SEDIMENT TRANSPORT ANALYSIS OF TELUK KEPAYANG USING HEC-RAS

BY

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ABSTRAK

Acoustic Doppler Current Profiler (ADCP) telah digunakan dalam kajian ini bagi mendapatkan keratan rentas di dasar sungai serta lebar sungai yang dikaji.Sungai di kebanyakkan negara tropika mudah untuk mendapatkan pasir dan kerikil, serta tidak memerlukan banyak proses daripada penggredan saiz. Pasir adalah bahan utama yang digunakan dalam industry pembinaan dan permintaan semakin meningkat disebabkan oleh pembangunan yang semakin pesat. Walaubagaimanapun pasir, kerikil dan bahan lain yang diekstrak tidak boleh melebihi kadar yang dihasilkan semula jadi. Penyingkiran pasir yang berlebihan dapat merosakkan keseimbangan semula jadi saluran sungai. Objektif yang utama dalam kajian ini adalah mensimulasikan Teluk Kepayang Sungai Perak sepanjang 2.6 kilometer menggunakan HEC-RAS untuk mendapatkan graf keratan rentas yang menunjukkan berlakunya pengangkutan sedimen. HEC-RAS 1D sediment transport telah digunaka dalam kajian ini untuk mengkaji empat line yang telah dipilih. Empat line yang dilabelkan sebagai Line 4 iaitu di bahagian hulu sungai, Line 3, Line 2 dan Line 1 yang terletak dihilir sungai di Kawasan Teluk Kepayang. Perbezaan purata bagi ketinggian hakisan sedimen disebabkan berlakunya pengangkutan sedimen di dasar sungai di Teluk Kepayang adalah 1.1827 pada Line 4, 0.8781 bagi Line 3, 1.1159 bagi Line 2 dan 1.0167 bagi Line 1. Sebanyak 15% penurunan paras air apabila simulasi HEC-RAS dilakukan dari hulu ke hilir sungai. Perisian HEC-RAS telah digunakan untuk membantu menganalisis aliran saluran sungai yang dapat mensimulasikan sungai oleh penyelidik di seluruh dunia.

ABSTRACT

In this investigation, an Acoustic Doppler Current Profiler, or ADCP, was utilised in order to acquire both the cross section at the river's bottom and the width of the river that was being investigated. Sand and gravel can be obtained from rivers in the vast majority of tropical countries with little effort and little need for processing based on size grading. Sand is the primary material that is utilised in the building and construction sector, and demand is growing as a result of the industry's rapid development. However, the amount of sand, gravel, and other materials that are extracted shouldn't go above and beyond what can be produced naturally. An unsustainable amount of sand removal can throw off the natural equilibrium of river channels. The main objective in this study is to simulate the 2.6 kilometer Teluk Kepayang Sungai Perak using HEC-RAS to obtain cross-sectional graphs that show sediment transport events. In this study, HEC-RAS 1D sediment transport was utilised to study the four different lines that were chosen. Line 4, which is located in the upstream portion of the river, Line 3, Line 2, and Line 1 are all located downstream in the area of Teluk Kepayang. The lines are labelled with their respective locations. At the bottom of the river in Teluk Kepayang, the difference in height caused by sediment erosion as a result of sediment transport is, on average, 1.1827 metres along Line 4, 0.8781 metres along Line 3, 1.1159 metres along Line 2, and 1.0167 metres along Line 1. The water level drops by fifteen percent as the HEC-RAS simulation is run in the opposite direction, from upstream to downstream. In addition, HEC-RAS findings determined that the river was eroding from upstream to downstream, based on simulations of four different lines. Researchers from all over the world have made use of the HEC-RAS software in order to assist them in analysing river channel flows that can simulate rivers.

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LIST OF ABBREVIATIONS

HEC-RAS	**H**ydraulic **E**ngineering **C**enter’s **R**iver **A**nalysis **S**ystem
TNB	**T**enaga **N**asional **B**erhad
ACDP	**A**coustic **D**oppler **C**urrent **P**rofiler
MCO	**M**ovement **C**ontrol **O**rder
CMCO	**C**onditional **M**ovement **C**ontrol
COVID-19	**C**oronavirus **D**isease 2019

NOMENCLATURES

D_*	Particle parameter
K	Coefficients of Acker-White
A	Coefficients of Acker-White
N	Exponents
M	Exponents
F_{gr}	Mobility number
u*	Shear velocity √(grs) (m/s)
d35	Sediment particle size (m)
v	Kinematic viscocity (m^2/s)
q_t	Volume of total sediment load per unit time and width (m^2/s)
C_t	Sediment concentration (by weight)
q_t	Sediment transport rate by weight per unit width (m^2/s)
F_d	Desimetric Froude number
V	Average velocity of river profile (m/s)
W_s	Fall velocity of sediment (m/s)
g	Accelaration due to gravity (m/s^2)
t	Bed shear stress (kg/m^2)
ρ	Density of sediment (kg/m^3)

C_{pt}	Sediment concentration (ppm by weight)
h	Average depth of river profile (m)
d_{50}	Mean diameter of sediment (m)
Q	Flow discharge (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)
u	Kinematic viscocity (m^2/s)

CHAPTER 1

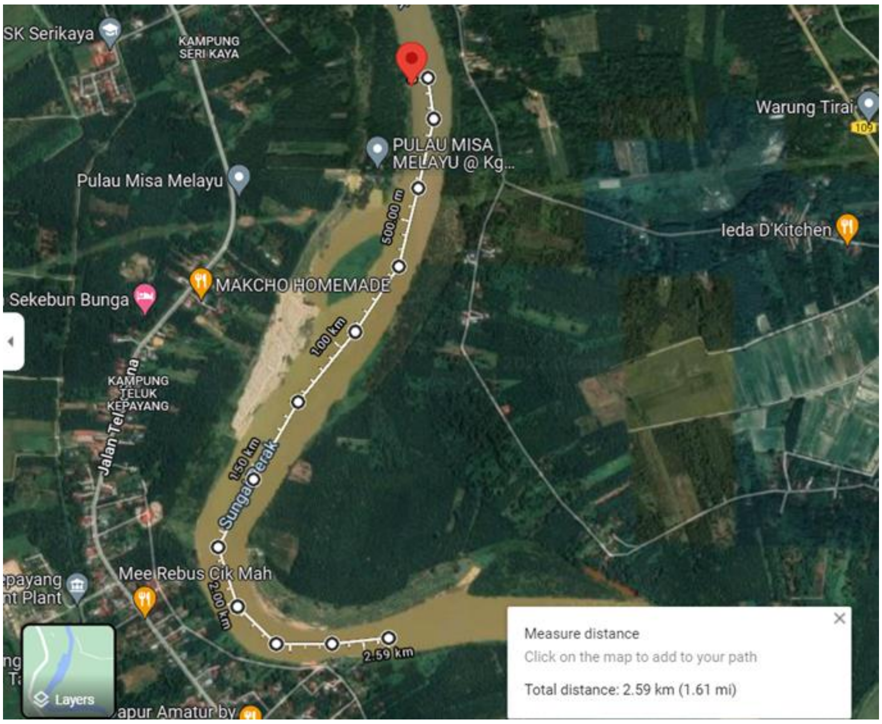
INTRODUCTION

1.1 Introduction

Sungai Perak is the second largest river in Peninsular Malaysia with a catchment area of about 14,908 km flowing from the upper Titiwangsa and Bintang mountain ranges. Sungai Perak is 93km long across Daerah Perak Tengah, Perak Darul Ridzuan. In this district, there are eight JPS pumphouses and three Water Treatment Plants along the Perak River. However, because the water level has dropped dramatically over the years, each outlet of these facilities can no longer perform its role. Moreover, the flow of Sungai Perak is also contributed by the TNB Chenderoh dam and the discharge of Sungai Pelus in the Kuala Kangsar District. Sand mining activities in Malaysian rivers have caused a number of challenges that require an immediate response. Furthermore, along the Perak River in the Perak Tengah District, there are 13 sand mining companies that are still actively operating. However, mining of sand resources from river areas especially in Perak is a common practice and can lead to the destruction of public assets as well as effect or increase pressure on commercial and non-commercial living resources that utilize these areas (Ismail et al., 2019)

Figure 1.1 shows the active sand mining activities operating in the Perak River. The New Straits Times,(2017) reported that there are almost 10 sand mining stations operating from Kampung Senin to Teluk Kepayang in Bota along 10 km with several stations located close to each other. In addition, sand mountains can be seen from afar on the banks of the river extracted from the bottom of the Perak River. The study area is Teluk Kepayang, which is located in the Central Perak District. Teluk Kepayang, Sungai Perak is located at latitude 4º19’52.89”, longitude 100º53’21.89”, and terminates at latitude 4º31’41.64”, longitude 100º88’87.16”.

Figure 1.1 Sand mining along Sungai Perak (New Straits Time online, 2017)



Measure distance

Click on the map to add to your path

Total distance: 2.59 km (1.61 mi)

Figure 1.2 Area of Study In Sungai Bertam, Cameron Highland (Google maps)

1.2 Problem Statement

In recent years, rapid urbanisation has raised the need for river sand as a construction resource. This has resulted in a mushrooming of river sand mining activities, which has spawned numerous concerns requiring immediate response from the government (Ashraf et al., 2010). The rate at which sand, gravel, and other materials are extracted exceeds the rate at which these materials are produced naturally, causing environmental difficulties. Significant damage to the natural balance of river channels can be caused by excessive sand removal. The amount of extraction in relation to the supply and access of base load sediment generally determines the size of the impact. Sand and gravel in large quantities may be extracted easily and affordably from several rivers, streams, and flood plains in Perak for several uses (Ismail et al., 2019).

Sand is a valuable resource in the construction industry and the demand for extensive construction material is due to the increasing urbanization process. Several sand mines on the river have been operating to supply construction material demands. These activities produce many impacts on the environment and morphology of the river (Kim et al., 2020). The river system may be negatively impacted by in-stream sand mining for a variety of reasons, including river bank erosion, increased turbidity, falling water levels, and unstable river structure. The mining of sand resources from rivers areas especially in Perak state is a common practice and may lead to the destruction of public assets as well as impacts or increased stress on commercial and non-commercial living resources that utilize these areas (Azlan, 2016).

The voids generated by mining (the pits and incised channels) hold silt delivered into the reach from upstream, reducing sediment loads downstream of the pit and thereby generating flow incision. The river's bed shifts as a result of this matter

(Kondolf et al., 2018). It is the only way to estimate the river's normal reaction to natural changes or activities resulting from project execution, course modification and protection, and wall stabilization (Nohani, 2018).

1.3 Objective of Study

The main objective in this study area is as follows;

(a) To obtain cross-sectional graph using HEC-RAS for sediment transport at Teluk Kepayang, Sungai Perak.
(b) To identify the potential erosion and deposition location of study cross section at Teluk Kepayang, Sungai Perak.

1.4 Importance of Study

Acquire knowledge about the soil erosion that takes place as a result of sand mining in the region of Teluk Kepayang, and gain an understanding of the flow profile of the river and how the changes take place in the morphology of the river.

1.5 Scope of Work and Limitation

The scope of work for this study is to focus on the initial assessment of sediment transport in the Teluk Kepayang area. It was carried out based on field research done during the study period. There are several limitations that present in the study to be conducted.

I. Limited to 2.6 km stretch of Teluk Kepayang, Sungai Perak.
II. Three types of sediment transport equations, including Yang (1973), Acker-White (1990), and Sinnakaudan et al., are presented (2006)

1.6 Dissertation Outline

The research project consists of five chapters and divided into the following:

Chapter 1: The first chapter gives a general introduction and a sample of the layout of the research

Chapter 2: The second chapter is a review of the relevant literature, and it focuses on the impacts of sand mining, as well as the morphology of rivers and sediment transport in rivers. Coverage of a case study of sediment transport in Malaysia can also be found in this chapter.

Chapter 3: Chapter three explains the methodology which covers the data collection and the process in order to get output results.

Chapter 4: Chapter four which is the biggest chapter in this research shows the result of four lines of the cross-section of the river and analysis of the sediment transport of the river.

Chapter 5: Chapter five is the last chapter. It includes the conclusions and recommendations of the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Aggregate materials such as sand and gravel are the most important materials for the construction of buildings and roads. The rapid population growth and development contributed to the increasing demand for aggregate materials which are widely used as the main source of building materials. In most tropical countries are easy to obtain sand, gravel and sediment from river sources, as well as not requiring much process than size grading. This is in contrast to subtropical countries that still rely on river resources such as deep sediments, floodplains, and terraces to meet the needs of aggregate, especially fine aggregate sand that is widely used in construction works. In Malaysia, sand mining is the main source to obtain sand to meet the needs of aggregate sand. Due to that, river sand mining is common in Malaysia, where many sand mining locations are in river areas.

The ecological and socioeconomic environment of the region may sustain damage that cannot be repaired and cannot be reversed if the mining of sand continues unabatedly and without discrimination for an extended period of time. As a result of the ban that was placed on traditional sources of supply, the price of sand has multiplied by several orders of magnitude. Uncontrolled and unsupervised sand mining has led to the exploitation of sand from fragile and remote places causing more damage to road infrastructure as a result of heavy load trucks carried on poor rural roads. (Teo et al., 2017)

2.2 Impacts of Sand Mining

Sand and gravel extraction is a global industry that takes place in both developed and developing countries. Industrial sand and gravel are manufactured, processed, and used all over the world in construction and industry. Mining companies, in collaboration with resource authorities, must work diligently to ensure that extraction is carried out ethically. Grading, drainage, and access roads are all examples of improvements that can be made to a parcel of land during development. For the construction of strong structures, pit sand is mixed with cement to make concrete, mortar, and plaster. Road bases and covers, concrete products, and coastline protection all employ aggregate (Madyise., 2013). Sand and gravel have been mined for road and cement aggregate for ages all over the world.

Natural aggregate mining, such as sand mining, is the primary source of construction aggregates used all over the world. However, sand mining operations whether small or large scale disturb the environment. As a result, mining and environmental protection cannot coexist because the two variables are not mutually exclusive. The road network system has improved as a result of sand and gravel mining. This improves the quality of the driveway as it transitions from gravel to tar. Sand is also used to improve the stormwater drainage system on the roadside, which transports water away during the rainy season when mixed with concrete. Sand mining, on the other hand, generates a slew of issues, including noise, dust, truck traffic, pollution, and unsightly landscapes (Mngeni et al., 2016).

Madyise, (2013) explained about the mechanical removal of gravel and sand from an active channel is known as in-stream mining. Channel incision is caused by in-stream mining methods such as pit excavation and bar skimming, which induce river bottom degradation. As a result, the process is known as head cutting or hungry water.

On an active channel, head-cutting extraction lowers the stream bed to produce a nick point, steepening the channel slope and increasing energy flow. Figure 2.3 shows the progression of the camouflage point during more hole excavation, which becomes the location of base erosion as it moves upstream, as indicated by A. B depicts the continuation of river sand mining, which lowers the river bed, resulting in bank erosion, bed degradation, high water flow, and excavation.

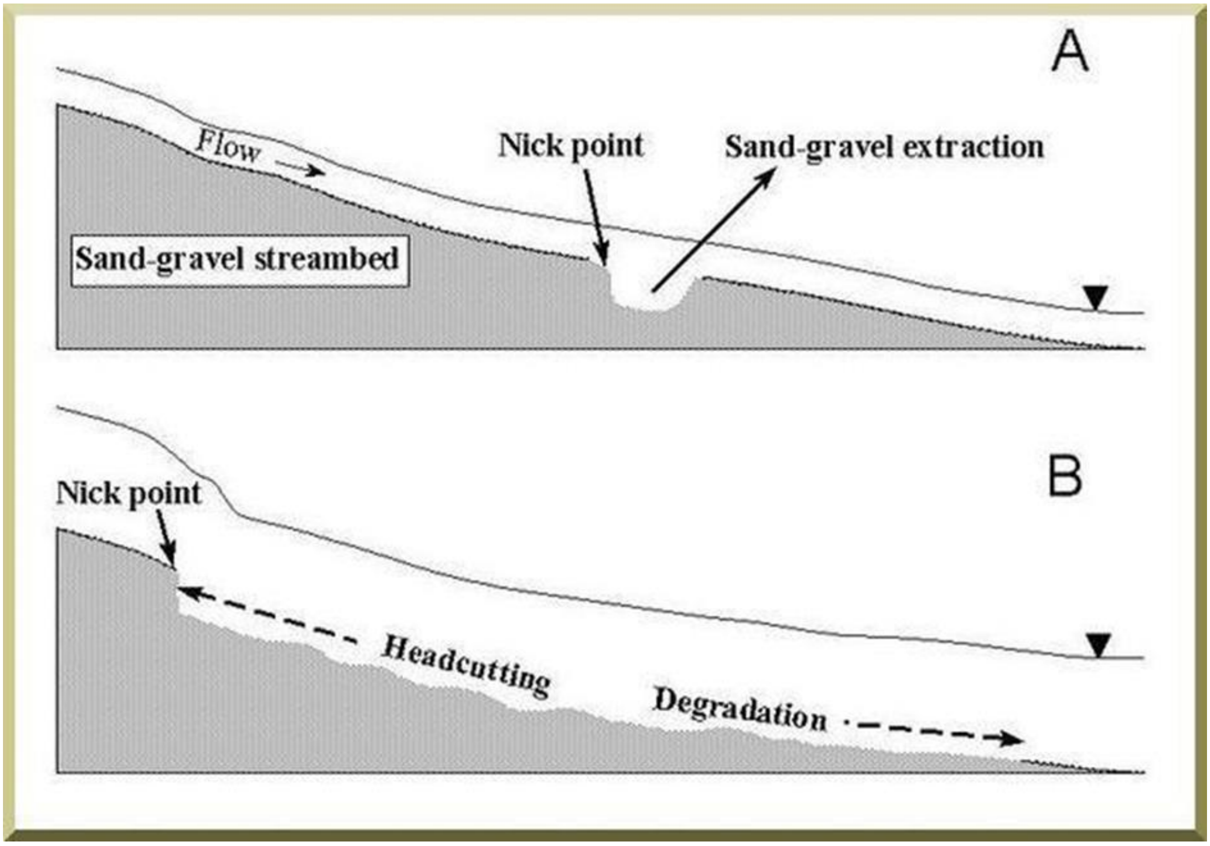


Figure 2.1 Nick point formation by Kondolf (Madyise, 2013)

2.3 River Morphology

River morphology refers to the field of science that deals with changes in river plan shape and cross-sectional shape as a result of sedimentation and soil erosion. A key element in river morphology is river flow dynamics and transport. The morphology of a river is essentially determined by the valley topography and characteristics of river basins such as geology, soil, and mechanical properties. The shape and pattern of rivers are also the results of a long history of climate change, tectonic activity, land use, and human intervention (Ghimire., 2020).

Appledorn et al., (2019) investigated river morphology and its relationship to catchment physical conditions, resulting in a holistic understanding of river geomorphology and hydrology, lowland highlands, and observed intertwining in terms of channel morphology, flooding, channel stability, and river ecology. As a result, studying fluvial systems at both the basin and reach scales will aid in understanding river dynamics and developing countermeasures to concerns such as soil conservation and water catchment management, flooding, erosion banks, and channel avulsion.

Rivers and channels have been classified and named using a variety of classification and naming schemes, including single channel and multiple channel networks as shown in Figure 2.2 (Li et al., 20022). Two common classifications for river plan shapes are presented by Brice (1983) and Fuller (2007). As shown in Figure 2.3, Brice divides river plan shapes into winding caniforms, winding point bars, winding braids, and non-inverted braid types, whereas Fuller divides river plan shapes into degrees of sine, braid, and anabranching, as shown in Figure 2.4 (Leng et al., 2016).

Figure 2.3 shows four river plan classifications developed by Brice. Classication for (a) Nonsinuous braided; (b) sinuous braided; (c) sinuous point bar, and (d) sinuous braided canaliform. Figure 2.4 shows 3(three) river planform classifications based on the degrees of sinuosity, braiding, and anabranching. Classification for (a) is the different degrees of sinuosity, the degree of sinuosity of river planform 2 is higher than that of river planform 1. For (b) is the different degrees of braiding, the degree of braiding of river planform 2 is higher than that of river planform 1, and (c) is the different degrees of anabranching, the degree of anabranching of river planform 2 is higher than that of river planform 1.

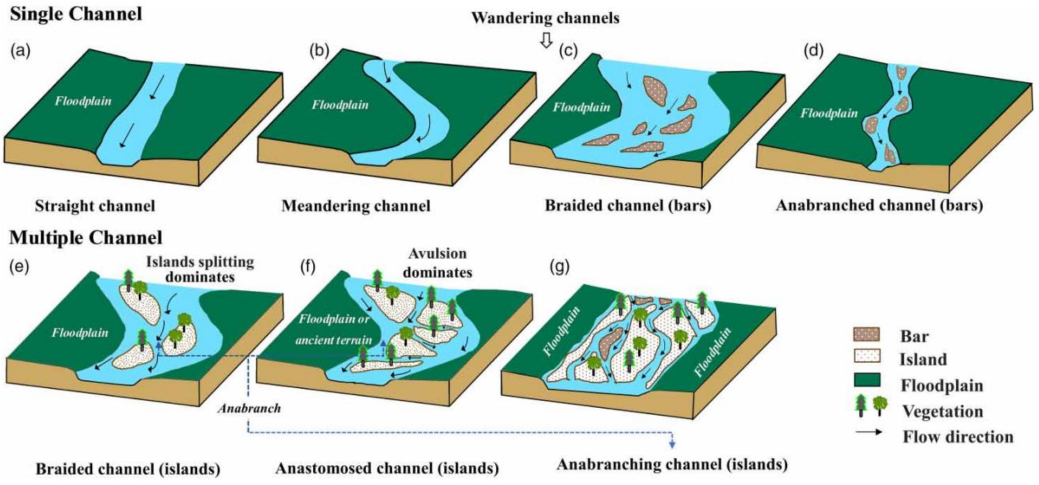


Figure 2.2 Schematic diagram of river classification. (Leng et al., 2016)

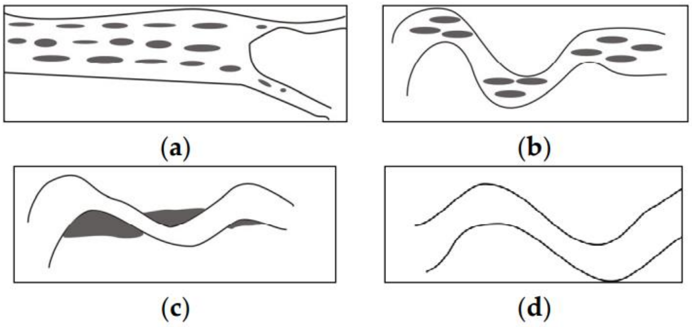


Figure 2.3 River classification developed by Brice (Leng et al., 2016)

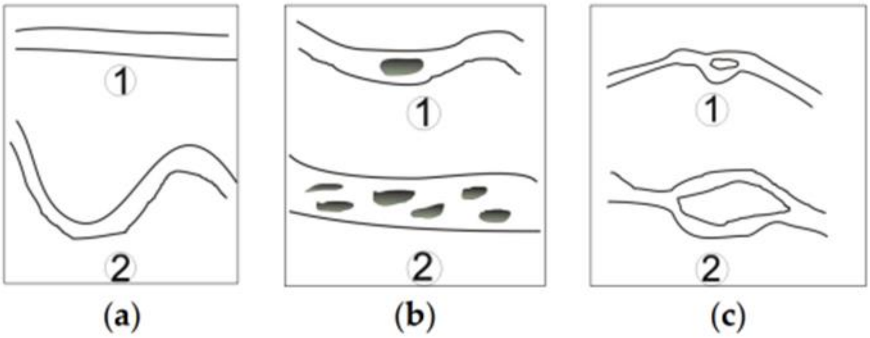


Figure 2.4 River planform classification based on the degrees of sinuosity, braiding and anabranching by Fuller (Leng et al., 2016)

2.4 Sediment Transport

Sediment transport is a key geology component that is linked to the mechanics of sediment load generation, transport, and sedimentation. It is frequently linked to the impacts of flowing fluids (air or water) on cohesive or non-cohesive sediments, as well as the flux from particle source to sink. Sediments are a crucial contact between humans and the environment since they cover the majority of the earth's surface and their long-term movements affect the landscape. Human activities such as sediment mining in rivers have resulted in bed erosion, destabilization of dykes and bridges, rapid colonization of river beds by woody plants, a reduction in habitat variety, and an increase in flooding risk. (Claude et al., 2012).

According to Walling, (2009), sediment redistribution and erosion are fundamental drivers of landscape formation and play a crucial role in soil development. Similarly, a river's sediment load is an important indicator of its morphodynamics, the hydrology of its drainage basin, and the erosion and sediment delivery processes at work in the basin. The amount of sediment carried by rivers has a significant impact on system performance, such as on material flow, geochemical cycles, water quality,