OPTIMAL SAND REMOVAL CAPACITY FOR IN-STREAM MINING

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OPTIMAL SAND REMOVAL CAPACITY FOR IN-STREAM MINING

by

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LIST OF SYMBOLS

Δ	Relative density of sediment in the fluid
A	Coefficients of Acker-White
b	B/n
C_f	1 for laboratory flumes and 1.268 for field channels
cm/s	Centimeter per second
C_t	Sediment concentration (by weight)
C_{pt}	Sediment concentration (in ppm by weight)
C_u	Uniformity Coefficient
C_v	Sediment concentration (by volume)
d_{50}	Mean sediment size (m)
d_{35}	Sediment particle size (m)
d_s	Diameter of sediment
F_d	Densimetric Froude number
F_{dc}	Densimetric Froude number corresponding to sediment threshold
F_{gr}	Mobility number
g	Acceleration due to gravity (m/s^2)
K	Coefficients of Acker-White
Kg/s	Kilogram per second
km^2	Kilometre square
M	Exponents of Acker-White Equation
m	Meter
m/s	Meter per second
m^3/s	Meter cubic per second

m^3/year	Meter cubic per year
mg/l	Miligram per mililiter
mg/ml	Milligram/milliliter
MHz	Megahertz
mm	Milimeter
N	Exponents of Acker-White Equation
n	Manning number
N/m^2	Newton per meter square
Ohm-m	Ohm-Meter
ppm	Part per million
Q, Q_w	Water Discharge
q_s	Sediment transport rate by weight per unit width (m^2/s)
q_t	Sediment transport rate by weight per unit width (m^2/s)
R, R_b	Hydraulic radius (m)
Re*	Shear Reynolds number = $w_s d_{50}/v$
S, S_0	Slope of river profile
T	Time of measurement
T_t	Suspended Sediment load of cross section in kg/s
u*	Shear velocity ($\sqrt{grs}$) (m/s)
V	Average velocity of river profile (m/s)
υ	Kinematic viscocity (m^2/s)
V_c	Unit stream power ((m-kg/kg)/s)
V_cS	critical unit stream power required at incipient motion ((m-kg/kg)/s)
y	Depth of river profile (m)

γ	Specific weights of water (kN/m^3)
γ_s	Specific weights of sediment (kN/m^3)
ρ, ρ_s	Density of sediment (kg/m^3)
σg	Gradation coefficients
τ	Bed shear stress (kg/m^2)
τ_0	Shear stress (kg/m^2)
Φ	Transport parameter
Φ_t	Total-load transport intensity

LIST OF ABBREVIATIONS

1D	One dimensional
2D	Two dimensional
ADCP	Acoustic Doppler Current Profiler
ASCE	American Society of Civil Engineers
BS	British Standard
DID	Department of Drainage and Irrigation Malaysia
ERT	Electrical Resistivity Tomography
GDP	Gross Domestic Product
JICA	Japan International Cooperation Agency
LCD	Liquid Crystal Display
LiDAR	Light Detection and Ranging
MPCA	Minnesota Pollution Control Agency
RMS	Root Mean Square
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey

PENGELUARAN KAPASITI PASIR SUNGAI SECARA OPTIMUM DALAM ALIRAN PERLOMBONGAN

ABSTRAK

Hakisan sungai disebabkan perlombongan pasir dan kelikir secara berlebihan berpunca daripada kurangnya pengurusan perlombongan pasir secara lestari. Biasanya, pasir dikorek keluar secara terus dari sungai tanpa panduan yang betul daripada pihak pemegang konsesi yang menyebabkan saluran sungai tidak stabil dan hakisan yang teruk di tebing-tebing sungai disebabkan perlombongan pasir tidak terkawal. Dalam kajian ini, Acoustic Doppler Current Profil (ADCP) digunakan untuk mengunjurkan profail sungai. Dengan menggunakan ADCP, keratan rentas sungai yang lebar boleh diunjurkan dengan mudah dan juga mampu menambahbaik ketepatan data dalam kajian pengangkutan endapan. Berdasarkan analisis makmal, jenis endapan yang di bawa empat sungai kajian kebanyakannya merupakan pasir dan batu kerikil halus (d_{50} = 0.8 hingga 2.0 mm). Beberapa persamaan telah digunakan untuk menentukan kesesuaian persamaan jumlah beban bahan dasar. Keputusan menunjukkan bahawa persamaan terbaik untuk empat sungai ialah persamaan Ariffin, Sinnakaudan et al. dan Molinas-Wu. Persamaan Ariffin mampu meramalkan pengangkutan endapan keempat-empat sungai dengan begitu baik sehingga 94.12% tepat untuk Sungai Perak, 71.43% untuk Sungai Kemaman, 66.67% untuk Pergau Sungai dan 75% untuk Sungai Kurau. Penentuan persamaan yang bersesuaian sangat berguna untuk rekabentuk saluran yang stabil, pembangunan lengkung kadaran endapan dan penentuan kapasiti pengorekkan pasir daripada sungai. Berdasarkan analisis beban endapan, Sungai Perak menunjukkan

beban endapan tertinggi dan ini menunjukkan Sungai Perak sesuai untuk aktiviti perlombongan pasir. Pengukuran Rintangan Elektrik (ERT) menunjukkan subpermukaan tebing sungai mengandungi lapisan pasir lebih kurang 5 hingga 15 meter kedalaman berdasarkan profail diunjurkan. Hasil daripada profail ERT, kajian mendapati dataran banjir dan pulau sungai mampu menjadi sumber alternatif untuk pasir sungai. Lengkung kadaran endapan digunakan untuk menentukan masa yang diambil untuk endapan pulih dan kapasiti pengesktrakan pasir daripada sungai. Kajian juga mendapati tempoh pengisian semula endapan untuk 2 meter pengorekan pasir ialah lebih kurang enam hari untuk pulau sungai yang kecil dan 98 hari untuk pulau sungai yang besar.

OPTIMAL SAND REMOVAL CAPACITY FOR IN-STREAM MINING

ABSTRACT

River degradation due to excessive in-stream sand and gravel mining can be attributed to lack of sustainable management. Sand is usually extracted directly from river without proper guidance from concessioners which can lead unstable river channel and excessive erosion in rivers as well as river banks due to uncontrolled extraction of sand. In this study, the Acoustic Doppler Current Profile (ADCP) was used to project river profile. By deploying the ADCP, the profiling of large river cross section could be done easily and would improve the data accuracy in sediment transport study. The characteristic in four rivers from soil laboratory analysis are mostly sand and fine gravel (d_{50} = 0.8 to 2.0 mm). Three equations namely Ariffin, Sinnakaudan et al. and Molinas-Wu were used to estimate total bed material load. Ariffin equation has given the best prediction for four rivers with to 94.12% accuracy for Sungai Perak, 71.43% for Sungai Kemaman, 66.67% for Sungai Pergau and 75% for Sungai Kurau. The determination of suitable equations would be useful for design stable channel, develop rating curve and determine sediment discharge in river. From analysis, Sungai Perak was found to yield the highest sediment load indicating its suitability for sand mining actvities. Electrical Resistivity Survey (ERT) shows that riverbank subsurface consist of sand between 5 to 15 meter depth based on projected profile. This implies that both floodplain and river islands can be alternative sand mining sources. The sediment rating curve is used to estimate the sediment recovery period and capacity of sand extraction from river. This study

infers that the sediment recovery period for two (2) meters extraction is about six (6) days for a small river island and 98 days for a large river island.

CHAPTER ONE

INTRODUCTION

1.1 Overview

The extensive use of sand in construction and the huge demand of sand in the construction industries have resulted in the river environmental degradation. Sand is widely used as aggregate in concrete and road construction (Kondolf, 1997). According to Sreebha (2008), sand are sedimentary materials, finer than a granule and coarser than silt, with grains between 0.06 and 2.0 millimetre (mm) in diameter in geology term. They are loose and non-cohesive granular material with minor impurities of feldspar, mica and iron oxides.

Demand for sand is huge, especially in urban areas and new townships undergoing rapid development. This is in response to Gross Domestic Product (GDP) from the construction industries in Malaysia averaged RM 9349.48 million from 2010 until 2016 (Trading Economics, 2016). The increases in sand demand have caused serious implications such as illegal and improper sand mining operation. The unregulated mining activities have resulted in massive damages to the river bed and banks.

The *Final Report of Comprehensive Management Plan for Sungai Muda Basin* by Japan International Cooperation Agency (1995) reported huge sand mining operation activities along Sungai Muda. There activities have led to serious erosion and sedimentation along the river which is the main cause of flooding in that area (Ab. Ghani et al., 2010).

This study seeks to establish the sustainable sand removal capacity to reduce river bed degradation and channel instability. This requires the estimation of sediment transport along the selected rivers and cross-section profiling to estimate safe volume of sand that could be removed with minimal impacts (Ponce, 2014).

1.2 Problem Statement

Sand mining can be defined as the temporary or permanent lowering of the productive capacity of land (Saviour and Stalin, 2010). In-stream sand mining can cause many negative impacts toward the river system. The sand mining can cause river bank erosion, high turbidity, lowered the water level, and instability of river structures. However, in-stream sand mining also gives positive impacts such as maintaining river roughness and improves the hydraulic performance of river by deepening the river.

In developing country, the in-stream sand mining usually is done by small scale companies. The small scale company commonly lacks of technologies and effective management, which subsequently leads to inability to control the sand extraction activities. Additionally, the permission of grant or permit to extract in-stream sand mining in developing country is less formal or even non-existent which can cause problem to control sand mining operation (Scott and Harrison, 2008).

Sometimes, the licensed company also is not following the right practices such as exceeding the legal mining limits and resort to illegal practices to the point of threatening river (Bravard and Goichot, 2013; Nguyen, 2011) plus the involvement of local criminal gangs, official corruption and lack of enforcement were the main difficulties for the ban on illegal sand mining (Bravard and Goichot, 2013). Due to these reasons, sand mining cannot be managed properly by government even after implementing the procedure or guideline.

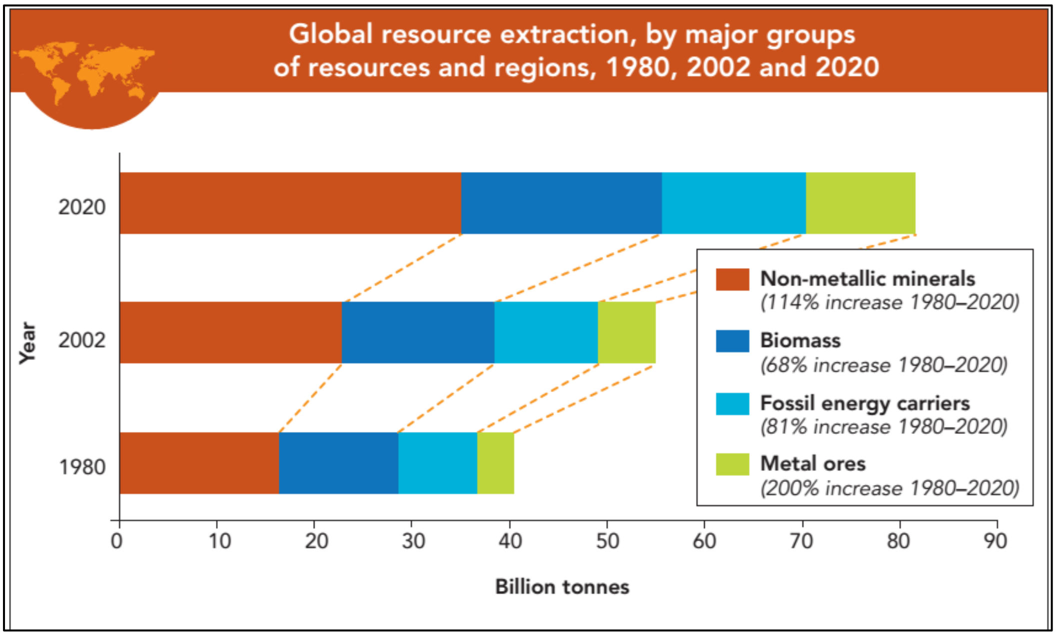

Figure 1.1: The predicted global demand of production of natural resources on 2020 (United Nation, 2010).

The other reason why sand mining cannot be managed properly is because the demand of sand is become higher from year to year. Figure 1.1 shows the predicted global demand of production of natural resources on 2020. Industry or construction materials which are included sand usage is categorised as non-metallic minerals. Based on Figure 1.1, the demand of non-metallic minerals are increasing