ASSESSING CUMULATIVE WATERSHED EFFECTS BY ZIG-ZAG PEBBLE COUNT METHOD

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ABSTRACT

Cumulative effects are the combined effects of multiple activities for example such as agricultural activities, logging activities, unpaved roads, grazing and recreation, while the watershed effects are those which involve processes of water transport. Almost all impacts are influenced by multiple activities, so almost all impacts must be evaluated as cumulative impacts rather than as individual impacts. This paper attempts to present and discuss the cumulative effects occur within the Endau watershed, current issues on water resource planning and management and the approaches/strategies required to confront present and emerging critical problems. In this study, the deposition of fine sediment (particle size < 8 mm) are main concern because this can adversely affect macro-invertebrates and fish by filling pools and interstitial spaces, decreasing inter-gravel dissolved oxygen concentrations, and inhibiting fish fry emergence. The bed material particle-size distribution is believed to be one of the first channel characteristics to change in response to management activities. This study was carry out on Jasin River as reference stream while Mengkibol River and Sembrong River and as study stream. The method for assessing these CWEs is by using Zig-Zag pebble count method. As result, the sediment loading is in the order of Sembrong River > Mengkibol River > Jasin River. As the Sembrong River is heavily silted, sediment transport process is expected to be more active here compared to the Mengkibol River. For the Jasin River, due to the presence of much larger material, movement of fine particles is impeded thus minimizing sediment transport. From the study, it suggests that agricultural erosion is the primary sediment source due to the large areas involved and the land disturbance effects of cultivation. This follows up by urban erosion due to sediment originates mainly from exposed soils in areas under construction and from street dust and litter accumulation on impervious surfaces.

ABSTRAK

Kesan kumulatif legeh adalah kesan terkumpul pelbagai aktiviti penggunaan tanah seperti aktiviti pertanian, pembalakkan, tanah tak berturap dan reakreasi. Manakala kesan legeh pula adalah kesan yang melibatkan proses pengangkutan air. Hampir keseluruhan impak adalah kesan daripada kepelbagaian aktiviti penggunaan tanah. Maka, keseluruhan impak ini haruslah dinilai sebagai satu kesan kumulatif. Tujuan kertas kerja ini adalah untuk membentangkan serta membincangkan kesan kumulatif legeh yang terjadi di Legeh Sungai Endau, isu semasa dalam pengurusan dan perancangan sumber air serta masalah-masalah yang timbul berikutan daripada impak berkenaan. Untuk kajian ini, taburan endapan (partikel bersaiz kurang daripada 8 mm) telah dinilai kerana ia menyumbangkan kesan negetif terhadap hidupan macro-invertebrat serta ikan dengan memenuhi ruangan paya, mengurangkan kandungan oksigen terlarut dalam air serta menghalang kemunculan anak ikan. Kajian ini dijalankan di Sungai Jasin (sungai rujukan) dan Sungai Mengkibol serta Sungai Sembrong (sungai yang dikaji). Kaedah yang digunakan untuk menilai kesan kumulatif legeh ini adalah dengan "*Zig-Zag Pebble Count Method*". Daripada hasil kajian, beban endapan adalah dalam turutan Sungai Sembrong > Sungai Mengkibol > Sungai Jasin. Sumber utama endapan ini adalah berpunca daripada kakisan pertanian. Aktiviti pertanian adalah merupakan salah satu aktiviti utama yang menjadi punca endapan di Malaysia, maka banyak kawasan hutan telah giat diterokai serta diusahakan untuk aktiviti pertanian. Seterusnya, ini diikuti dengan hakisan urbanisasi dimana endapan berpunca daripada aktiviti pembinaan di kawasan persekitaran yang sedang dibangunkan terutamanya daripada tanah yang terdedah. Sesungguhnya ini telah menyumbangkan beban endapan yang tinggi terhadap Sungai Sembrong dan Sungai Mengkibol.

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LIST OF SYMBOLS

p_r	-	Proportion of Less 8 mm for Reference Reach
p_{s1}	-	Proportion of Less 8 mm for Study Reach 1
p_{s2}	-	Proportion of Less 8 mm for Study Reach 2
n_r	-	Sample Size for Reference Reach
n_s	-	Sample Size for Study Reach
f	-	Factor relating Reference reach to Study Reach for Sample Size
yr	-	Year
m	-	Metre
km	-	Kilometre
Ha	-	Hectare
%	-	Percentage
mm	-	Millimetre
^{o}C	-	Degree Celsius
<	-	Less Than
Cum %	-	Cumulative Percentage
BMPs	-	Best Management Practices
CWEs	-	Cumulative Watershed Effects
EQA	-	Environmental Quality Act, 1974
GDP	-	Gross Domestic Product
CEQ	-	Council on Environmental Quality

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In Malaysia, 90% of water resources required for domestic, industrial, and other purposes are derived from surface water with naturally defined watershed. Though the rainfall is considered abundant, due to uncontrolled land-use activities and unsustainable development coupled with poor land-use management policies/strategies, our precious water resource has been subjected to continuous degradation and other negative impacts limiting its utility. This has led to disastrous and/or catastrophic socio-economic events nationally (Johari, 1993)

Hence, there is a need to seek systematic management approaches/strategies that will support a sustainable balance between land-use activities and the need to protect our precious resource. This is critical in the long term considering the accelerated growth and the impending socioeconomic development of the country against the growing demand and the rising expectation for adequate and sound water supply for domestic and industrial needs (Ramadasan *et al.*, 1999).

In United State, the National Environmental Policy Act requires federal land managers to assess the impact on the environment of any proposed management activities (Thatcher, 1990). Although single actions can create an adverse environmental impact, the degradation of water resources is usually a result of multiple activities over time and space. In many forested areas a primary concern is the cumulative effect of management activities on the designated beneficial uses of water, particularly coldwater fisheries (MacDonald *et al*., 1991)

Cumulative watershed effects are result from multiple land use activities including agricultural activities, logging activities, unpaved roads, grazing, and recreation. Logging activities has been shown to increase annual water yields (Stednick, 1996), the size of peak flows (Troendle and King, 1985), the rate of surface erosion and the frequency of mass movements (Everest *et al*., 1987). Logging activities and the associated road network usually increase the amount of sediment delivered to the stream channel and basin-scale sediment yields (Reid, 1993).

Numerous methods have been developed to quantify the cumulative watershed effect of land management activities, and these include the *Equivalent Clearcut Area (ECA)*, *Equivalent Roaded Area (ERA)* and computer models such as *HYSED* and *R1-WATSED*. However, very few studies have directly tested these procedures with respect to water or sediment yields, or related these indices to stream channel condition, quality of aquatic habitat, or coldwater fish production (Reid, 1993).

The deposition of fine sediment is of concern since this can adversely affect macro-invertebrates and fish by filling pools and interstitial spaces, decreasing intergravel dissolved oxygen concentrations, and inhibiting fish fry emergence (Meehan, 1991). The bed material particle-size distribution is believed to be one of the first channel characteristics to change in response to management activities (Madsen, 1994). And one of available methodology for assessing cumulative watershed effects through sediment distribution in the stream is by using the Zig-Zag pebble count method.

The Zig-Zag pebble count method was developed by Bevenger and King (1995). This method is to characterizing the particle-size distribution and thus evaluates management effects on aquatic habitat in the study stream. These distributions can be used for comparative purposes to determine, with statistically reliability, if there has been a shift toward finer size material (fine gravels to sands) in the study stream (Bevenger and King, 1995). Knowledge of such a shift is important because increases in the finer size material can negatively impact the aquatic ecosystem (Meehan, 1991).

This paper attempts to assess and discuss the cumulative effects occur within the Endau watershed, current issues on water resource planning and management and the approaches/strategies required to confront present and emerging critical problems.

1.2 Problem Statement

Until recently in Malaysia, indiscriminate development and environmental mismanagement through various human activities have brought many changes in the watershed which have resulted in disruption of ecological processes. Various human activities such as unplanned land development, massive land clearing, logging activities and construction of dams are disrupting the environmental balance in the watershed. This includes the quantity and quality of the water, the hydrological cycle and the alteration of the natural habitats. All of this impacts will accumulated and become the cumulative watershed effects (CWEs). However, currently there no comprehensive method was applied to evaluate regarding this matters in Malaysia. This study was conducted to assess the CWEs that occur within Endau watershed by determine the delivery of fine sediment to the stream in the Mengkibol River and Sembrong River as the impacted river. Jasin River in the Endau-Rompin National Park was used as the reference river.

1.3 Study Area Description

The Study areas are located within Endau watershed in the Johor State. These cover mainly Kluang District and Endau Rompin National Park.

1.3.1 Kluang District

Kluang district is located roughly in the middle of the state of Johor in Malaysia. Kluang lies about 110 km north of Johor Bahru, east-southeast of Batu Pahat, west of Mersing and south of Segamat. The population of Kluang district now exceeds 250,000 residents and the town itself has over 140,000 residents. The geographical coordinates of the city centre are: 2°2′01″N, 103°19′10″E.

Kluang lies in an area of undulating hills. The highest point in Kluang is Gunung Lambak, a 510 m tall mountain and one of the southernmost mountains in the Malaysian main range which lies not far from the town. Kluang is landlocked and has no seafront. The rivers that flow through Kluang district are Sembrong River, Kahang and Mengkibol River which are also river of the tributaries of the Endau River. Kluang is served by a railway and roads linking it to all neighboring districts. It has a railway station as well as a bus interchange. The closest on-ramp to the North-South Highway is at Air Hitam although travelers approaching Kluang from the south may find exiting at Simpang Renggam more convenient. There is an airfield in Kluang but it is a military airfield, not a civilian one.

Urban sprawl in Kluang over the last three decades or so from the 1970s to 2000 has been roughly along the major roads. The town center itself has more than tripled in size in terms of the number and land area occupied by commercial and retail buildings in that time. Kluang is served by a district hospital, a district police station and fire station. It has numerous primary schools, several secondary schools and a public library. Sekolah Menengah Sains Johor, a government boarding secondary school with a special emphasis on science subjects, was built in the 1970s on the outskirts of Kluang along the Batu Pahat road.

Kluang initially grew as a rubber planting district. Rubber planting has, however, since then taken a back seat to other types of crops. Kluang now boasts large tracts of oil palm plantations as well as pineapple and tea plantations. From its early days as an entirely agricultural economy, Kluang has developed various industries including paper, textiles, ceramics and electrical products. Most of Malaysia's major banks have branches in Kluang. In the last few years, several stock brokerages have opened shop in Kluang.

1.3.2 Endau-Rompin National Park

Located on the Johor-Pahang border, this two and half century old extensive lowland forest is home to several rare and endangered species. Endau-Rompin National Park is made up of a lush, pristine tropical rainforest. Covering an area of 48,905 hectares (800 km^2), it is the second largest national park in the Peninsula after Taman Negara. With rock formations dating back some 248 million years, Endau-Rompin is mostly hilly with some prominent sandstone plateau. It also happens to be the watershed of several rivers such as Endau River, Seal River, Jasin River, Marong River, Kinchin River and Kemapan River.

The hills of Endau are made up largely of ignimbrite, overlain in places with shale, sandstone and clay. This mixture lends itself to some very interesting features like cliffs, waterfalls, rapids and boulder-pools carved out from solid rock by water action. This latter feature is most distinct at Upeh Guling on Jasin River, where many boulder-pools can be found. Bands of granite from steps or sheer cliffs, including the spectacular Buaya Sangkut Falls, discovered in 1985 by the Malayan Nature Society Malaysian Heritage and Scientific Expedition.

The Endau River catchments area covers over 420 km^2 of forested lands. Botanists and scientists researching the area founds the water there of excellent, pure quality. Several plants were discovered that are found nowhere else in the world. Animals in the vicinity of the Endau River include the rhinoceros, elephant, tiger, fox, mouse deer, tapir, bearded pig, wild boar and monkey. Altogether, well over 60 species of mammals have been recorded in the area – an amazing variety that shows the richness of the environment here.

The entire length of the river has scattered settlements of Orang Asli who use the river for their daily needs. As the Endau River nears the sea, it nurtures a unique mangrove swamp ecosystem. Endau town is situated at the river mouth where the river flows into the South China Sea. As the forest had only recently been established, access to it is quite difficult and entry to the park requires a special permit from the National Park (Johor) Corporation, which only entertains requests for research and fishing limited to designated areas only.

There are two entry points to the park, Kampung Peta and Nitar. The former is located 56 km from Pahang. The visitor would have to traverse through rubber and oil palm plantations, as well as dense jungle along dirt tracks to the base camp. From Nitar, a FELDA Plantation scheme, the park can be reached after an eight hour boat ride along the Endau River. Kampung Peta is also the most remote Orang Asli (aboriginal) settlement in Johor.

1.4 Objective of The Study

1.4.1 To compare reference stream (Jasin River) with the impacted streams (Mengkibol River and Sembrong River)

1.4.2 To determine the possible sources of the fine sediment to this impacted streams.

1.5 Scope of The Study

1.5.1 This study will only cover on CWEs by land-use activities within in the Endau watershed which by evaluating the baseline streams (Jasin River) and impacted stream (Mengkibol River and Sembrong River).

1.5.2 The evaluation of this study will focus on fine sediment delivery, sources and the level of impacts it cause to the impacted stream as it indicating CWEs.

1.5.3 The factor that effects the evaluation of the study also will be discussed

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