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Freshwater discharge of Bangpakong River flowing into the inner Gulf of Thailand

Thanomsak BOONPHAKDEE*, Pichan SAWANGWONG* and Tateki FUJIWARA**

Abstract : Bangpakong River debouches into the northeastern corner of the inner Gulf of Thailand. Monthly discharge of this river at its mouth was estimated during the water years of 1993–1996. The discharge is highly seasonal with the highest peak of 1152 m^3sec^{-1} and lowest peak of 8 m^3sec^{-1} appearing in September and February, respectively. The averaged annual discharge is 267 m^3sec^{-1}. The Bangpakong catchment basin consists of mountain and plain areas. The ratio of discharge to precipitation yield is 0.30 in the mountain area and only 0.09 in the plain area.

Key words : *river discharge, Bangpakong River, Bangpakong Estuary, precipitation, troical rivers, Thailand*

1. Introduction

Estuaries are one of the most productive and sensitive systems. They form an essential link between marine and river ecosystems (SMITH *et al.*, 1997). Their importance has been recognized in terms of carbon fixation, fisheries habitat, nutrient assimilation, sediment stabilization and so on. This might be due to the fact that estuaries are dynamic systems which sustain extreme changes (BABAN, 1997).

However, almost every estuarine study has been focused on the estuaries in mid latitudes. There are large rivers in tropical latitudes between southeast Asia and Australia that supply large amount of freshwater to the ocean. Flow of those rivers exhibit remarkably seasonal variations as a result of monsoon cycle. These variations influence on the continental region around Malaysia, Indonesia and Gulf of Thailand (SIMPSON, 1997). Consequently, nutrients transported into estuarine and coastal waters exert occasional and transient impacts on phytoplankton productivity.

The freshwater discharge from the Bangpakong River delivers dissolved nutrients into the inner Gulf of Thailand and occasionally causes phytoplankton blooms (BOONPHAKDEE *et al.*, 1997). We have been conducting a long-term monitoring program for this estuary since 1995 in order to understand chemical, physical and biological characteristics of this estuary as well as to detect trend in water quality variation. Although we have measured concentration of nutrient to estimate nutrient load from the river but river discharge data are unavailable. At the river mouth there is no hydrographic station which continuously records river discharge data.

In this paper, we estimate fresh water discharge of Bangpakong River at its mouth from continuously collected discharge data in the upstream watersheds and study the relationship between the discharge and precipitation.

2. Description of the study area and analysis method

Bangpakong River (Lat. 13 degree N, Long. 100.5 degree E) is one of four main rivers draining into the inner Gulf of Thailand (Fig. 1). This river gathers water from Nakhon Nayok

* Department of Aquatic Science, Faculty of Science, Burapha University, Chonburi 20131, Thailand
** Fisheries and Environmental Oceanography, Graduate School of Agriculture, Kyoto University, Sakyo-ku, Kyoto 606–8502, Japan

River and Prachinburi River and debouches into the northeastern corner of the Gulf. The length, mean depth and area of catchment basin of this river are about 240 km, 4 m (SOJISUPORN and JIRASIRILERT, 1991) and 19,786 km^2 (this study). River discharges are measured at various stations in the catchment basin by Royal Thai Irrigation Department. Details of each station are listed in Table 1. The discharges of Bangpakong River and its tributaries are highly seasonal due to the influence of monsoon.

Bangpakong catchment basin is divided into mountain and plain areas (Royal Thai Survey, 1966). The mountain area occupies the northern part of the catchment basin and includes some parts of Kao Yai and Tub Lan National Parks, which are well-reserved forest in average altitude of 600m. KGT14, KGT15A, KGT27, NY1B and NY3 watersheds cover whole mountain area and have a total area of 1,663km^2. A sum of discharges from the mountain area is denoted by Q_0.

The rest of the catchment basin, the plain area, has an area of 18,123 km^2 and mean altitude of 80 m. This area adjoins the watershed of Chao Praya River to the west. There are many canals around the divide line for irrigation purposes, therefore, decision of the divide line accompanies some ambiguities. Vast majority of the plain area is used as agricultural area (Land Development Department, 1996). The river receives many kinds of anthropogenic loadings, such as domestic and agricultural wastes from municipal communities and farms (BOONPHAKDEE *et al.*, 1997). KGT10, KGT12, KGT18 and KGT19 watersheds are included in the plain area and cover upstream and mid-stream parts. We denote a sum of discharges from these watersheds and sum of areas as Q_1 and S_1 (5,549 km^2), respectively. In downstream and plain area, there is a land

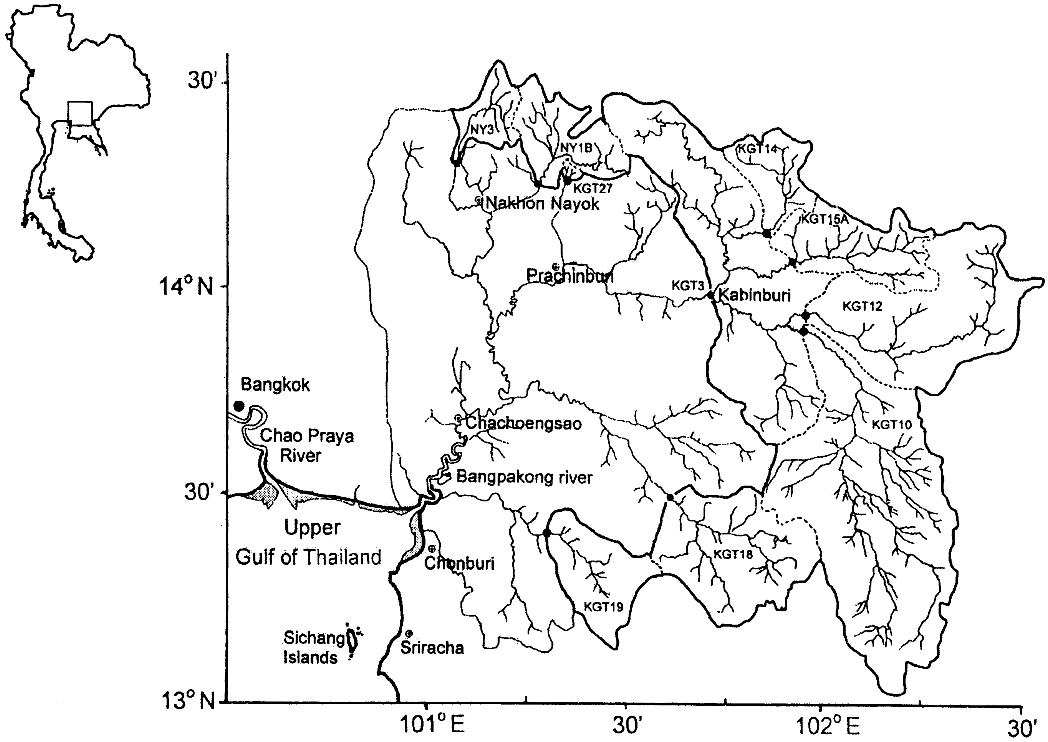

Fig. 1. Map of watershed areas of Bangpakong catchment basin. The area surrounded by thick line indicates an area where discharge data are available. Details of each watershed are listed in Table 1.

where discharge data is unavailable. We, therefore, estimated discharge from this non-data area (Q_2) from Q_1 by using equation

$$Q_2 = S_2 Q_1 / S_1 \quad (1)$$

where S_2(10,031 km^2) is an area of the non-data area. We assumed Q_2/S_2 as equal to Q_1/S_1.

Then, the discharge of Bangpakong River at the mouth (Q_3) is obtained as a sum of measured discharges and estimated Q_2. Most measured discharge values used in this study are monthly data from the water years from 1993 to 1996, though the data of KGT18 and KGT19 watersheds are long-term data of the water years 1965–1996. All discharge data in this study are supported by Royal Thai Irrigation Department.

In this paper we used water year instead of the calendar year. In general, water year begins and ends in a relatively dry season. It is used for hydrological statistics. The water year of Thailand which is used in this paper begins on April 1 and ends on March 31 of the following calendar year. For example, the water year 1993 is the period covering from April 1, 1993 to March 31, 1994.

3. Results and discussion

Distribution of long-term mean annual precipitation in and around the Bangpakong catchment basin is presented in Fig. 2. The annual precipitation in this basin varies form 1200mm/year in the southwestern part and northeastern corner to 1600mm/year in the northern mountain area. However, the difference in precipitation values between the mountain and plain areas is rather small which averaged annual precipitation in the mountain and plain area are 1600 and 1400mm/year, respectively. Figure 3 shows monthly variation of the precipitation in Bangpakong catchment basin. About 90% of the annual rainfall ocurs between May and October with highest peak in September, and the rest of the rain falls between November and April with the lowest value in December and January.

To indicate the relationship between precipitation and river discharge in the mountain area, we present in Fig. 4 the monthly precipitation at Ban Tap Lan and corresponding discharge from KGT14 watershed. Precipitation increases form April to September and rapidly decreases in October. Following this variation, the river discharge begins to increase in May, and attains its peak value in September before rapidly decreases in October. The ratio of the annual amount of discharge to annual precipitation yield which is a product of the precipitation and the area of watershed is 0.30.

Monthly precipitation and discharge in the plain area abtained by long-term average values for KGT18 and KGT19 is shown in Fig. 5. Though precipitation and discharge attain their peak values in September, river discharge delays significantly to the precipitation, especially at the beginning and the end of rainy

Table 1. Area and classification in each watershed of Bangpakong catchment basin.

Station name	Watershed area	Area (km^2)	Classification
Krabinburi	KGT3	7,502	Plain/mountain
Ban Wang Khian	[a]KGT10	2,523	Plain
Ban Kaeng	[a]KGT12	1,540	Plain
Ban Thung Faek	[a]KGT14	366	Mountain
Ban Kaeng Din So	[a]KGT15A	530	Mountain
Ban Tha Kloi	KGT18	951	Plain
Ban Mai	KGT19	535	Plain
Ban Klong Yang	KGT27	45	Mountain
Ban Kao Nam Buat	NY1B	519	Mountain
Ban Pa Kha	NY3	203	Mountain

[a]are sub-area of KGT3 watershed

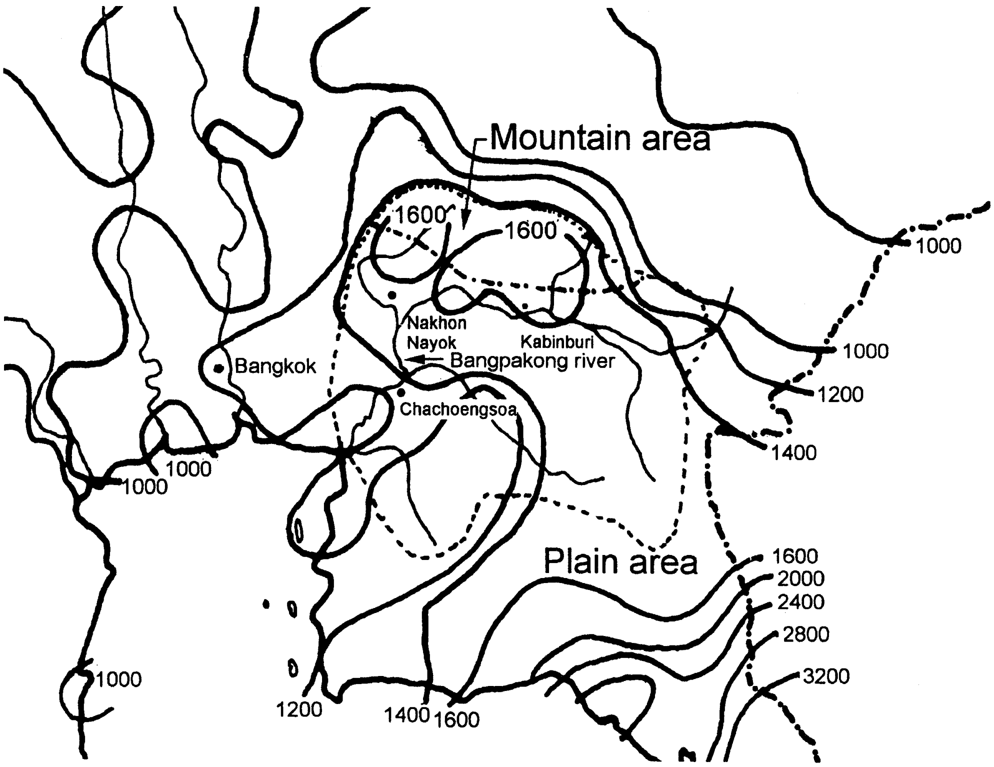

Fig. 2. Annual precipitation in Bangpakong catchment basin averaged over the water years 1952–1996.

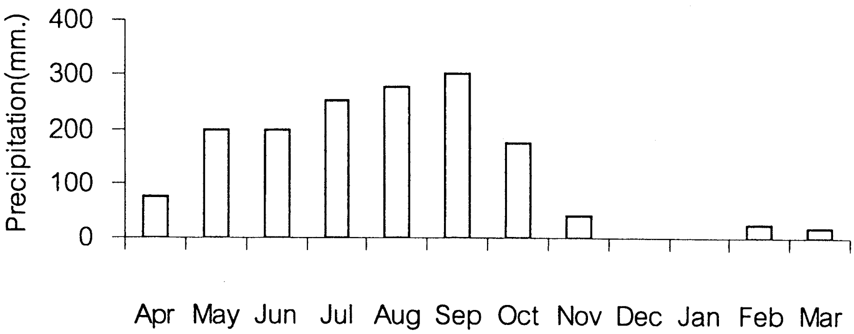

Fig. 3. Monthly precipitation averaged over Bangpakong catchment basin during the water years 1952–1996.

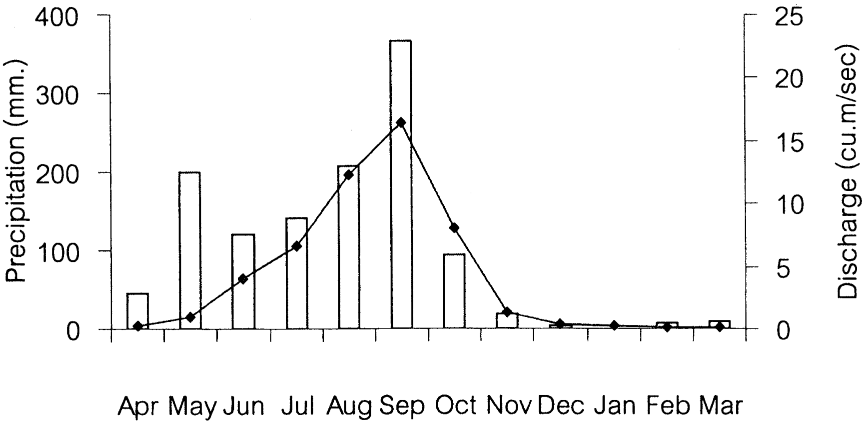

Fig. 4. Monthly precipitation and water discharge of the mountain area averaged over the water years 1993–1996. Vertical bars are precipitation measured at Ban Tap Lan and a solid line is discharge from KGT14 watershed.

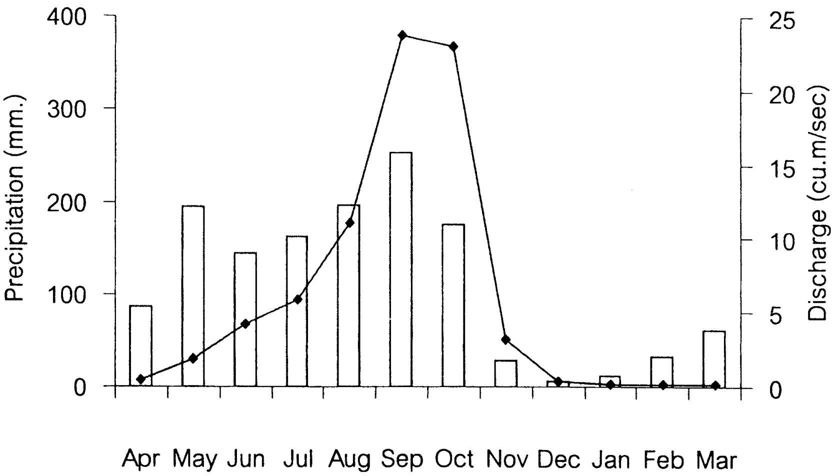

Fig. 5. Monthly precipitation and water discharge of the plain area averaged over the water years 1965–1996. Vertical bars are averaged value of precipitation measured at Klong Si Yat and Klong Luang, and a solid line is averaged discharges of KGT18 and KGT19 watersheds.

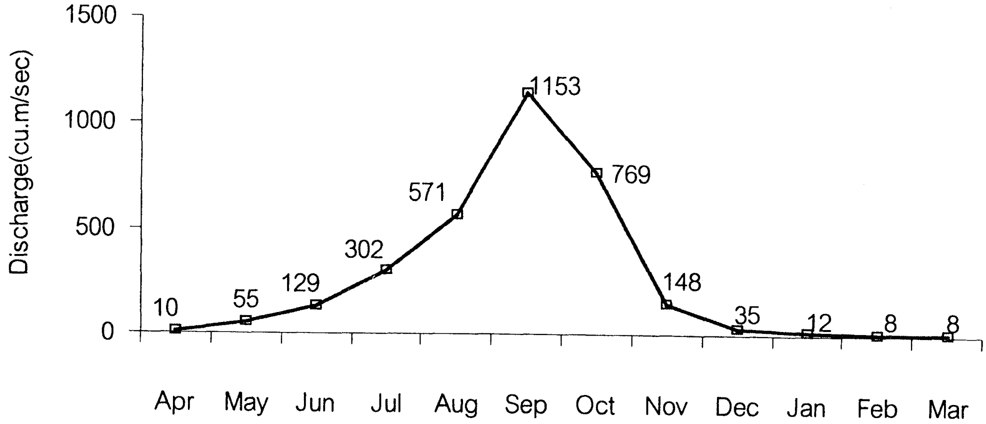

Fig. 6. Monthly discharge of Bangpakong River at the river mouth averaged over the water years 1993–1996.

season. In the plain area, the ratio of annual amount of river discharge to precipitation yield is 0.09. This ratio is far less than that of mountain area. This indicates that the mountain area is more efficient to convert rainfall to runoff than the plain area. In the plain area most part of the precipitation evaporates from the soil and returns again to the air.

Monthly mean discharge of Bangpakong River (Q_3) is exhibited in Fig. 6. The discharge has a great seasonal variation indicating large discharge during rainy season and small discharge in dry season. The highest and lowest values appear in September and March, respectively. Volume of river water, which is an integrated volume of discharge over the rainy or dry seasons, is presented in Table 2. These volumes are obviously different between rainy and dry seasons. The ratio of river discharge to precipitation yield is 0.22 for whole catchment basin of Bangpakong River.

Highly seasonal variation of Bangpakong River discharge is one of the typical features of tropical rivers (SIMPSON, 1997) as well as Choa Praya River (KANCHANALAK, 1998) and Mekong River (STANSFIELD and GARRETT, 1997). Though this valiability is induced by seasonal rainfalls, discharge delays from precipitation in both plain and mountain areas, especially in the beginning of rainy season. The river discharge does not immediately follow up the increasing of precipitation.

Table 2. Comparison of discharges and volumes of water at Bangpakong River mouth between rainy and dry seasons.

Season	Water discharge (m^3/sec)	Volume of water (m^3)
Rainy (May–October)	496	78.7×10^8
Dry (November–April)	37	5.8×10^8
Annual mean	352	

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