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A Chemical Survey of the Batang Belungkung River and the Gombak River

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Key words: discharge; rubber effluent; domestic sewage; organic; inorganic; nutrient; dilution; pollution.

RINGKASAN

Suatu tinjauan kimia terhadap kualiti air di Sungai Batang Belungkung dan Sungai Gombak telah dijalankan dengan tujuan untuk mengkajikan kadar pencemaran yang disebabkan oleh pembuangan kekotoran dari tempat-tempat kediaman dan kilang-kilang getah. Kandungan oksigen terlarut (DO), keperluan oksigen dari segi biokimia (BOD), keperluan oksigen dari segi kimia (COD), zat makanan (fosforus dan nitrogen), pepejal dan logam yang jumlahnya kecil (natrium kalsium, kalium, magnesium) dalam air pun ditentukan sepanjang hilir sungai. Didapati sungai Batang Belungkung berkecemaran tinggi dengan mempunyai keadaan anaerobik di hilir sungai. Kawasan yang di ulu Sungai Gombak membawa air yang tidak dicemarkan jika dibandingkan dengan yang di hilir yang mempunyai kecemaran tinggi. Di dalam tempoh sepuluh tahun dari tahun 1968/69 ke tahun 1978/79, didapati kawasan yang di hilir Sungai Gombak ini mempunyai tambahan empatbelas kali ganda di dalam kandungan keperluan oksigennya.

SUMMARY

A chemical survey of water quality in the Batang Belungkung River and the Gombak River was conducted to assess the degree of pollution due to the continuing discharge of rubber and domestic wastes. Levels of dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrients (phosphorus and nitrogen), solid and trace elements (sodium, potassium, calcium and magnesium) were monitored sequentially downriver. The Batang Belungkung River was found to be severely polluted with anaerobic conditions existing downriver. The upper region of the Gombak River was relatively unpolluted while the lower region of the Gombak River was found to be severely polluted. An increase of approximately fourteen-fold was found in the oxygen demand in the lower region of the Gombak River over the ten year period from 1968/69 to 1978/79.

INTRODUCTION

Rubber processing wastes and domestic sewage are considered to be the main sources of water pollution in the Batang Belungkung and Gombak rivers. Effluents from rubber industries consist of processed water containing small amounts of uncoagulated latex, serum containing residual proteins, carbohydrates, lipids, carotenoids, organic and inorganic salts including nitrogen and phosphorus (Chin *et al* 1978). Wastes derived from urban communities contain large amounts of organic and nutrient trace materials.

The impact of these two sources of wastes on the aquatic environment is severe. Rubber effluent is rich in bacterial nutrients and its biochemical oxygen demand is between 750 and 2700 ppm (mg/1) as compared to domestic sewage of 200 to 400 ppm (Chin *et al* 1978, Pfafflin and Ziegler 1976).

Organic loading estimated by biochemical oxygen demand and chemical oxygen demand as reported by Norris and Charlton (1962) and Bishop (1973) showed an increase in the mean BOD from 2.0 to 3.4 ppm and COD from 2.1 to 2.8 ppm during the ten year period from 1958/59 to 1968/69 at station F (*Fig. 1*).

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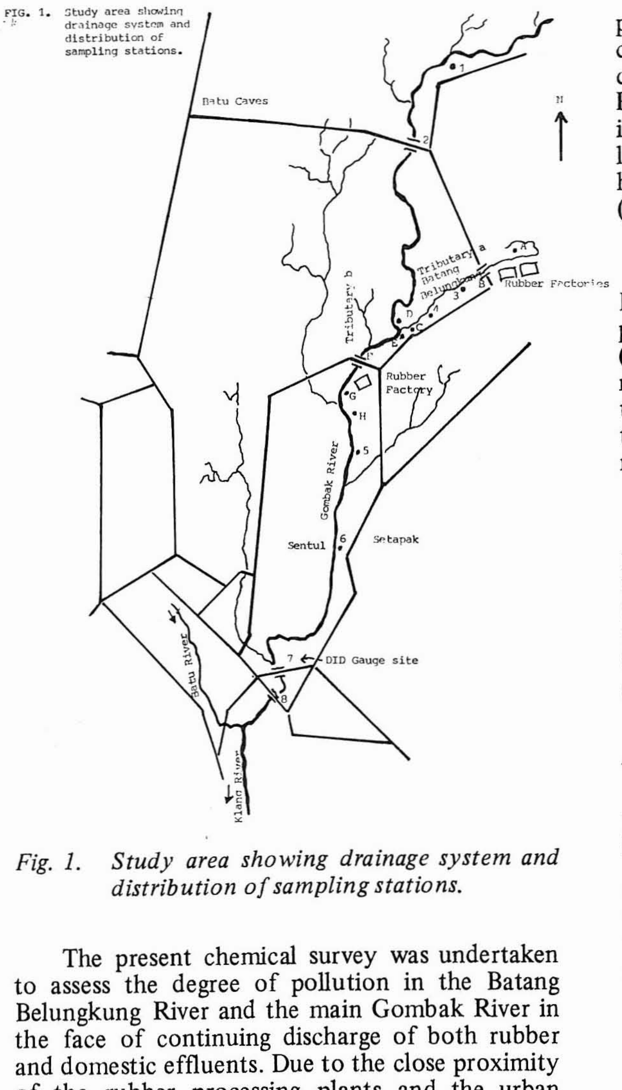

Fig. 1. Study area showing drainage system and distribution of sampling stations.

The present chemical survey was undertaken to assess the degree of pollution in the Batang Belungkung River and the main Gombak River in the face of continuing discharge of both rubber and domestic effluents. Due to the close proximity of the rubber processing plants and the urban communities (*Fig. 1*), it has not been possible to study the effect of pollution from these two sources separately.

EXPERIMENTAL

Sampling

Field work was begun in October 1978 and continued until 1 January 1979, a period which represents the main wet months of the year. Samplings were carried out during the day (9.00 am. – 6.00 pm.) and once at night (7.00 – 11.30 pm.) River water for chemical analysis was collected from mid-river by integrating samples from three or more depths (5 cm to 1m). River depth varies from 8 cm – 1 m.

Samples retained for laboratory study were preserved by refrigeration and addition of mercuric chloride (for nitrogen and phosphorus analysis), or concentrated sulphuric acid (for COD analysis). Polyethylene sample bottles were cleaned by an initial soaking with 50% sulphuric acid; subsequently they were conditioned by soaking in either hydrohloric acid (2 M) or in ammonia solution (2 M, for samples required for phosphate analysis).

The parameters reported here include pH, DO, BOD. (3 days at 30°C), COD, nutrients (orthophosphate-phosphorus (PO_4-P), total-phosphorus (Total-P), ammonia-nitrogen (NH_3-N), total-nitrogen (Total-N), total suspended solids (TSS), total solids (TS), total dissolved solid (TDS) and trace elements (sodium, potassium, calcium, and magnesium).

High and low flow rates at various sampling periods were assessed qualitatively and quantitatively at the Drainage and Irrigation Department (DID) guage site *(Fig. 1)*. The mean flow rates of the Batang Belungkung River at station C was 0.087 m^3/sec on 10th April 1969 (Bishop 1973) and assumed to have remained constant.

Analytical Methods

Dissolved oxygen was determined by the Alsterberg (Azide) modification of the Winkler method (Golterman 1969). BOD was estimated by measurement of DO before and after three days incubation at 30°C of suitably diluted samples (Lee, 1975). The pH of the river water was determined on the river bank at the time of sampling with a portable Jenco Digital pH meter model 602. Standard methods of APHA 1971 for the analysis of COD, Total-P, PO_4-P, NH_3-N, Total-N, TSS, TS, TDS were used. Sodium, potassium, calcium, magnesium were determined by Atomic Absorption Spectrophotometer (Perkin Elmer 107)

RESULTS AND DISCUSSION

Fig. 1 shows the geography of the river system under study. The whole Gombak river and its tributaries have a catchment of approximately 124 sq. km. Water sampling stations A, B, C were established on the tributary (a), the Batang Belungkung river and the remaining ones D, E, F, G and H on the Gombak river. In addition, subsidiary stations were established on the Gombak river (1, 2, 5, 6, 7 and 8) and the Batang Belungkung river (3, 4) so as to provide a complete longitudinal survey of DO levels along both rivers.

Station A was located beside a small urban residential area and just up-stream of the two rubber factories, a latex concentrate factory with an average production of 40 tonnes/day which discharges at a rate of 0.62 m^3/hr and a rubber re-milling factory with an average production of 75 tonnes/day dry rubber content which discharges wastewater at a rate of 80m^3/hr. The effluents from these two types of rubber factories have organic and nutrient loading as shown in Table III. Station B was approximately 167m away from station A and 5 m downstream of the discharge outlets of the two factories. Station C, 1¼ km away from station B, was located just downstream of a dense urban area and 10m away from the confluence, (Station E) of the Batang Belungkung river and the Gombak river. Station D was established on the Gombak river approximately 3 m upstream of the confluence point. Stations D, E, F, G and H were 18m, 0.6, 0.13, 0.48 km apart respectively with G 100 m downstream of the discharge outlet of another rubber remilling factory. It has an average production of 80 tonnes/day of dry rubber content and discharges wastewater at a rate of 70m^3/hr.

The Batang Belungkung River

A drastic depletion of approximately 50–80% saturation DO was experienced at Station B (*Fig. 2*). This is believed to be due to the continuous discharge of wastewater effluents from the two rubber factories. The fairly high levels of BOD and COD of 389.0 and 1023.0 ppm respectively and 43.6% saturation DO in the receiving water detected at night at Station B confirmed that the discharge of effluent from the factories also took place at night (Table 1).

Deoxygenation processes continued to take place from station 3 onwards (*Fig. 2*). The presence of additional indiscriminate discharge of domestic sewage, waste engine oil from motor repair shops and dumping of household rubbish downstream as observed during the sampling period has contributed in the main to the low channel capacity of this river. It also explains why no DO was detected at Stations 4 and C which had high mean BOD_3 concentration of 192.8 ppm and high mean COD concentration of 420.5 ppm. A strong stench of H_2S could be de-

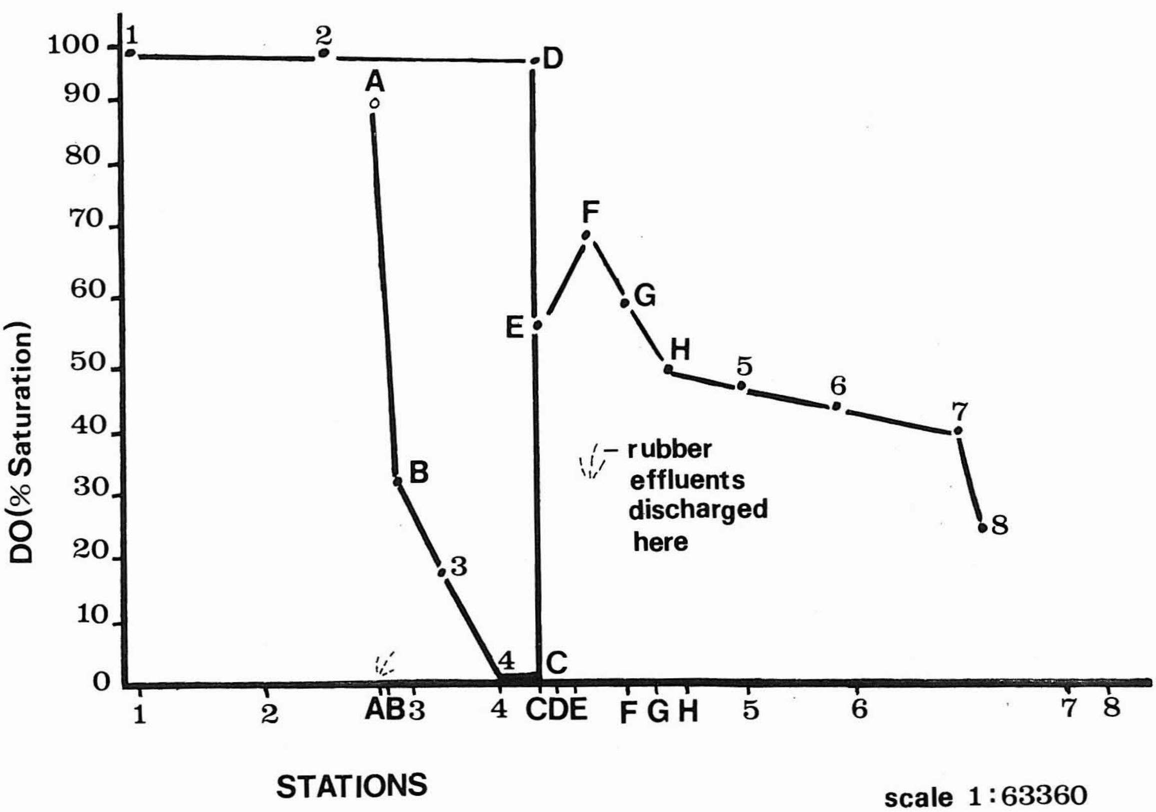

Fig. 2. Longitudinal Survey of DO (% Saturation).

TABLE 1
Analytical data for samples collected at the sites specified

Parameter/ Stations		A	B	C	D	E	F	G	H
	mean	82.0	17.1	0	96.7	59.1	74.1	65.3	58.6
DO	min.	79.4	0.0	0	95.6	44.6	64.3	57.7	45.8
(% sat.)	max.	86.7	43.6	0	99.1	73.5	81.4	76.4	66.9
	av. dev.	2.4	13.3	0	1.2	9.7	4.9	7.4	8.5
BOD	mean	2.5	477.4	192.8	24.0	66.7	41.6	424.3	64.1
(3 days at 30° C)	min.	1.1	389.0	154.0	11.0	48.0	22.0	160.0	48.0
(in ppm)	max.	3.7	544.0	234.0	52.0	97.0	70.0	676.0	91.0
	av. dev.	0.9	54.4	27.8	14.0	20.2	19.7	95.4	17.9
COD	mean	3.1	1420.0	420.5	32.1	166.1	92.6	1538.0	153.8
(in ppm)	min.	1.9	1023.0	207.0	19.0	70.0	27.3	246.0	60.5
	max.	4.4	2057.0	789.0	62.0	356.0	188.0	2418.0	305.0
	av. dev.	1.1	381.0	204.5	15.0	126.6	57.7	861.3	100.8
PO_4–P	mean	0.20	14.13	4.00	0.04	0.79	0.55	0.69	0.68
(in ppm)	min.	0.08	3.93	2.05	0.01	0.68	0.20	0.29	0.36
	max.	0.37	26.55	10.63	0.09	0.97	0.84	1.06	0.98
	av. dev.	0.11	6.69	3.70	0.03	0.12	0.28	0.26	0.22
Total–P	mean	0.71	21.81	9.59	0.53	1.64	1.61	2.57	1.59
(in ppm)	min.	0.28	6.14	3.10	0.12	1.42	0.90	1.80	1.33
	max.	1.29	41.53	16.08	1.26	1.80	2.42	4.00	1.87
	av. dev.	0.42	12.76	5.85	0.37	0.15	0.67	0.96	0.28
pH	mean	6.9	6.6	6.7	7.2	6.8	7.0	6.6	7.0
	min.	6.6	6.2	6.5	7.0	6.6	6.6	6.5	6.6
	max.	7.5	6.9	6.8	7.4	7.1	7.2	6.9	7.3
	av. dev.	0.14	0.19	0.10	0.18	0.12	0.20	0.20	0.23
NH_3 –N	mean	1.37	29.12	13.31	0.16	3.68	4.28	11.08	4.44
(in ppm)	min.	0.29	16.00	5.30	0.07	2.85	2.06	5.32	2.45
	max.	3.46	45.75	21.89	0.28	5.08	6.48	12.69	6.59
	av. dev.	1.05	11.27	7.81	0.07	0.94	1.64	3.61	1.44
Total–N	mean	2.75	43.17	18.75	1.95	6.64	6.62	13.70	6.36
	min.	1.30	21.80	9.10	1.10	5.15	4.27	8.73	4.08
	max.	6.43	68.43	27.90	3.49	9.46	8.58	20.20	7.79
	av. dev.	1.84	14.47	9.10	0.77	1.88	1.93	4.35	1.52
TS	mean	115.5	608.3	318.5	331.8	375.3	286.5	329.3	261.0
(in ppm)	min.	91.0	433.0	260.0	130.0	184.0	152.0	168.0	148.0
	max.	145.0	826.0	382.0	696.0	653.0	523.0	522.0	452.0
	av. dev.	20.4	127.8	57.0	182.2	185.1	134.5	128.4	127.3
TSS	mean	29.3	278.3	82.5	235.3	300.7	190.8	224.7	166.3
(in ppm)	min.	16.0	170.0	43.0	84.0	99.0	94.0	111.0	98.0

Table 1 (Continued)

TABLE 1
Analytical data for samples collected at the sites specified

Parameter/ Stations		A	B	C	D	E	F	G	H
	max.	61.0	410.0	108.0	534.0	493.0	379.0	366.0	283.0
	av. dev.	21.3	85.8	24.0	149.4	110.0	143.8	94.2	77.8
Na	mean	8.38	11.27	16.00	7.69	10.73	9.24	10.64	8.95
(in ppm)	min.	6.35	7.53	12.04	5.42	8.25	7.3	8.86	8.00
	max.	11.15	11.90	19.25	11.00	13.95	11.50	11.90	10.00
	av. dev.	1.69	2.86	1.97	1.80	2.14	1.77	1.18	0.70
K	mean	3.33	24.14	18.90	3.09	7.55	5.26	5.16	6.01
(in ppm)	min.	3.04	20.74	13.80	2.77	6.83	4.01	4.22	4.15
	max.	3.64	25.94	23.40	3.59	8.64	5.81	6.42	7.02
	av. dev.	0.25	1.70	3.55	0.26	0.72	0.63	0.84	1.07
Ca	mean	0.60	1.31	1.34	0.35	0.58	0.50	0.65	0.66
(in ppm)	min.	0.40	0.86	1.15	0.14	0.49	0.32	0.48	0.54
	max.	0.77	1.80	1.55	0.69	0.63	0.57	0.92	0.70
	av. dev.	0.14	0.31	0.13	0.17	0.06	0.08	0.17	0.06
Mg	mean	0.44	4.40	2.87	0.19	0.42	0.33	0.89	0.50
(in ppm)	min.	0.27	3.64	2.29	0.10	0.37	0.18	0.60	0.31
	max.	0.62	4.72	2.94	0.20	0.48	0.44	1.23	0.60
	av. dev.	0.11	0.38	0.46	0.07	0.04	0.08	0.22	0.09

ppm = mg/L
av. dev. = average deviation

tected during the sampling period. All these gave proof that anaerobic conditions actually prevailed in this stretch of the river which is biologically dead.

The Gombak River

Stations 1, 2 and D located on the main Gombak river just above the confluence had DO levels near to saturation (95.8 – 99.2%) indicating that this region of the waterway was relatively unpolluted. The principal station D which represented the receiving end of any discharge from the upper region of the Gombak river had PO_4-P concentration as high as 0.09 ppm and exceedingly high ratio of Na+K to Ca+Mg of 9.0-58.8 (Table 2). This is believed to be due to the run off from human settlements, rice growing areas (Kanapathy 1968) and the use of river water for bathing and laundry washing up-stream from station D. A fairly high total solid of 130-695 ppm was detected here which could be attributed to the tin mining activities of alluvial tin extraction and erosive processes up-river which were transported down-river. As a result of the diluting effect of the larger volume of relatively unpolluted river water from the upper region of the Gombak river (mean discharge of 3.41 m^3/sec) on the wastes carrying water from the heavily polluted Batang Belungkung river, which had a discharge of only 0.087 m^3/sec, organic and inorganic nutrients and DO levels at the confluence point (Station E) were considerably reduced and were between those of Stations C and D (Figs. 2, 3, 4). Further dilution due to tributary (b) caused some reduction in COD and BOD_3 levels; a simultaneous increase in DO level of receiving water to 81% saturation was observed at Station F (Fig. 3). A slight increase in NH_3-N content (Table 1) indicated sewage discharge near Station F. However, station G experienced a sharp rise in COD, BOD_3 and solid levels but a relatively lower rise in Total-N, Total-P levels (Figs. 3, 4, Table 1). This is thought to be due to the discharge of wastewater from a rubber remilling factory, characterized by its high oxygen demand and solid content but lower nitrogen and phosphorus levels (Table 3) because unlike the latex concentrate factory, the remilling factory does not use ammonia and phosphoric acid in the processing of rubber (Chin *et al* 1978).

TABLE 2
Ratios of solids and trace metals at different conditions

Parameter/Stations	A	B	C	D	E	F	G	H
Low Flow, Total–S ($2.05\ m^3/sec.$)	127.0	433.0	263.0	306	289	319	298	–
TDS:TSS	4.77	1.01	2.56	0.55	0.87	0.63	0.51	–
Na+K:Mg+Ca	10.6	5.2	6.8	9.0	16.4	15.1	6.1	11.5
(All in ppm)								
High Flow, TS ($4.66m^3/sec.$)	145.0	532	260	696	653	523	522	452
TDS:TSS	1.38	2.12	5.05	0.30	0.38	0.43	0.0.43	0.6
Na+K:Mg+Ca	13.8	8.55	10.6	58.8	19.2	34.2	14.8	16.3
Low Flow, TS ($2.50m^3/sec.$)	91.0	826	382	195	184	152	168	183
TDS:TSS	4.69	1.02	0.72	0.55	0.86	0.62	0.51	0.55
Na+K:Mg+Ca	13.1	6.15	8.0	29.5	–	17.1	13.0	13.8
Low Flow (night)TS ($2.73m^3/sec.$)	99.0	642	369	130	–	–	–	148
TDS:TSS	0.51	0.51	0.72	0.55	–	–	–	0.51
Na+K:Mg+Ca	5.39	5.39	9.1	17.2	–	–	–	11.3

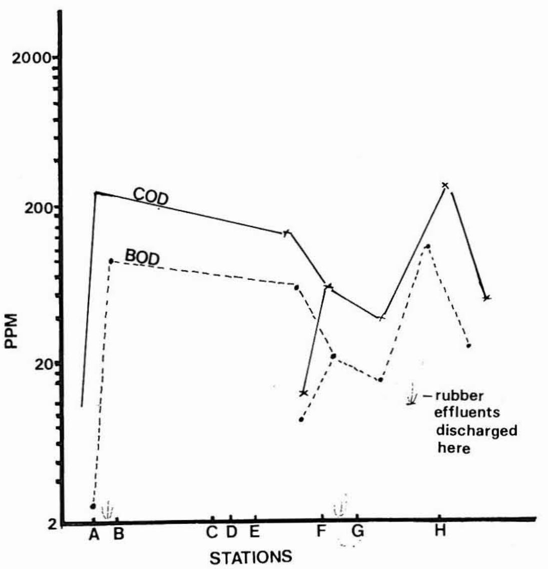

Fig. 3. Longitudinal Survey of COD and BOD.

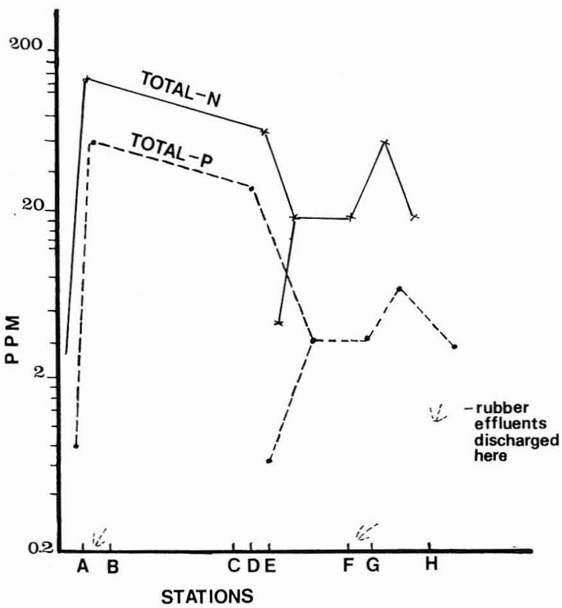

Fig. 4. Longitudinal survey of Total-N and Total-P.

The constant low reading of DO level of 30-67% saturation from station F onwards was due to the discharge of organic domestic and industrial sources in the urbanised community further down-river.

A survey of the solid and metal contents of the study areas indicated that, in general,

TABLE 3
Characteristics of Effluent in Relation to Product Type (Chin *et al* 1978)

Product type	Kg/Ton Dry Rubber Output					
	BOD	COD	TS	TSS	Total-N	NH_3—N
SMR Block Rubbers (from rubber remilling plant)	58.3	92.9	55.8	9.9	4.9	2.6
Latex concentrate (from Latex concentrate plant)	40.0	79.0	108.8	3.8	8.4	6.5

high flow is associated with relatively lower ratio of dissolved materials to suspended solids, but, a higher ratio of Na+K to Ca+Mg and total solids, while the reverse is true for low flow of the river (Table 2).

A comparison of Bishop's data (1973) and our findings revealed a sharp increase of mean BOD concentration from 2.8 to 40.0 ppm at station F. In a span of ten years (1968/69 – 1978/79), there has been a drastic deterioration in the water quality as shown by an almost fourteen-fold increase in oxygen demand levels in the receiving water of the lower region of the Gombak river. The survey was conducted mainly during the wet months when the chemical parameters were affected by dilution and washout. A greater degree of pollution could be expected to prevail during the dry months in both the Batang Belungkung and the Gombak rivers if no proper measures of water pollution control were undertaken.

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REFERENCES

AMERICAN PUBLIC HEALTH ASSOCIATION (1971): Standard Methods for the Examination of Water and wastewater, (13th ed). American Public Health Association, Washington D.C. 874 pp.

BISHOP, J. E. (1973): Limnology of a small Malayan River: Sungai Gombak Vol. 22. The Hague. Dr. W. Junk B. V., publishers, 141 pp.

CHIN, P. S., PONNIAH, C. D., JOHN, C. K., and LEE, H. (1978): Effluents from natural rubber processing factories and their abatement in Malaysia. Proceedings of the water pollution control in developing countries international conference. Vol. II, Bangkok, 231 pp.

GOLTERMAN, H. L. (1969): Methods for Chemical Analysis of Fresh Waters. Oxford. Blackwell Science Publishers, 127 pp.

KANAPATHY, K. (1968): A Survey of the quality of some padi irrigation water in Malaya and its interpretation. *Malay. Agric. J.* **46**: 286–297.

LEE, H. and CHOW, W. M. (1975): Determination of Biochemical oxygen Demand of rubber factory effluent. Proceedings of the Agro-Industrial Wastes Symposium. RRIM, Kuala Lumpur. 49 pp.

NORRIS, E. C. and CHARLTON, J. I. (1962): A chemical and biological survey of the Gombak river. Kuala Lumpur. Government Printer. 57 pp.

PFAFFLIN, J. R., and ZIEGLER, E. N. (Eds.) (1976): Encyclopedia of Environmental Science and Engineering. Vol. 1. London and New York. Gordon and Breach Science Publishers. 450 pp.

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