UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF OPTIMUM VOLUME OF SAND MINING IN AN URBAN RIVER SYSTEM

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By

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Faculty : Environmental Studies

The illegal river sand mining activity has taken place in a sand-bed river system in Selangor, Malaysia for decades before legalization was initiated in 2008. The present study focuses on the determination of optimum sand extraction by considering sand during the critical period (dry season). The sand replenishment rate was used as the benchmark in determining the threshold level of the extractable rate in Langat River system, with a specific focus in relating the temporal variation and extraction frequency as the dominant influencing factors. This analysis was executed using Yang equation to predict the sediment replenishment rate. The equation suitability was developed with 43% of similarity by using the discrepancy ratio (ratio of calculated values to measured values) of sediment transport. The sample of sand from different critical locations, flow data, and other physical river parameters were used. Concentrating on sand replenishment rate during the critical period, the optimal sand mining is calculated by reducing 10% from total replenishment rate, which is then converted into Truck Loads per month (taking standard 25 tons truckload). The comparison of sand replenishment rate in high and low flow season proved that the river system has quicker capabilities in sand replenishment rate at the extraction point during the wet season compared to the latter by 83%. Therefore, the quantifiable volume of the extractable sand rate at each extraction points is proposed specifically during dry months (May to September) whereby the slower replenishment rate is critical and riskier.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENILAIAN ISIPADU OPTIMUM BAGI PERLOMBONGAN PASIR DALAM SISTEM SUNGAI

Oleh

NUR HIDAYAH HUQMAH MAHMUD

Januari 2018

Pengerusi : Nor Rohaizah binti Jamil, PhD
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Aktiviti perlombongan haram pasir sungai di sistem dasar pasir sungai sudah berdekad digiatkan di Selangor, Malaysia sebelum ianya dibenarkan pada tahun 2008. Kajian terkini memfokuskan kepada penentuan bagi pengekstrakan pasir optimum dengan mengambil kira kadar penggantian pasir semasa waktu kritikal (musim kering). Kadar penggantian pasir telah digunakan sebagai tanda aras bagi menentukan ambang tahap kadar kebolehdapatan pasir di sistem Sungai Langat, dengan fokus spesifik dalam menghubungkan variasi tempoh dan kekerapan pengekstrakan pasir sebagai faktor pengaruh dominan. Analisis yang telah dibuat menggunakan persamaan Yang untuk meramalkan kadar penggantian mendapan. Kesesuaian persamaan telah dikira sebagai 43% persamaaan dengan menggunakan kadar percanggahan (kadar dari nilai terkira kepada nilai terukur) daripada pengangkut mendapan. Sampel pasir daripada lokasi kritikal yang berlainan, data arus, dan parameter sungai yang lain turut digunakan. Dengan penumpuan keatas kadar penggantian pasir semasa tempoh kritikal, perlombongan pasir optimum akan dikira dengan mengurangkan 10% daripada jumlah kadar peggantian pasir, yang kemudiannya diubah menjadi Isi Trak setiap bulan (dengan mengambilkira dasar 25 tan isi trak). Perbandingan antara kadar penggantian pasir pada musim arus tinggi dan rendah membuktikan bahawa sistem sungai mempunyai keupayaan yang tinggi dalam kadar penggantian pasir semasa titik ekstraksi ketika musim hujan, berbanding musim kering dengan perbezaan sebanyak 83%. Dengan itu, kebolehkiraan kuantiti isipadu pasir yang boleh diekstrak di setiap titik ekstraksi adalah diusulkan, secara khususnya semasa bulan kering (Mei sehingga September) di mana kadar penggantian pasir yang perlahan adalah lebih kritikal dan berisiko.

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Declaration by graduate student

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LIST OF SYMBOL

A	Channel Area
b	Ratio between channel width
C_t	Sediment concentration
D	Dimensionless grain size
d_{50}	Median grain size
h_S	Nozzle width
kg/s	Kilogram per second
mm	Millimeter
m^3/s	Cubic meter per second
m/s	Meter per second
n	Manning's coefficient
q_s	Bedload transport rate
Q	Water discharge
R	Hydraulic radius
s	Channel slope
T	Duration of sampling in sec
T_j	Rate of bedload rate
Wb	Weight of bedload sample
W_s	Fall Velocity

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
DID	Department of Irrigation and Drainage
LUAS	Lembaga Urus Air Selangor
EIA	Environmental Impact Assessment

CHAPTER 1

INTRODUCTION

1.1 Problem statement

The contribution of sand and gravel in economy growing enables to alleviate the occurrence of over extraction subsequently give an impact towards the sedimentation process. The environmental impacts from river sand mining has been address in early studies from the developed country (Dunne and Leopold, 1978; Follman, 1980; Kondolf 1994, 1997) and followed by other studies that includes other developing countries such as Vietnam (Nguyen et al., 2015), China (Wu et al., 2007; Lu et al., 2007), India (Mattamana et al., 2013; Pitchaiah, 2013). The concern of excessive mining activity will eventually interrupt the bedload transportation in the river that would cause riverbed erosion and riverbed stability instability (Kondolf et al., 2002; Mmom et al., 2012). The studies about riverbed degradation and changing in replenishment rate towards downstream is part of the impact of the excessive or unplanned mining activity (Ariffin et al., 2002; Collins et al., 2011). Based on the fundamental of hydraulic, river flow has the ability to transport the debris as the resisting force exerted on the water (Leopold and Maddock, 1953). Alongside, the downstream of the river are based on the gravitational force act as an inducing force while the friction resistance help in degrading process of the channel (Rosgen, 1994; Kondolf et al., 2002; Ra et al. , 2012). The sediment transportation is positively influenced by the grain size (Engelud et al., 1976; Julien et al., 2003; Hafifi et al., 2015) as the movement influenced by the instable turbulence at the bed of the channel (Van Rjin, 1993; Julien and Tuzson, 2003).

In Malaysia, to meet the industrial demands the sand mining production has increased about 15% in 2015 with value approximately RM100 million (Economic Cencus, 2016). In Malaysia, sand resources mainly coming from rivers, alluvium and coastal areas. Mohamed et al., 2009 stated that Langat watershed has undergone rapid development towards urbanization and industrialization. The evaluation of replenishment rate has been stated in River Sand Mining Management Guideline (2009) by DID. Evaluate the sediment transport and replenishment rate is important in order for appropriate extraction management practices and policy interventions to be implemented by local government units within the Langat watershed. However, there is no specific study on the optimum volume of sand mining during the dry season where the replenishment rate is slower compared to the dry season.

1.2 Research questions

1. How do current in-stream sand mining activities influence the sand replenishment rate and riverbed changes?
2. What is the optimum volume of sand extraction allowed during critical period (dry season)?
3. What is the impact of unstable sediment transport towards the river stability? How this information could help in priorities the river health?

1.3 Research objectives

1. To measure the sediment transport in temporal variation determination.
2. To evaluate the optimum volume of sand extraction based on the sediment replenishment rate during critical months for sustainable extraction practices.
3. To determine the channel stability based on the river geometry approach for long-term river monitoring plan.

1.4 Scope of this study

This study focused on Langat River as this one of the biggest white sand producer in Selangor. This research will only focus on the sand transportation and physical parameter of Langat River in one water cycle from 2016 to 2017. The sand replenishment rate calculation is based on Yang (1973) equation. This based on the previous assessment by Ab. Ghani (2003) has concluded the Yang and Engelund and Hansen equations can be used to predict sediment transport rate for sand-bed rivers in Malaysia. The river stability focuses on the physical parameter changes based on river geometry proposed by Julien (1995).

1.5 Significance of Study

The purpose of this study is to carry out the impact of current practice of sand mining activities towards the river geomorphology of Langat River. As there is limited information about the sand extraction activity in Langat River and the sediment transport is the major driver of all processes in a river system, thus, the quantification of sediment transport is needed to calculate the optimum volume of sand extractions. The quantified optimum volume of sand extraction obtained from this research would benefit future river management plan of Langat River during critical period (dry season) to sustain the natural sediment replenishment cycle. Hence, this would help the related stakeholder to strategize the needed action. At the end of this research, the important to study about river hydraulic and geomorphology in order to understand the main contributor of the problem so this will leads to the important and best river management practice.

1.6 Research justification

Sand mining activity in the river must follow the River Sand Mining Management Guidelines made by Department of Irrigation and Drainage Malaysia. This to ensure the guidelines objectives is achievable which align with the practice of sustainable gravel extraction.

Besides that, it helps to maintain the river equilibrium with the principle of sediment transport principles in determining the location, period and quantity of extraction.

1.7 Thesis organization

Chapters 1 consists on the background of this study, problem statements, and the objectives of this study. Scope and significance of the study are provided a comprehensive understanding. This chapter further introduces the study about sediment transport study in Langat River and current management practice of sand mining. Besides that, this chapter discusses on the in-stream sand mining activity in Malaysia and other country.

Chapter 2 provides a broad literature reviews in related studies. The current practice and background studies have been obtained from journals and academic books.

Chapter 3 covers the methodology of the research. The procedures on primary and secondary data collection and data analysis will be discussed in depth within this chapter.

Chapter 4 encompasses the results and discussions of this study. The hydrology and hydraulic data are quantified and presented. Subsequently, results are interpreted where the recommendations of optimum sand extraction volumes are proposed in this section. The preferable channel physical parameters such as, velocity, depth and width for channel stability will be discussed based on critical period. In conjunction of that, all analyzed hydraulic data has been integrated into statistical database which also be presented in this chapter.

Chapter 5 the conclusion of this study and recommendations proposal for future research in filling the gap uncovered in this research, and how the findings in this research can help future research and management guidelines revision.

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