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A STUDY ON WATER QUALITY EVALUATION OF THE CHAO PHRAYA RIVER

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Abstract

Water quality evaluation of the Chao Phraya River was studied on the survey from 1978 to 1980. From this present study the following results were obtained. Tidal effect reached up to about 60 km from the river mouth during dry season, but seldom reached up to 10 km from the river mouth during rainy season. Spatial and temporal changes of dissolved oxygen (DO) and biochemical oxygen demand (BOD) supported the assumption that water quality of the Chao Phraya River, especially in Bangkok Metropolitan Area, is influenced by three main factors, namely tidal effect, flow rate of the river, domestic and industrial wastewater. Correlations between salinity and chloride ion, between BOD and DO could be observed.

Introduction

The Chao Phraya River is one of the most important rivers in Thailand which covers a basin area of about 162,000 km^2. The river flows from the Northern Valleys through the central plain and into the Gulf of Thailand. Bangkok metropolitan area is located on the river estuary and is therefore subjected to tidal effects. The present situation of water quality of the river is heavily polluted by industrial wastewater and domestic wastewater. Water pollution of the Chao Phraya River mainly caused by the development of industries along the river's bank and concentration of population in the Metropolis should be a matter of considerable concern. Few researches on water quality of the Chao Phraya River have been reported[1,2]. Therefore, it is very important to get the fundamental data of water quality for the Chao Phraya River in viewpoint of water quality and pollution control and management.

In this paper, the characteristic phenomenon of water quality of the Chao Phraya River from the results of three year surveys is reported.

Materials and Methods

Method of survey

1) Period of Survey

Surveys were carried out 34 times from 1978 to 1980.

2) Sampling stations of the Chao Phraya River

Sampling stations were fixed in every 2 kilometers from km 10 to km 64 during the periods between January 1978 to February 1980. Sampling stations during the periods between March 1980 to September 1980 were located in 10, 14, 20, 24, 28, 30, 36, 42, 44, 48, 52, 58, 62, 68.8, 82.4, 91.6, 98.4, 131.1, 137.2, 142.6, and 147.8 kilometers from the river mouth as shown in Fig. 1.

3) Collection of sample

In each sampling stations, the water samples were collected about in the middle of the river and at a point about one half the depth of the river by using Ditto type water sampler.

Methods of analysis

1) Parameters

Dissolved oxygen (DO) was analysed by using azide modification method[3], chloride ion was analysed by using mercuric nitrate method[3] and BOD analysis was carried out according to the "Standard Methods for the Examination of Water and Wastewater" (p.543, 14th Edition, 1975)[3].

2) Amount of rainfall and flow rate

Date on rainfall were taken from Metereological Department of the Ministry of Communication.

Flow rate at Chao Phraya Dam which is in Chainat province near Amphoe Muang and is in 241 km from the river's mouth was obtained from the Irrigation Department of the Ministry of Agriculture.

Results and Discussion

Tidal effects in the estuary of the Chao Phraya River

In order to evaluate the characteristics of water quality of the Chao Phraya River, data gathered from the surveys from 1978 to 1980 were analysed.

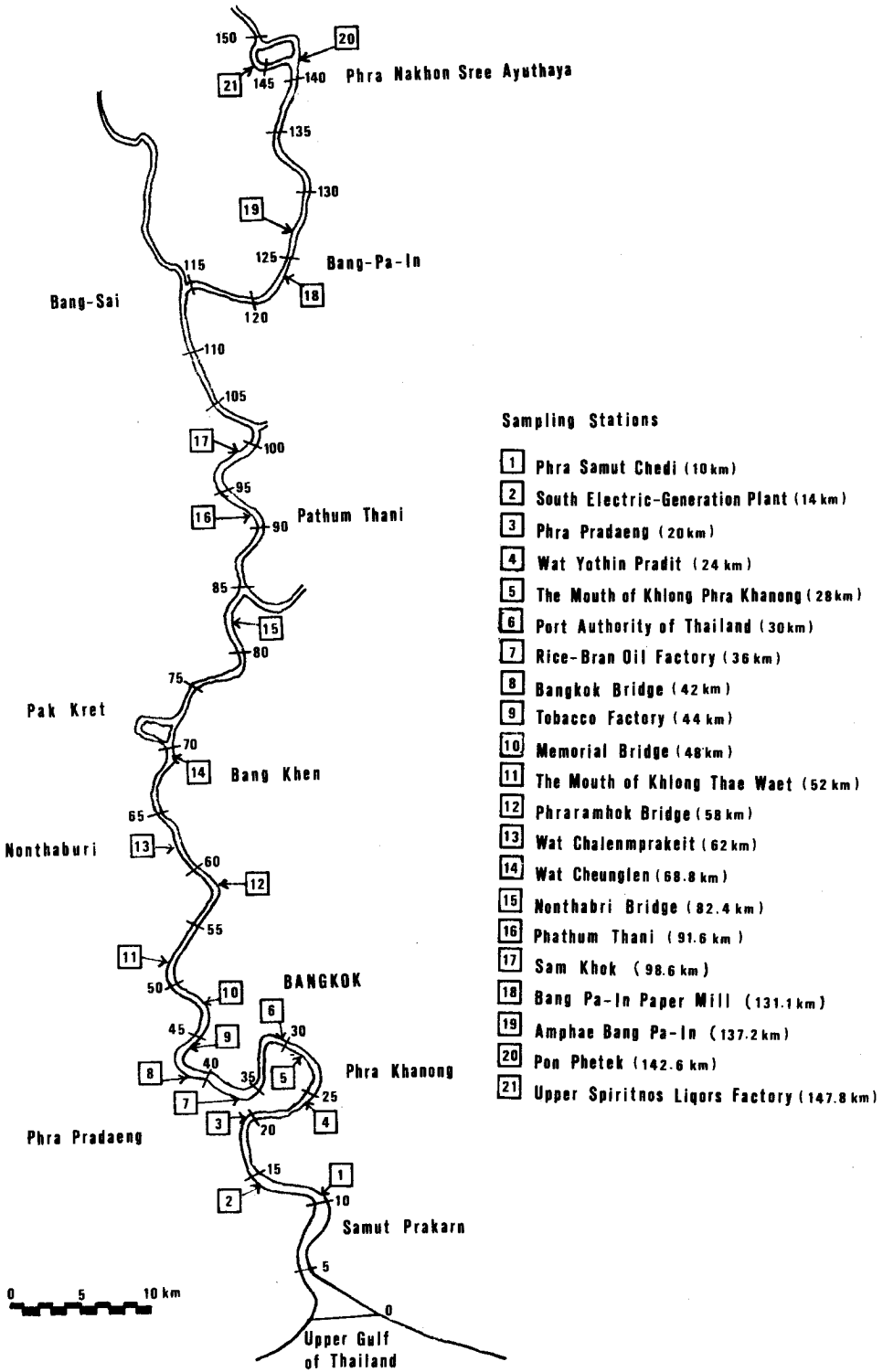

Fig. 1. Map of Sampling Stations in the Chao Phraya River

In Thailand, all the main rivers entering the Gulf of Thailand strongly influenced by the tidal effects. Because tides and rainfall affect the chemical composition of the river, chloride ion distribution was measured during winter (January), summer (March) and rainy season (August) from 1978 to 1980. The spatial distribution of chloride ion in the river water from the river's mouth to about 60 km is shown in Fig.2. It was found from these data that during winter and summer seasons the sea water reaches as far as 40 to 60 km from the river's mouth during both high and low tides. In summer in 1980 the tidal effects reached about 60 km from the river's mouth. However, during the rainy season the tidal effects did not reach 10 km from the river's mouth. Salinity distribution along the Chao Phraya River in 1980, as shown in Fig.3, is similar to chloride ion concentration. The salinity is greatest from the river's mouth to the 10 km station.

The results shown in Fig. 3 make clear that during the dry season including winter and summer from 1978 to 1980, the estuary of the Chao Phraya River was influenced by the tidal effects, but during the rainy season it was seldom influenced by the tidal effects. In order to check this tidal phenomenon further, the yearly changes of chloride ion in three sampling stations which are located at 10, 30 and 60 km from the river's mouth are shown in Fig.4. Ratios of river and sea water during high tide in the dry season at 10 km were 50 to 60%. So, it is considered that the tidal effects depend on seasons, that is, flow rate of the river or amount of rainfall in the basin of the Chao Phraya River.

Fig.5 and 6 show yearly changes of flow rate of the Chao Phraya River at the Chao Phraya Dam and yearly changes of rainfall in the basin of the Chao Phraya River. Yearly changes of flow rate is recognized to have very similar patterns as compared with yearly changes of rainfall in the basin of the river. Yearly changes of the rainfall in the whole Chao Phraya River basin showed the same pattern as the yearly changes of the rainfall in the basin of the lower reach below the Chao Phraya Dam. These results revealed that during the rainy season from June to October, the flow rate and the rainfall increase in parallel and during the dry season from November to May, both of them decrease in a similar manner. Fig.5 and 6 support Tingsanchali's report[4] that due to low rainfall, the flow of the river in 1979 was lower than the normal average value.

From the results described above, it is considered that the tidal effects in the Chao Phraya River reach the upper stream which is about 60 km from the river's mouth during the dry season, but rarely are influenced by the tidal effect even near the river's mouth during the heaviest rainy season.

Characteristics of water quality of the Chao Phraya River

Distributions of dissolved oxygen (DO) and biochemical oxygen demand (BOD) along the Chao Phraya River were investigated.

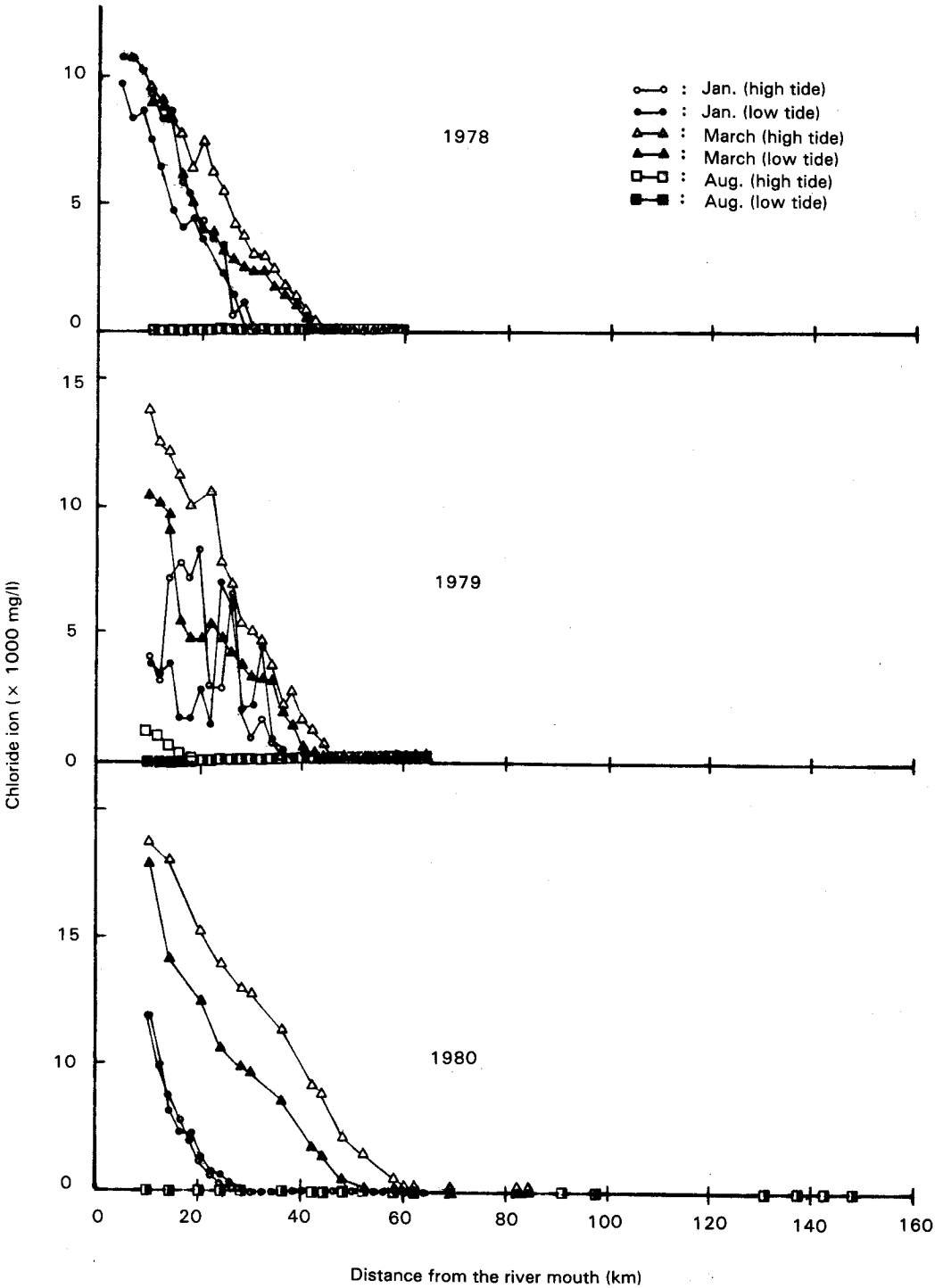

Fig. 2. Chloride ion distribution along the Chao Phraya River in various seasons (winter, summer and rainy seasons) from 1978 to 1980

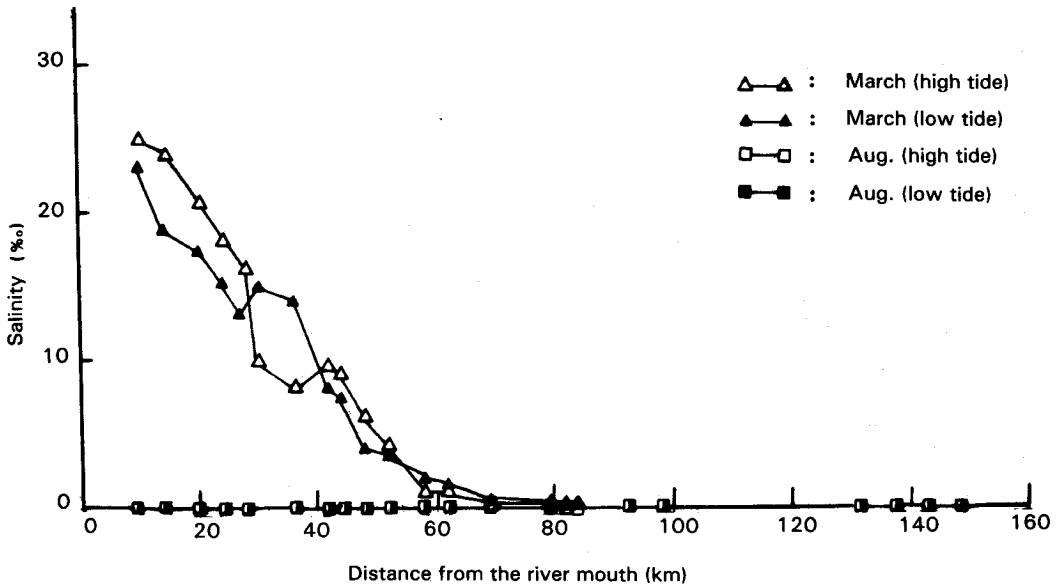

Fig. 3. Comparison of salinity in the Chao Phraya River among typical seasons (summer and rainy seasons) in 1980

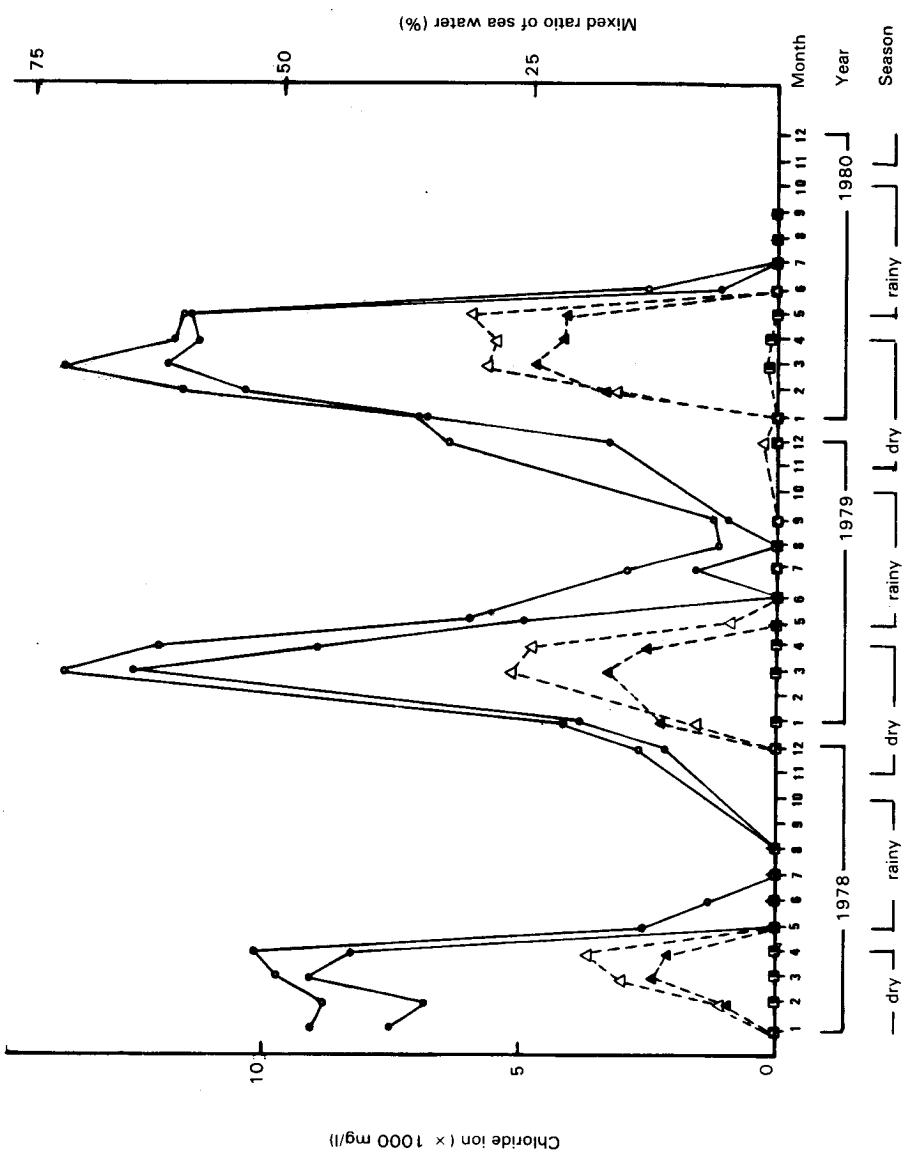

Fig. 4. Yearly changes of chloride ion in three sampling stations located in 10, 30 and 60 km from the Chao Phraya River Mouth

○ : 10 km (high tide) , ● : 10 km (low tide) , △ : 30 km (high tide) , ▲ : 30 km (low tide) ,
□ : 60 km (high tide) , ■ : 60 km (low tide)

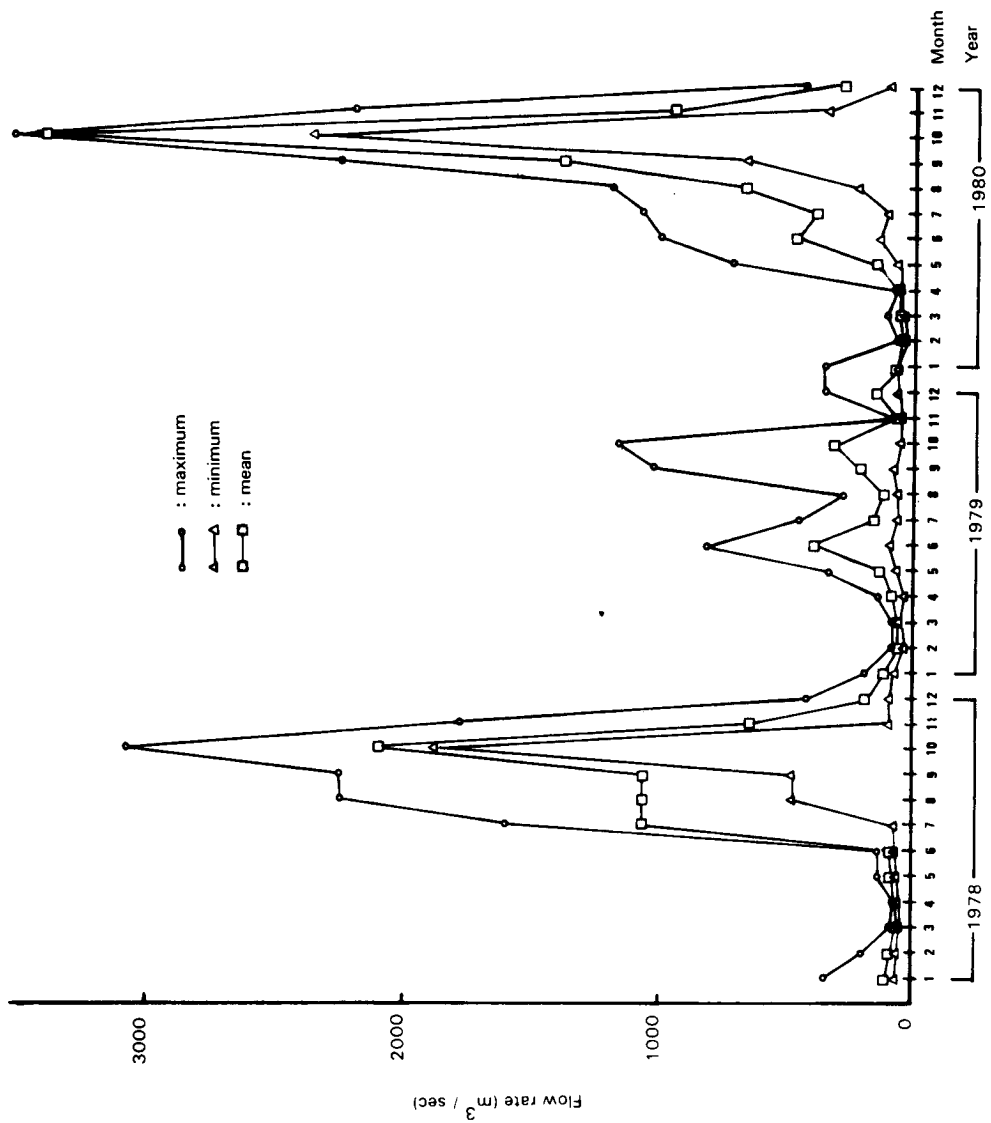

Fig. 5. Yearly changes of flow rate of the Chao Phraya River at the Chao Phraya Dam

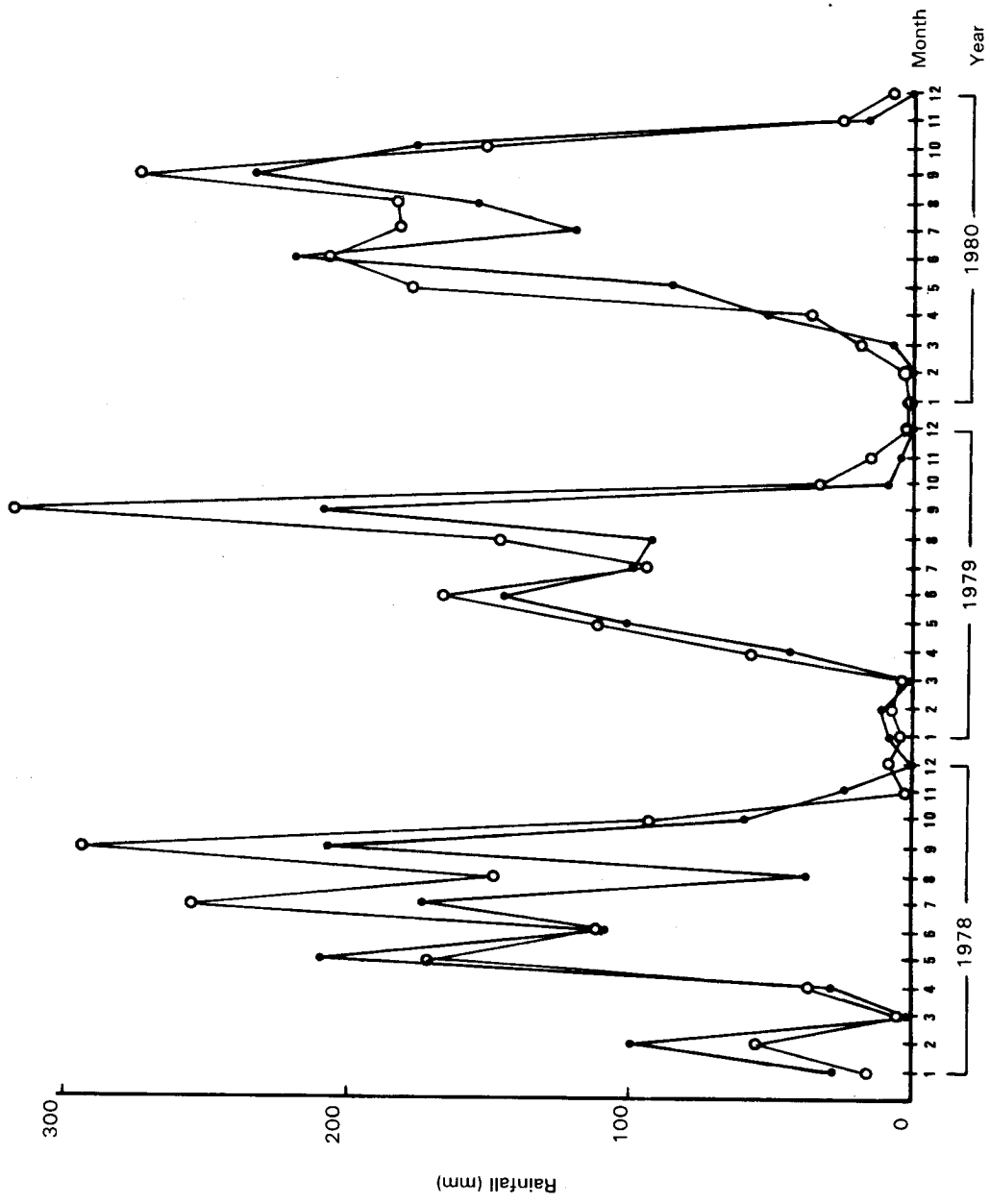

Fig. 6. Yearly changes of rainfall in the Chao Phraya River Basin

Fig.7 shows DO distributions along the Chao Phraya River below near Ayudhya Province (below sampling station 147.8 km from the river mouth) in typical seasons from 1978 to 1980.

In the rainy season (August) during 1978 to 1980 DO concentration increased gradually from 2.5 mg/l to about 6 mg/l and the nearly similar distribution pattern in the dry season (January and March) indicated that DO concentration in the lower reaches of the river decreased up to near 20 km from the river mouth and plane thereafter between 20 to 40 km station, being about 1 mg/l and then increased again going up the stream. The elevation of DO values within the vicinity of the river mouth during dry season 1978 and 1980 may come from the tidal effects depending upon higher mixed ratio of the fresh sea water. The lower DO distributions between 20 to 40 km from the river mouth are believed due to the effluents of domestic and industrial wastewater in Bangkok Metropolitan Area. However, DO distribution patterns in typical seasons in 1979 showed the different profile from the other years. It is considered that the different patterns are caused by small amount of rainfall in 1979. On the other hand, in order to investigate seasonal changes of DO along the Chao Phraya River, yearly changes of maximum DO concentration obtained from DO values from all sampling stations are shown in Fig. 8. It is found that the mean values of DO concentration in the river increase during rainy season and decrease during dry season. It is considered that DO distribution in the river is closely related to the rainfall in the Chao Phraya River basin and flow rate of the river. From these results, the phenomenon which occured in August in 1978 and 1980, the gradual increase of DO values from the near river mouth toward the upper stream, may be due to the high flow rate and without tidal effects during rainy season.

Fig. 9 shows BOD distribution along the Chao Phraya River near Ayudhya Province in typical seasons from 1978 to 1980. These BOD distribution show high variation in every season. However, it is recognized that BOD values from 20 to 40 km from the river mouth (in Bangkok Metropolitan Area) tend to be higher than the other portion of the river. So, it is considered that the high BOD values are caused by the inflow of effluent of domestic and industrial wastewater by way of many klongs in Bangkok Metropolitan Area[5].

On the other hand, in order to evaluate roughly the seasonal changes of BOD along the Chao Phraya River, yearly changes of maximum, mean and minimum BOD values calculated from BOD values from all sampling stations are shown in Fig.10. It is found that yearly changes of mean and maximum BOD concentration tend to be higher (mean value of about 5 ppm) in dry season and lower (mean value of about 1 ppm) in rainy season. These trends seem to be highly correlated with the flow rate of the river and the rainfall.

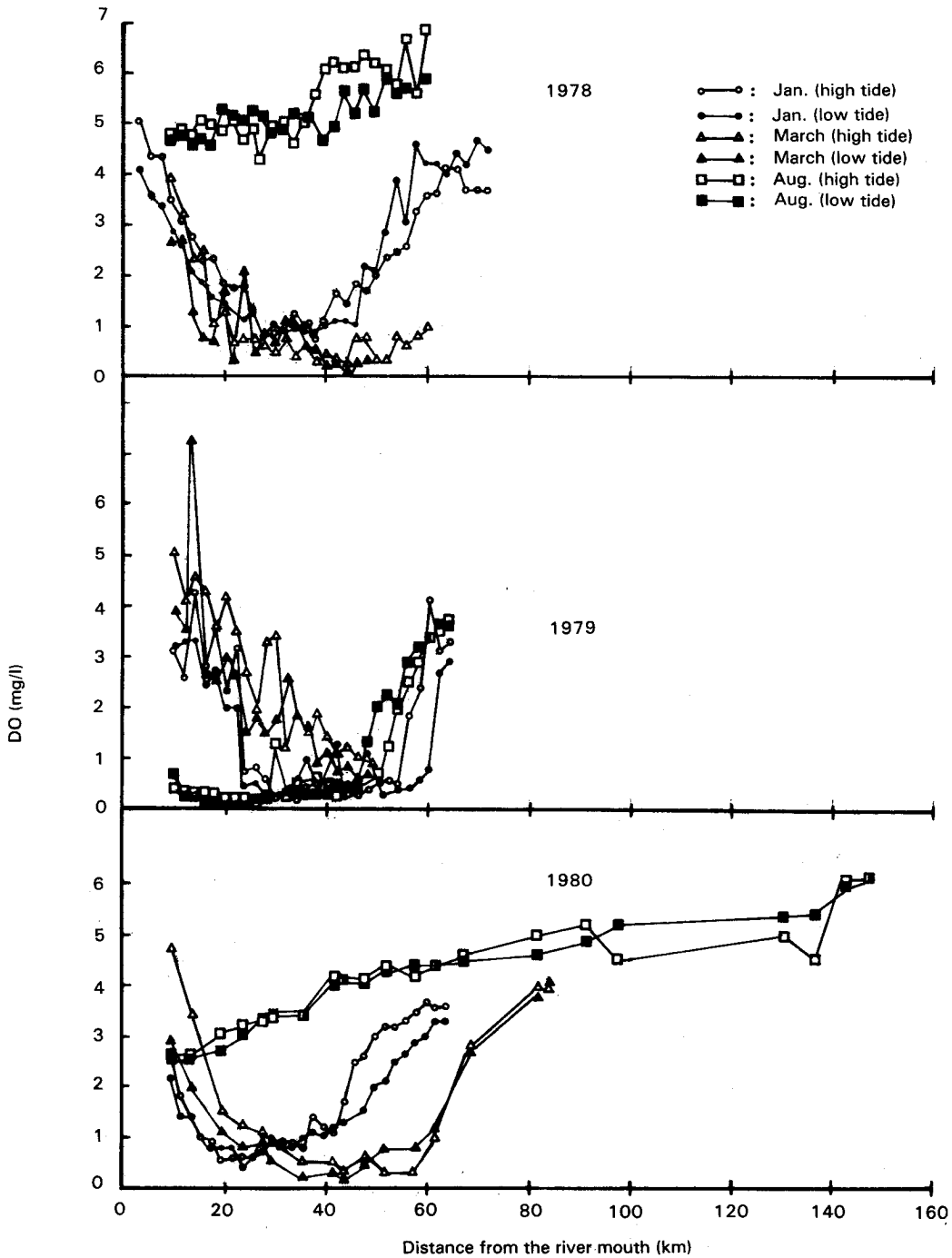

Fig. 7. DO distribution along the Chao Phraya River in various seasons (winter, summer and rainy seasons) from 1978 to 1980

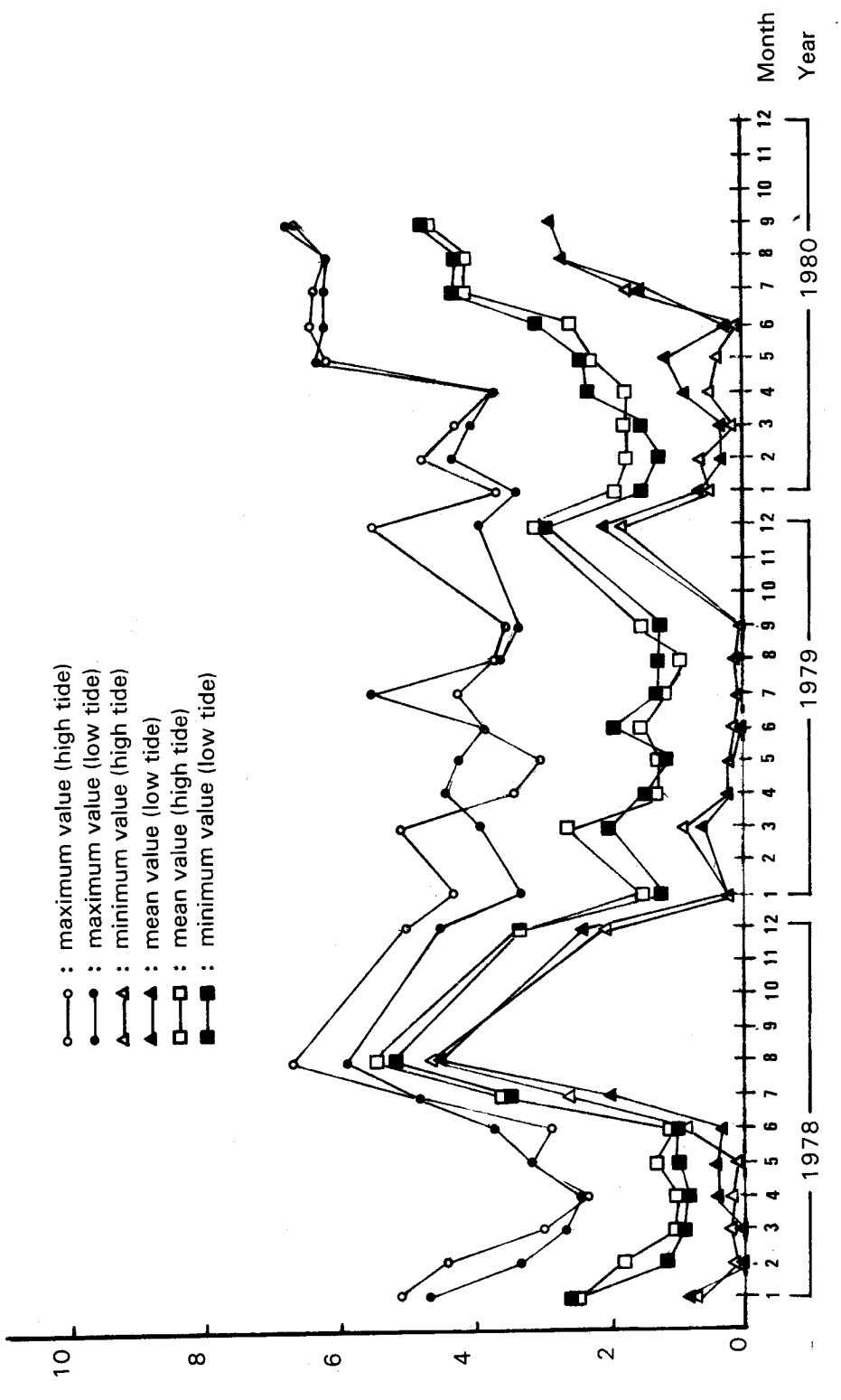

Fig. 8. Yearly Changes of DO in the Chao Phraya River

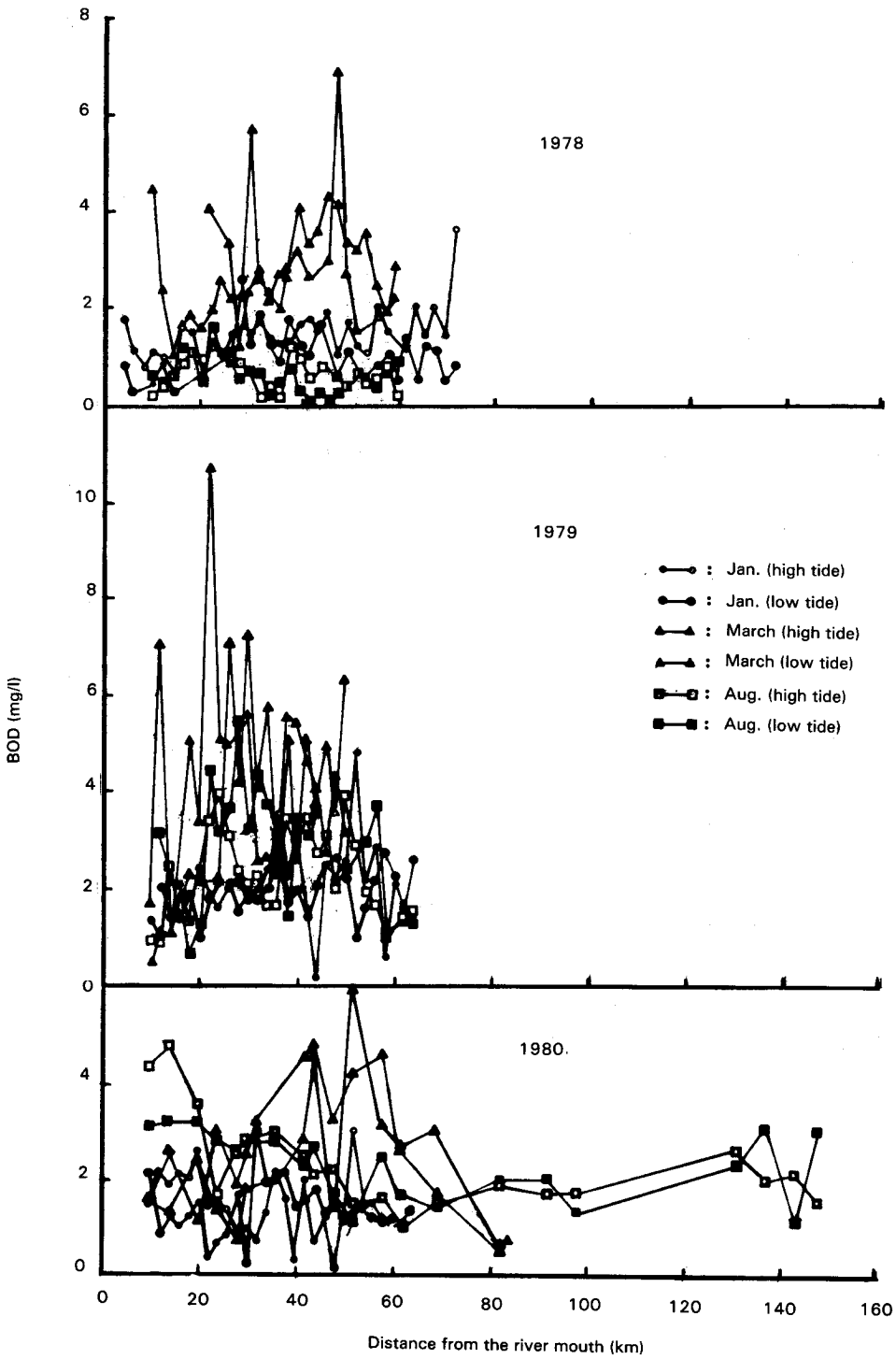

Fig. 9. BOD distribution along the Chao Phraya River in typical season (winter, summer and rainy seasons) from 1978 to 1980

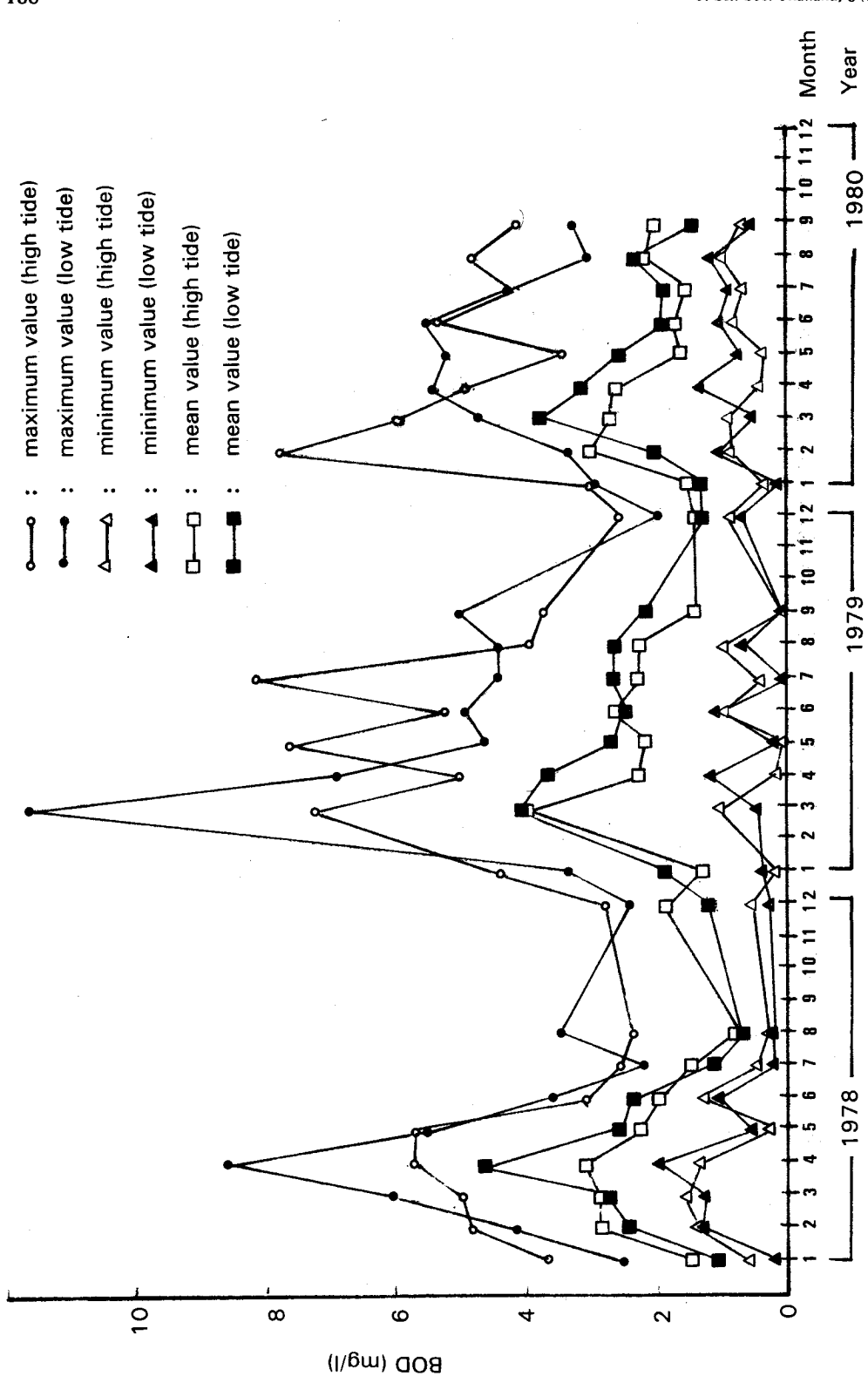

Fig. 10. Yearly change of BOD in the Chao Phraya River

Table 1 shows the relative correlation on components of water quality of the Chao Phraya River. Characteristic pattern of water quality is the high correlation between salinity and chloride ion, which in 1980 had a correlation coefficient (r) 0.9840 and the regression line $y = 563.7814\ x - 73.717$. A correlation between BOD and DO was found in August of 1978 to 1980 when the correlation coefficient $r = -0.635$ and the regression line $y = -1.138\ x + 5.534$.

This present study showed that the distribution of DO, BOD, chloride ion and salinity along the Chao Phraya River is strongly influenced by tidal effects and flow rates of the river.

TABLE 1 RELATIVE CORRELATION ON COMPONENTS OF WATER QUALITY OF THE CHAO PHRAYA RIVER

x	y	Sampling time	Number (n)	Correlation coefficient (r)	Regression line $y = a\ x + b$
Salinity	Chloride ion	1980	114	0.984	$y = 563.781\ x - 73.717$
BOD	DO	January (from 1978 to 1980)	160	-0.286	$y = -0.515\ x + 2.687$
BOD	DO	March (from 1978 to 1980)	160	-0.209	$y = -0.160\ x + 1.843$
BOD	DO	August (from 1978 to 1980)	136	-0.635	$y = -1.138\ x + 5.534$

Conclusion

This three year survey of the Chao Phraya River shows:

1) That during dry season including winter and summer, the lower Chao Phraya River from 0 km to 60 km is influenced by tidal effects. There are no tidal effects during the rainy seasons.

2) Distancial distribution of DO in dry season indicated a difference in patterns as compared with rainy season. It is recognized that yearly changes of DO distribution in the rainy season are higher than during dry season. DO distributions along the Chao Phraya River are influenced by three main factors, namely tidal effects, effluent of domestic and industrial wastewater and flow rate of the river.

3) BOD distribution showed high variation in every season. However, it is considered that the higher BOD values from 20 to 40 km from the river mouth is caused by the inflow of effluent of domestic and industrial wastewater in Bangkok Metropolitan

Area[5]. Yearly changes of mean and maximum BOD values have the tendency to be higher in dry season and lower in rainy season.

4) Characteristics of water quality include the correlations between salinity and chloride ion, and BOD and DO in August.

5) Further investigations on the mechanism of tidal effects on the Chao Phraya River and on the detailed characteristics and behavior of water quality such as nitrogen compounds, phosphate, heavy metals and toxic substances should be carried out.

Acknowledgements

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บทคัดย่อ

การประเมินค่าของคุณภาพน้ำของแม่น้ำเจ้าพระยานี้ ใช้ข้อมูลจากการสำรวจและวิเคราะห์คุณภาพน้ำ ของสำนักงานคณะกรรมการสิ่งแวดล้อมแห่งชาติ จากปี พ.ศ. 2521 ถึง ปี พ.ศ. 2525 เป็นเกณฑ์ ซึ่งมีผลพอสรุปได้คือ

การหนุนของน้ำทะเล มีอิทธิพลต่อคุณภาพน้ำของแม่น้ำเป็นระยะทางถึง 60 กิโลเมตรจากปากแม่น้ำในช่วงฤดูแล้ง แต่จะมีอิทธิพลน้อยลงไปในช่วงฤดูฝน กล่าวคือจะมีอิทธิพลเฉพาะในระยะทาง 10 กิโลเมตรจากปากแม่น้ำเท่านั้น

พิจารณาจากการเปลี่ยนแปลงของค่าออกซิเจนละลาย (Dissolved Oxygen, DO) และค่าบีโอดี (Biochemical oxygen demand, BOD) ในลำน้ำ ช่วงที่ไหลผ่านกรุงเทพฯ เห็นได้ว่าเกิดขึ้นจากองค์ประกอบสำคัญ 3 ประการ ได้แก่ น้ำทิ้งจากบ้านเรือน, น้ำทิ้งจากอุตสาหกรรม และอัตราการไหลของน้ำในแม่น้ำ นอกจากนี้ยังพบค่าความสัมพันธ์ระหว่างค่าความเค็ม (salinity) และค่าคลอไรด์อิออน (chloride ion) และความสัมพันธ์ระหว่างค่า BOD และ DO เป็นไปอย่างเห็นได้ชัดเจน