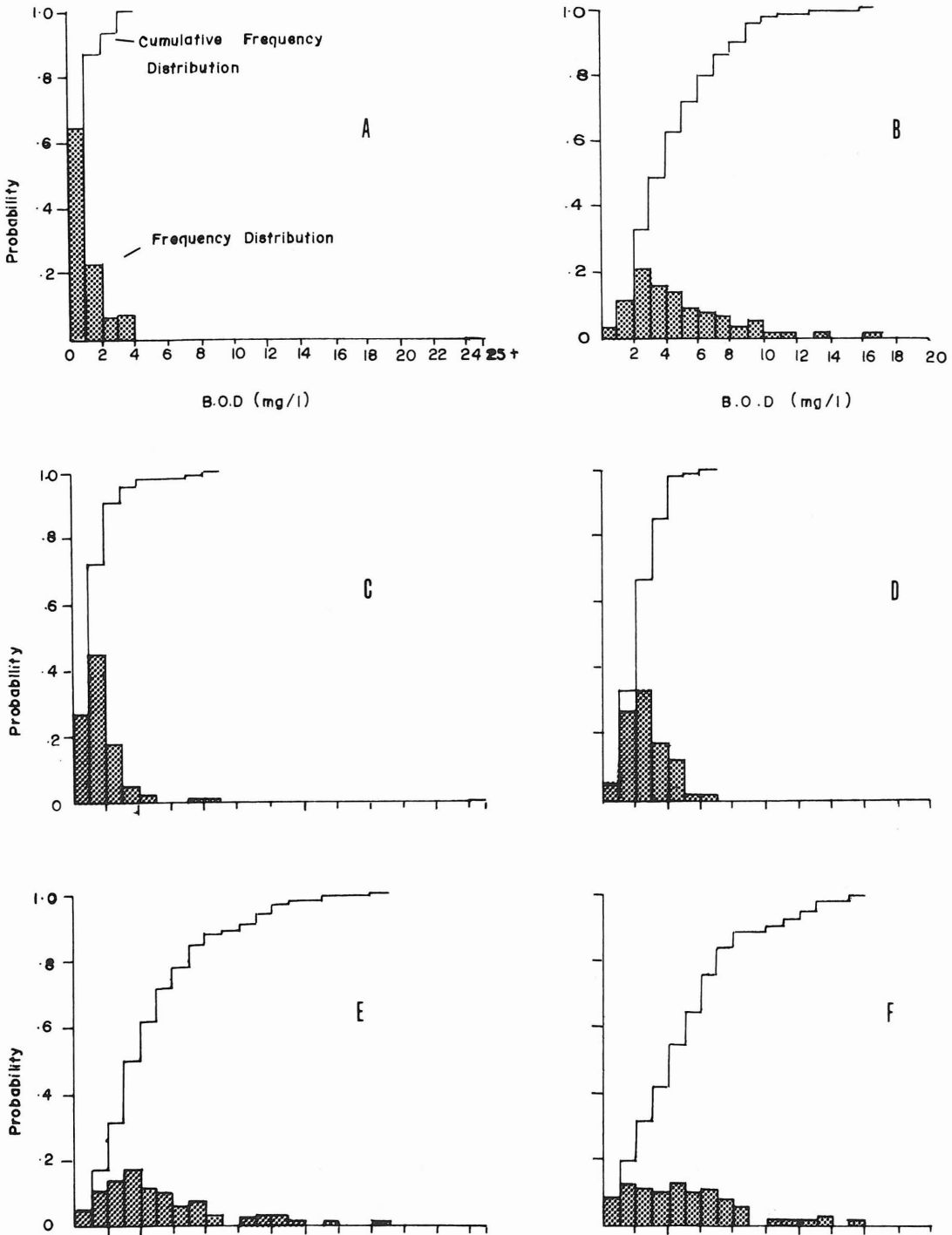


Fig. 5. Cumulative frequency distribution and frequency distribution of B.O.D. concentration: Sg. Kelang basin – A: Sg. Batu at Kg. Tau; B: Sg. Batu at Sentul; C: Sg. Gombak at Genting Klang; D: Sg. Kelang at Kg. Bharu; E: Sg. Gombak at Pekeliling; F: Sg. Kelang at Jambatan Sulaiman; G: Sg. Kelang at Puchong Weir.

B.O.D. CONCENTRATION OF TWO RIVER BASINS IN SELANGOR

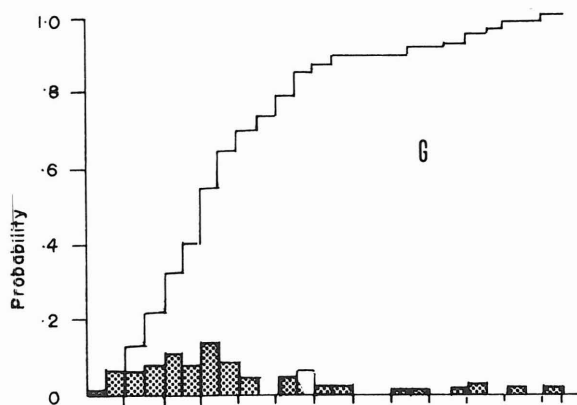


Fig. 5. (Contd.) Cumulative frequency distribution and frequency distribution of B.O.D. concentration: Sg. Kelang basin - A: Sg. Batu at Kg. Tua; B: Sg. Batu at Sentul; C: Sg. Gombak at Genting Klang; D: Sg. Kelang at Kg. Bharu; E: Sg. Gombak at Pekeliling; F: Sg. Kelang at Jambatan Sulaiman; G: Sg. Kelang at Pucong Weir.

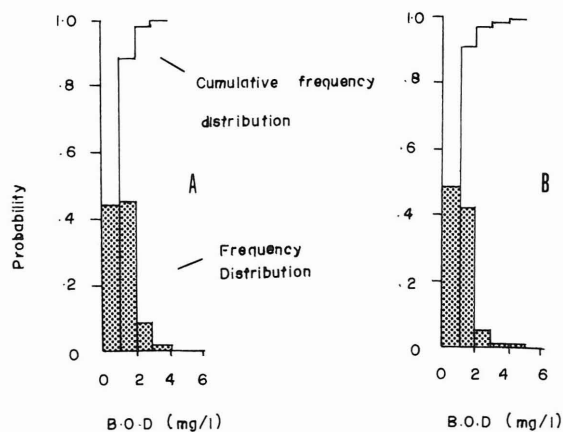


Fig. 6. Cumulative frequency distribution and frequency distribution of B.O.D. concentration: Sg. Selangor basin - A: Sg. Selangor at Rasa; B: Sg. Selangor at Rantau Panjang.

An important implication of the B.O.D. variability is the state of equilibrium. It has been stated that long term changes in water chemistry of river systems occur because of slow changes in land use patterns within watersheds. On this, Smith (1974) (cited in Inland Waters Directorate, 1979) noted that a time lag exists between the initiation of an activity (eg. forest clearing, agriculture, urbanisation) and the time when a new equilibrium is established for the water chemistry of the river system. Graphically, the concentration diagrams of Sungai Kelang basin (Fig. 7) stations further away from Puchong Weir display variability

at lower B.O.D. values. This implies that the lower reaches of Sungai Kelang at stations Jambatan Sulaiman, Sentul and Kampong Bahru have already attained higher equilibrium values than the upper reaches of Kampong Tua and Genting Kelang. Greater B.O.D. values at Puchong Weir imply higher equilibriums further downstream, reaffirming the steady deterioration of water quality of the lower reaches of Sungai Kelang as has been observed by Law and Mohsin (1980). Conversely, Sungai Selangor demonstrates a somewhat steady maintenance of B.O.D. concentration (Fig. 8) at Rasa and Rantau Panjang.

The river water quality of the various sampling points in this study can be classified in terms of their polluted level with respect to the B.O.D. concentrations by way of a classification adopted by the United Kingdom Royal Council on Sewage Disposal (1898-1915). This classification is summarised as follows:-

Classification	BOD <sub>5</sub> (mg/l)
Very clean	< 1
Clean	2
Fairly clean	3
Doubtful	5
Bad	> 10

Although this classification has been designed for use only in Britain, it has been used indiscriminately in countries climatically different (Mara, 1976). For our purpose, this recommendation is used to compare the status of the river water quality with respect to their mean B.O.D. load. From Table 4, it can be seen that the results are straightforward, indicating clearly the water quality level of the two river basins. It can be iterated that only the upper reaches of Sungai Kelang basin (about 25 km upwards) have fairly clean to clean river water which is comparable to that obtaining in Sungai Selangor basin.

The B.O.D. data of the river basins appear useful. However, consideration of other sensitive parameters normally used in water quality indices should not be overlooked. The two approaches in describing the relative polluted level of river basins with respect to B.O.D. concentrations are of some use. Firstly, probabilistic statements help in quantifying the occurrences of permissible or undesirable B.O.D. levels and secondly, by using the U.K. Sewage Royal Council on Sewage Disposal (1898-1915) recommendations, the water quality of river basins could be classified.

TABLE 3  
Cumulative distribution of B.O.D. (mg/l)

Station name	Cumulative probability																													
	B.O.D. (mg/l)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+				
<b>A. Sg. Kelang at Puchong Weir basin</b>																														
a. Sg. Batu at Kg. Batu		0.64	0.87	0.93	0.93	1.00																								
b. Sg. Batu at Sentul		0.03	0.12	0.33	0.49	0.63	0.72	0.80	0.87	0.90	0.96	0.97	0.98	0.99	0.99	0.99	1.00													
c. Sg. Gombak at Genting Klang		0.27	0.73	0.91	0.96	0.98	0.98	0.98	0.99	1.00																				
d. Sg. Klang at Kg. Bharu		0.64	0.87	0.93	1.00																									
e. Sg. Gombak at Pekeliling		0.06	0.18	0.32	0.50	0.62	0.72	0.78	0.85	0.88	0.89	0.91	0.94	0.97	0.98	0.98	0.99	0.99	0.99	1.00										
f. Sg. Klang at Jamb. Sulaiman		0.08	0.21	0.32	0.42	0.55	0.65	0.76	0.84	0.89	0.89	0.91	0.93	0.95	0.98	0.98	1.00													
g. Sg. Klang at Puchong Weir		0.01	0.07	0.14	0.22	0.33	0.41	0.56	0.65	0.70	0.74	0.79	0.85	0.87	0.89	0.89	0.89	0.90	0.91	0.91	0.92	0.95	0.96	0.98	0.98	1.00				
<b>B. Sg. Selangor at Rantau Panjang basin</b>																														
a. Sg. Selangor at Rasa		0.45	0.89	0.98	1.00																									
b. Sg. Selangor at Rantau Panjang		0.49	0.92	0.98	0.99	1.00																								



B.O.D. CONCENTRATION OF TWO RIVER BASINS IN SELANGOR

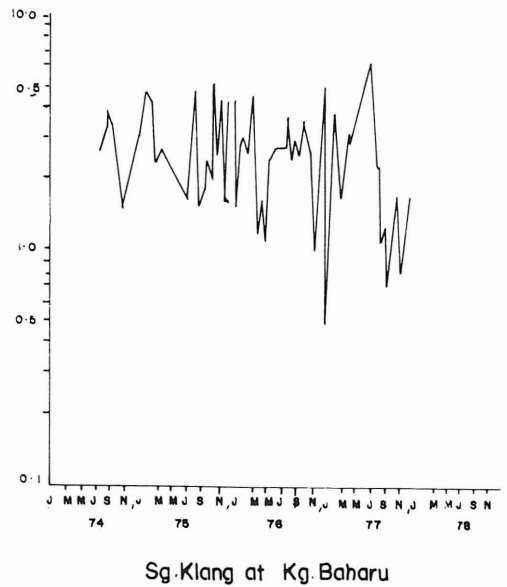
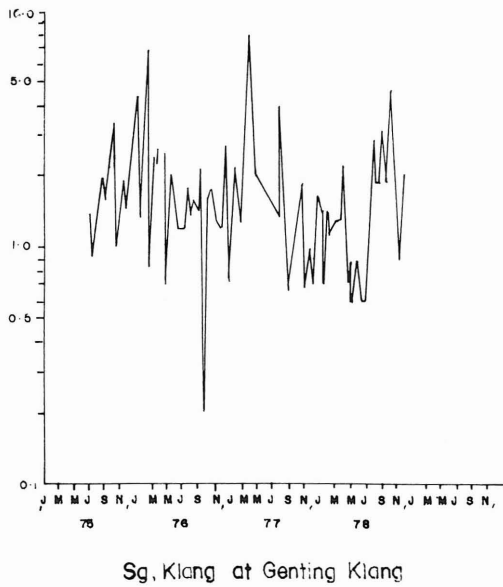
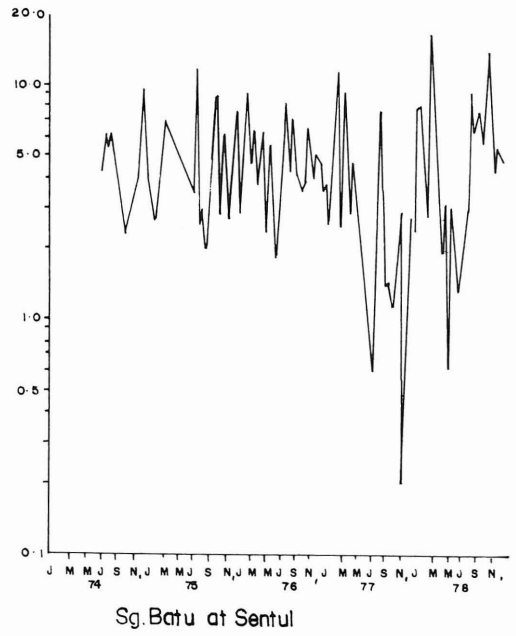
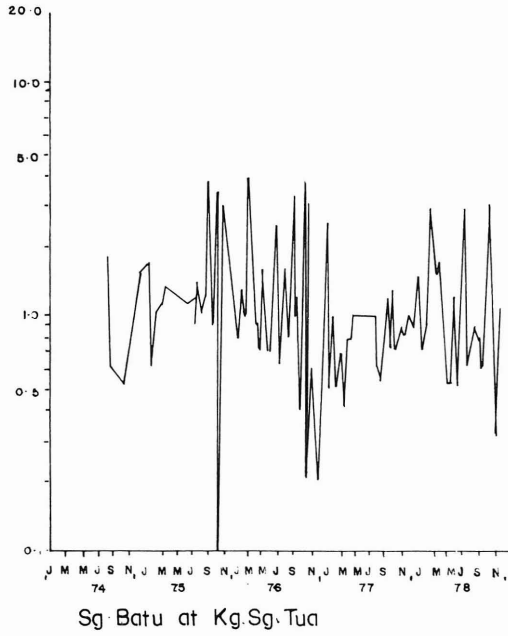
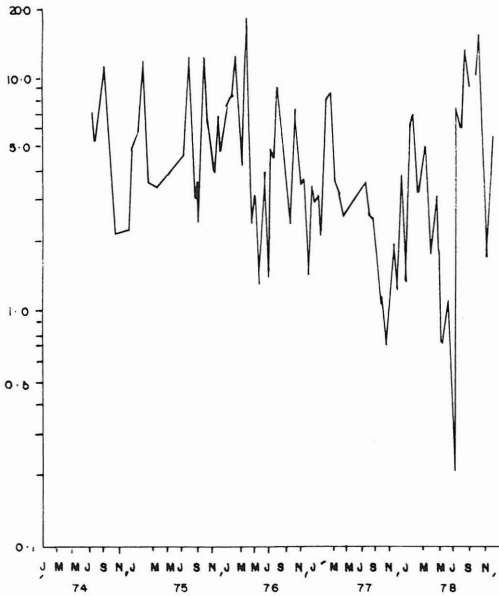
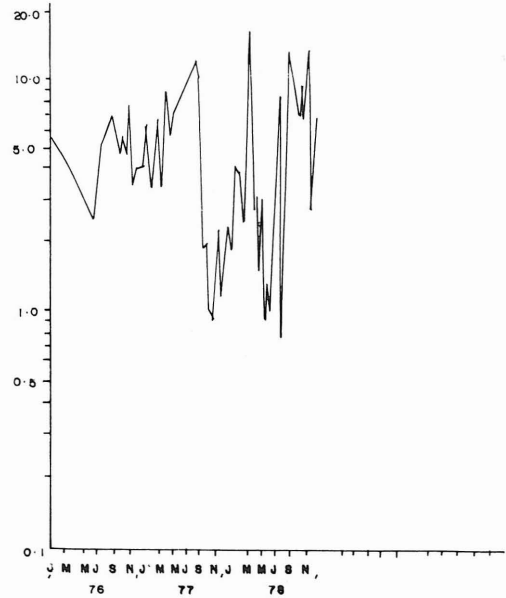


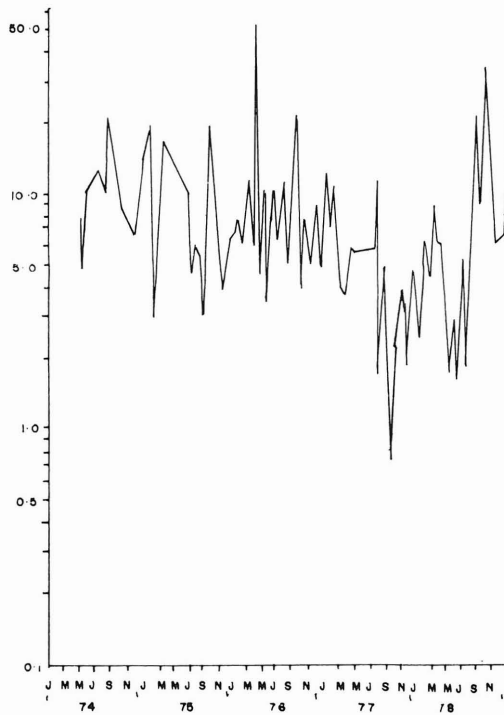
Fig. 7. Diagram illustrating B.O.D. concentration variability: Sg. Kelang basin.



Sg-Gombak at Pekelling



Sg-Klang at Jambatan Sulaiman



Sg-Klang at Puchong Weir

Fig. 7. (Cont'd.) Diagram illustrating B.O.D. concentration variability: Sg. Kelang basin.

## B.O.D. CONCENTRATION OF TWO RIVER BASINS IN SELANGOR

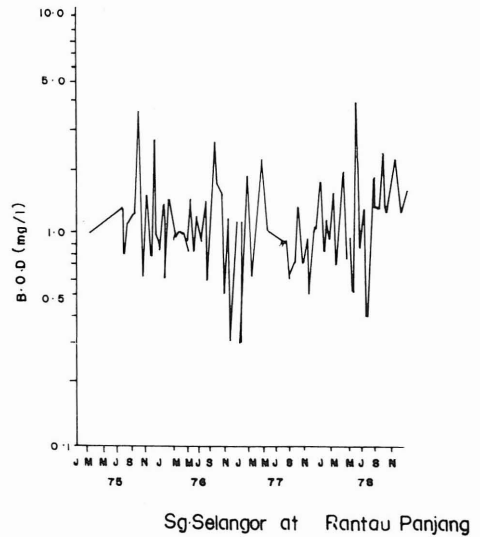
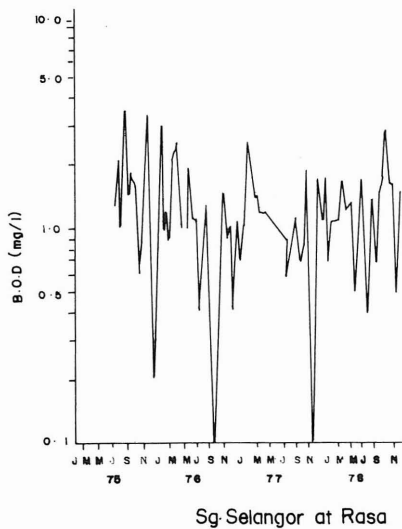


Fig. 8. Diagram illustrating B.O.D. concentration variability: Sg. Selangor basin.

TABLE 4  
Water quality based on mean B.O.D.<sub>5</sub> values using United Kingdom Royal Commission on Sewage Disposal (1898–1915) classification.

Station name	Classification
<b>A. Sungai Kelang at Pucong Weir Basin</b>	
a. Sungai Batu at Kampong Tua	Clean
b. Sungai Batu at Sentul	Doubtful
c. Sungai Gombak at Genting Klang	Clean
d. Sungai Kelang at Kampong Bharu	Fairly Clean
e. Sungai Gombak at Pekeliling	Doubtful
f. Sungai Kelang at Jambatan Sulaiman	Doubtful
g. Sungai Kelang at Puchong Weir	Doubtful
<b>B. Sungai Selangor at Rantau Panjang Basin</b>	
a. Sungai Selangor at Rasa	Clean
b. Sungai Selangor at Rantau Panjang	Clean

*Note:* The United Kingdom Royal Commission on Sewage Disposal's (1898–1915) classification is on the basis of 18.3°C (65°F) BOD<sub>5</sub>. Since the values in this study are based on 20°C BOD<sub>5</sub>, the classification in the above table is about 15 per cent stricter.

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### REFERENCES

- CHAN, K.C., DURANDEAU, M.M. and GOH, L.Y. (1978): Heavy metals pollution in the Kelang River. *Malaysian J. Sci.* 5: 137-141.
- CHOW, V.T. (1964): Handbook of Applied Hydrology. New York. McGraw-Hill.
- DRAINAGE and IRRIGATION DEPARTMENT: Hydrological Data – Water Quality Records 1974-1978. *Mins. of Agric., Malaysia.*
- HACK, J.T. (1957): Studies of longitudinal stream profiles in Virginia and Maryland, *U.S. Geol. Surv. Prof. Paper* 294-B.
- HO, Y.C. (1982): Maintaining water quality of rivers – the case for an integrated approach to water utilization and development. Paper presented at UNESCO/FEISEAP Workshop on Water Technology towards Rural Development, Serdang, January 19-22nd, 1982.
- INLAND WATERS DIRECTORATE, (1979): Water Quality Interpretive Report. Ontario, 1967-1977: 67 pp.

F.S. LAI

LAW, A.T. and MOHSIN, A.K.M. (1980): Environmental studies of Kelang River I. Chemical, Physical and Microbiological Parameters, *Mal. Nat. J.* 33(3): 175-188.

LAW, A.T. (1980): Sewage pollution in Kelang River and its estuary. *Pertanika*. 3(1): 13-19.

MARA, D. (1976): Sewage Treatment in Hot Climate. New York. John Wiley and Sons. 168 pp.

TAN, W.T. and NG, B.S. (1980): A Chemical Survey of the Batang Belungkung River and the Gombak River. *Pertanika*. 3(1): 40-46.

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