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Impact of the Proposed Oil Refinery to Sediment Yield in River Mati and Tok Kassim, Kedah Malaysia

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Abstract. This article discusses the information on potential hydrological impact of earth works (cutting and filling) within the propose gas processing plant on the nearest rivers, namely River Mati and Tok Kassim, Kedah Malaysia. The procedure for the cutting and filling involving the cutting down 62 m.s.l of terrains to 60m.s.l in elevation and filling in the adjacent valley. The valley is part of the River Mati drainage system which release surface runoff from the upper sites before meets River Temin around the swamp areas. The results for both rivers indicate that Total Suspended Solid (TSS) in the water samples ranged from 4 mg/l (WQ 3) to 43.66 mg/l (WQ 1). This indicates that both rivers received low input of solids. When compared to INWQS for Malaysia, TSS for River Mati and River Tok Kassim are fall into Class I and Class II. Total TSS measured from River Mati and River Tok Kassim is 42.4 mg/l and 51.2 mg/l, respectively. Meanwhile, the suspended sediment yield was also calculated as part of the total erosion production within the catchment. Highest TSS yield was recorded in River Tok Kassim (41.3 ton/km2/yr) compared with River Mati (16.2 ton/km2/yr). Without mitigating measures, this study predicted that cutting and filling activities will causing permanently lost on rills system and may cause adverse impacts on the water quality of the receiving waters due to silt laden runoff.

Keywords: Gas Processing Plant, Cutting and Filling, Total Suspended Solid, Sediment Yield.

1. Introduction

The demand for refined petroleum products has been growing in Malaysia and the world over. World demand for oil is set to increase by 37% in 2030 from the current level where demand growth is expected to be highest in the developing world [1]. Demand will hit 118 million barrels per day (bpd) from today's existing 86 million barrels, driven in large part by the transportation sector. Thriving economies such as China and India are quickly becoming large oil consumers. China has seen oil consumption growth by 8% yearly since 2002, indicating a doubling rate in less than 10 years. It currently imports roughly half its oil, with predictions of swift continued growth in coming years. India's oil imports are expected to more than triple to some 5 million barrels a day by 2020. The oil refinery development in Kedah is considered a high impact project because of its multi-billion value of investment. Local businesses in services, materials and manpower providers are expected to benefit greatly. The oil refinery also is expected to attract other petroleum related businesses i.e LPG bottling, lube blending and distribution in the area [2]. Petroleum coke in excess of 2000 tpd will be produced as by-product however it can become the source of fuel for a power plant. Petroleum coke also can be supplied to other industries i.e cement, steel mills, electrodes, etc. The positioning of the refinery in northern Peninsular Malaysia closed to the Malaysia-Thailand border offers the opportunity via pipeline to export finished products to East and also transfer crude between Indian Ocean and South China Sea. It removes the need for import and export vessels to traverse the congested and hazardous Straits of Malacca.

The project proponent suggests an area at Kota Perdana in Kedah, Malaysia as the proposed location for the oil refinery which require massive earthwork mainly cutting and filling activities. Therefore, this article discusses possibility an increase sediment yields within the adjacent tributaries, namely River Mati and River Tok Kassim. The results can be used to predict the volume of sedimentation flowing into the river and later to mitigate the impacts.

2. Study Area and Methodology

The main river of River Mati and River Tok Kassim flow from northern part at elevation about 170m. It flows approximately 8.2 km towards south to River Temin. Detailed morphometry of River Mati is obtained from Topographical Map Sheet 3369. The results are tabulated in Table 2. The drainage density (D) was calculated using the Strahler's method texture classification while the bifurcation ratio was calculated as the ratio of the number of streams of one order to the number of streams of the next highest order (n + 1) [3], [4].

Table 1: Morphometry of Mati River

Characteristics	Symbol	Value
Catchment area (km^2)	*CA*	17.1
Total stream length (km)	*Ct*	18.35
Length of main channel	*Lmc*	8.23
(km)	*SCA*	2
Stream order	*So*	1.35 (low)
Average bifurcation ratio	*Br*	1.07 (low)
Drainage density	*D*	1.07
Overland slopes (^{o})	-	17.32
Manning Roughness	-	0.0010
River morphology	-	Straight, small meander
Flooding		Moderate risk as stated by *So*

Geologically, the northern and north western part of Kedah adjacent to the international boundary with Thailand is underlain by two geological rock formations [5]. This basin is composed of semi-consolidated clays, sands and gravels, together with some thin coal seams. To the south of the Bukit Arang Beds, a sequence of shales, siltstones and quartzites is found. This sequence is referred to as the Kubang Pasu Formation, and is the major rock formation of this region.

Six sediment samplings were collected from the sites on 26 July 2010. The Global Positioning System (GPS) was used to determine the actual coordinates of sampling stations. Total suspended sediment (TSS) of water then was collected from each station; the concentration level measured using standard laboratory methods (APHA 1998). Surface water samples were collected about 5 to 10 cm below the water surface using a 500 ml HDPE bottle. As for the *in situ* measurements, the TSS measured including the velocity of stream flow (v); measured using flow meter, river width (w) and river depth (d); measured using staff gauge and measuring tape. These values will be used in formula to calculate exact stream flow value, shown as followed;

$$v = (v_{0.2d} \text{ x } v_{0.8d})/2 \text{ or } v_{0.6d}$$

The flow (Q) value can be calculated from the average velocity (v) and area of river's cross section (A) using following formula;

$A = dw\ (m^2)$ or $A = \frac{1}{2}dw\ (m^2)$
$Q = vA$. Or $Q = \frac{1}{2}vA$
$Q = m^3/sec$

To measure the TSS parameter, Gravimetric method was used to measure the values in mg/L unit, which later, being converted into kg/km^2 unit in order to calculate total suspended sediment yield. The calculation of TSS for each replicate has been done using following formula:

$$TSS = \frac{\{(\text{filter paper weight+dried residue})- \text{filter paper weight}\}\ (mg) \text{ x } 1000}{\text{Volume of filtered sample water (mL)}}$$

= mg / L x 1000 x 1000
= kg / L

Later, the value of suspended sediment yield (day) is determined by using the Q and TSS value as well as the total of river's catchment area.

SY = (Q x TSS) / total of river's catchment area
= (L/day x kg/L) / km²
= kg/ km²/day

3. Results and Discussion

The results for both rivers are presented in Table 2. TSS in the water samples ranged from 4 mg/l (WQ 3) to 43.66 mg/l (WQ 1). This indicates that both rivers received low input of solids. When compared to INWQS for Malaysia (See Table 5), TSS for River Mati and River Tok Kassim are fall into Class I and Class II. Total TSS measured from River Mati and River Tok Kassim is 42.4 mg/l and 51.2 mg/l, respectively.

Table 2: TSS measured at River Mati and River Tok Kassim

Station No	River	TSS (mg/l)
WQ 1	River.Tok Kassim	3.60
WQ 2	River.Tok Kassim	4.00
WQ 3	River.Tok Kassim	43.60
WQ 4	River. Mati	23.60
WQ 5	River. Mati	6.00
WQ 6	River. Mati	12.80

The TSS longitudinal profile for River Mati and River Tok Kassim are shown in Fig.1 and 2. Both figures illustrate different scenario of TSS concentrations. The TSS concentration of River Tok Kassim shows Class I at upstream sites but changed to Class II towards downstream. For River Mati, all three WQ stations show Class I in water quality profile. This indicates that, soil properties in the River Mati's catchment are in the state of stable condition. Even rainfall was recorded on previous day the sediment concentrations are quickly settled on the river bed.

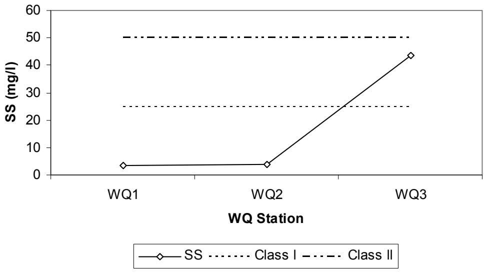

Fig.1: Longitudinal TSS concentration for River Tok Kassim

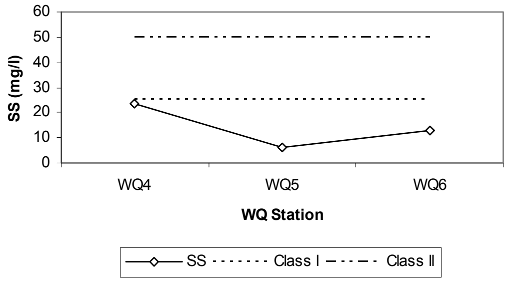

Fig. 2: Longitudinal TSS concentration for River Mati

To obtain TSS load of each river, the TSS load for day, month and year were calculated (Table 3). This information is important as suspended sediment yield of a catchment represents a part of the total erosion or sediment production within the catchment. As expected, highest TSS yield was recorded in River Tok Kassim (41.3 ton/km^2/yr). This is due to the fact that River Tok Kassim is bigger is size compared with River Mati (16.2 ton/km^2/yr). Both rivers however demonstrate low sediment production per unit area when compared with other catchments studied in Malaysia (i.e River Chini = 8741.8 ton/4.36 km^2/yr; River Sireh = 233 ton/15.3 km^2/yr; River Rantin = 78 ton/19.2 km^2/yr) [6]. [7]. [8]. However, without proper plans and mitigation structures, activities of cutting and filling may disturb surface runoff within the River Mati and River Tok Kassim systems especially for long term basis.

One of the major impacts from cutting and filling activities are the permanent modification of existing natural hill terrain. The cut and fill activities render the soil devoid of plant cover thus may increase the potential occurrence of erosion, nutrient and organic matter removal from the top soil. These activities will expose the soil causing accelerated erosion thus increasing the TSS concentration and subsequently reduce the down stream water quality and potentially localized flood.

Table 3: Suspended sediment yield of River Mati and River Tok Kassim

Sampling Station	Area (km^2)	∑ TSS	TSS (kg/l)	Estimated Q (m^3/s)	Estimated Q (m^3/day)	Estimated Q (L/day)
River Mati	17.1	42.4	0.0000424	0.207	17884.8	17884 800
River Tok Kassim	18.6	51.2	0.0000512	0.476	41126.4	41126 400

Daily sediment yield (kg/day)	Estimated load (kg/km^2/ day)	Monthly sediment yield (kg/km^2/ mth)	Yearly sediment yield (kg/km^2/ yr)	Yearly sediment yield (ton/km^2/ yr)
758.3	44.3	1329	16169.5	**16.2**
2105.7	113.2	3396.3	41 318	**41.3**

4. Conclusion

It can be concluded that base on the calculation carried out, the impacts of cutting and filling activities to Sg Mati and Sg Tok Kassim are relatively minimal. The TSS generated from the activities is expected not to cause severe sedimentation problems on the rivers. However, it is important that any land activities which involve changing in topography and land profile will not interfering Sg Mati and Sg Tok Kassim's drainage capacity (river hydraulic, regime or planform). In this respect, there are three major aspects that must take into consideration in reducing the TSS load into the rivers, which are:

- Sediment control structures at inlet points.
- Design drains, diversion and sediment ponds.
- River maintenance at downstream reach from the project sites.

Despite the results which are sound promising for the project activities, the mitigating measures as recommended in this study must not be compromised.

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