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Original Research Article

Erosion risk assessment: A case study of the Langat River bank in Malaysia☆

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ABSTRACT

River bank erosion is one of the major and unpredictable hazards worldwide including in Malaysia. Soil detachment at river banks is due to two processes: 1) hydraulic erosion imposed by channel flow and 2) sub aerial erosion due to the weakening and weathering of bank materials. This paper is focused on the second aspect of the erosion process which mainly depends on the combination of rainfall intensity and the ability of the soil to withstand the raindrop effects. The relative combination of sand, silt and clay in a soil is argued to have an impact on erosion resistance. In cohesive soil composition, sand forms the largest size ranging from 0.05 to 2 mm whereas silt is adequately moderate (ranging from 0.002 to 0.05 mm) and clay is the smallest of all three (less than 0.002 mm). With the knowledge that soil composition does indeed have an effect on erosion resistance, this paper will attempt to relate risk assessment index of river bank erosion specifically to soil composition. Thus, the objectives of this document are as follows; 1) to produce risk assessment index for river bank erosion and 2) to carry out a case study for selected rivers in Malaysia pertaining to river bank assessment. The index is produced by inferring the previously developed scale on soil erodibility. Past researchers created the "ROM" scale (named after the researchers, Rolan and Mazidah) to assess degree of soil erodibility into five classes namely "critical", "very high", "high", "medium" and "low". Instead of using semi empirical formula from the "ROM" scale, a percentage of soil composition was inferred to produce risk assessment index. It was found that as the percentage of clay decreased, susceptibility index became higher and approached a critical level. Application of the newly developed index is verified by conducting a case study at the Langat River, Kajang, Malaysia. The soil composition was classified and form fitted into the index. It was found that the middle reach of the Langat river is susceptible to severe erosion due to low percentage of clay. This finding agreed well with the visual observation of these reaches as a large portion of gully type of erosion had been observed throughout the study. The establishment of risk assessment index which firmly indicates the relationship between soil composition and river bank erosion can be used as a tool in forecasting the risk levels. This formulation is well proven to assess river bank conditions and the associated critical shear stress is very much close with the previously published shear stress.

1. Introduction

Over the past decade, there has been a dramatic increase of causes related to soil erosion. Soil erosion, is a natural process that continuously occurs without any symptoms or warning signs, and has been identified as a serious issue for decades. It is predicted to become even more critical in the future as a result of uncontrolled development. Julien (2012) hypothesized that the natural processes of erosion and sedimentation have been active throughout geological time and have shaped the present landscape of our world. River bank erosion would cause the riverbed to degrade and dump particles and sediments into receiving water body. The bedform particles, along with river bank particles, would be detached from their interlocking due to the action of water flow. The transportable particles would the start to move and deposit at the downstream part of a river section (see Fig. 1). This process would cause severe engineering and environmental problems if monitoring programs are not well-managed and practiced.

Based on past researches, two major agents of erosion were found; wind and water (Musa, Abdulwaheed, & Saidu, 2010). Water is perceived in many parts of the world as the most common agent of soil erosion. The influence of water as an agent includes the degradation of river basin, landform and seashore. Water erodes soil and

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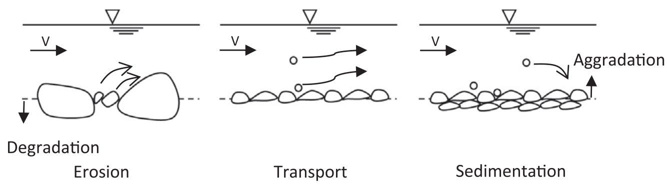

Fig. 1. The sequential process of erosion, transport and sedimentation.

Table 1
The "ROM" Scale (Zainal Abidin & Mukri, 2002).

'ROM' scale	Soil erodibility category
< 1.5	Low
1.5–4.0	Moderate
4.0–8.0	High
8.0–12.0	Very high
> 12.0	Critical

transports soil particles from higher altitudes and deposits them in low lying areas. Water has been identified as a major cause of soil erosion problems, compared to wind (Singer & Munns, 1999).

Malaysia, due to its tropical rainforest climate relatively has a hot and humid condition throughout the year and thus is identified to be prone to soil erosion. An average annual rainfall exceeding 2000 mm in Malaysia is above the global average. The highest annual rainfall ever recorded in the history of Malaysia was 5293 mm (NAHRIM, 2008). Heavy rainfalls can have adverse effects on soil particles because it heightens the ability of raindrops to detach particles. This phenomenon, also known as rainfall erositivity, greatly depends on rainfall intensity, kinetic energy and seasonal distribution of the rain as an impetus (Caracciola et al., 2012). Rainfalls with high intensities and low frequencies produces more erosion compared to rainfalls with high frequencies and low intensities (Wei et al., 2007). The amount of soil erosion loss depends upon the combination of the strength of the rain to cause erosion and the ability of the soil to withstand the rain.

Table 2
Percentage of occupy for clay, silt and sand.

'ROM' scale	Soil erodibility category	% Clay	% Silt	% Sand
0.5	Low	50	30	20
3	Moderate	14	60	24
5.75	High	8	30	62
9.5	Very high	5	25	70
49.5	Critical	1	26	73

Soil resistance against erosion is termed as soil erodibility and its value greatly depends on several factors such as soil structure, infiltration levels and organic matter content. River bank erosions could lead to the accumulation of sediment which in turn increases river pollution problems. The capacity of sediments flushing depends on the rate of the river flow. The initiation of sediment movement is highly anticipated by the action of velocity, bedform conditions and kinetic energies at the river bed (Yang, 2006). If the shear stress imposed by the flow exceeds the particle shear stress, then the particles start to move (Sulaiman, Sinnakaudan, & Shukor, 2013). More particles are transported if the imposed shear by the flow action exceeds the particle shear stress. However, the imposed shear by the action water flow starts to decrease at the downstream portion of river network due to a tranquil flow (Cengal & Cimbala, 2006). This phenomenon could lead to deposition or sedimentation at the downstream part of the river network. In Malaysia, the average suspended sediment concentration in the rivers due to soil erosion rose by 34% in 1998 (Mastura, Al-Toum, & Jaafar, 2003). During rainfall, sediments and eroded soil are flushed out to downstream where sedimentation takes place, hence resulting in the downstream becoming shallower and waters to be milky. This situation leads to water scarcity, flash floods and other environmental problems. It is important to acknowledge that soil detachment and subsequent entrainment at river bank section originates from two main processes; hydraulic erosion and subaerial erosion. Julian and Torres (2006) provided an in-depth

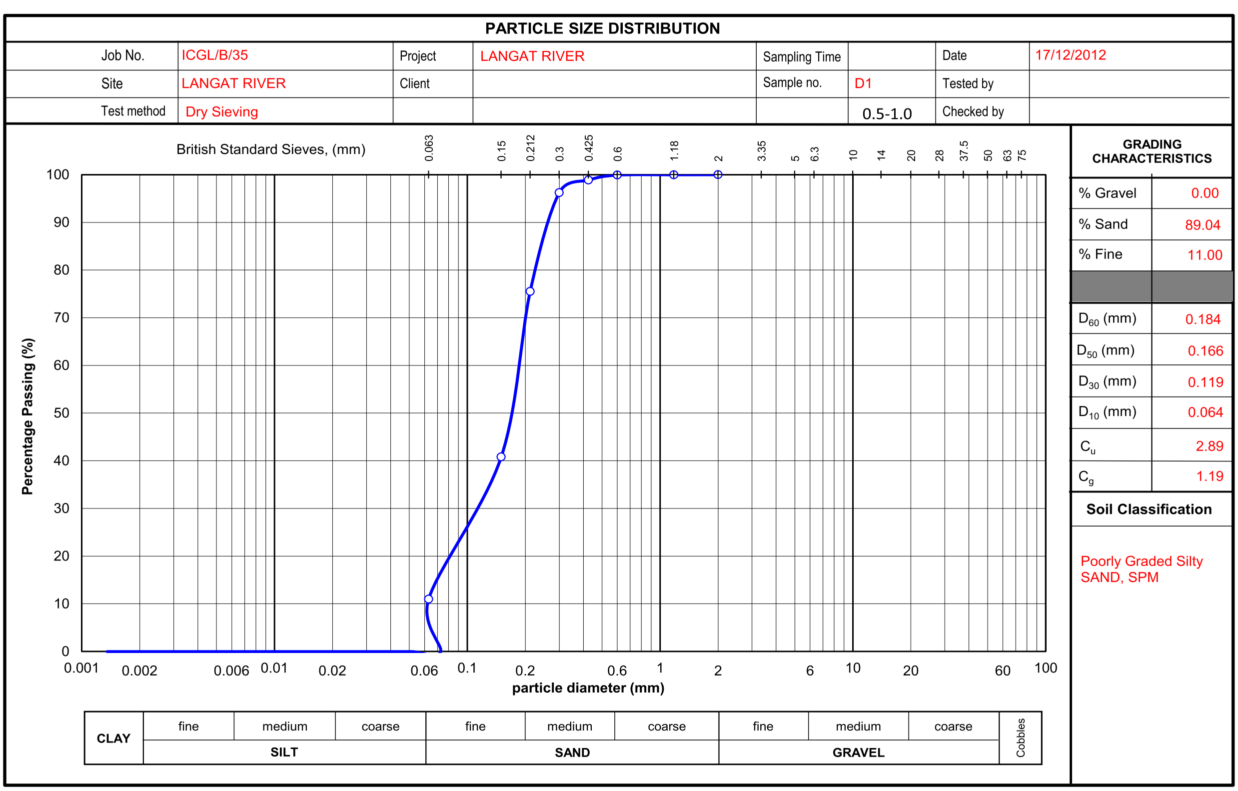

Fig. 2. Grain size distribution.