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Pollution Load Management To Improve Water Quality of Sungai Pusu

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ABSTRACT

Sg. Pusu is a river that flows through the campus of the International Islamic University Malaysia (IIUM). The river is murky in appearance, particularly after a rainfall event, which reflects elevated suspended solids (SS) levels. This study aims to characterize the water quality conditions of the river under high flow conditions, particularly in relation to SS, via a QUAL2K modeling approach and to determine the amount of load reduction needed to a achieve a Class II denotation of the National Water Quality Standards (NWQS). A total of 30 water quality stations were identified on the main-stem and east tributary for grab sample collection. The analysis results showed the SS levels ranged between 10 – 1,790 mg/L on the main-stem, whereas the levels were generally higher in the tributary, ranging between 10 – 140 mg/L. The increase was most significant in the middle segment of the river, where the levels went beyond 500 mg/L. The modeling revealed that at least 2,880 kg/hr of SS had to be reduced to achieve the Class II target. Sand-mining and developmental activities upstream were the primary source of SS. Besides this; BOD_5 and NH_3-N levels were also elevated, beyond the Class IV denotation. To achieve Class II, at least 122 kg/hr of BOD_5 and 42 kg/hr of NH_3-N have to be reduced.

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INTRODUCTION

The Sg. Pusu river, which flows through the International Islamic University Malaysia (IIUM), is murky due to elevated levels of Suspended Solids (SS). In Malaysia, major sources of SS includes agricultural based activities particularly oil palm; where runoff transports sediment to a receiving water column [1]. The effects therefore are usually more pronounced after a rainfall event, such in the case of Sg. Pusu. Besides being an eyesore, the constituent may also incur siltation, which decreases the overall hydraulic capacity of a water column [2]. Siltation disrupts fish habitation and may also affect propagation. SS can clog fish gills making respiration difficult [3]. There are likely two major sources of SS in the Sg. Pusu catchment; one is from the sand-mining activity upstream of the west tributary of Sg. Pusu; and another the development activities [either for housing or mixed development], upstream of the main-stem. Besides SS, other sources of pollution such as sewage and sullage also enter the river via perimeter drain. This study aims to characterize the water quality conditions of the river under high flow conditions and to ascertain the amount of pollution load reduction that needs to be achieved to improve water quality conditions up to Class II of the National Water Quality Standards (NWQS).

Methodology:

Samples were collected at a total of 30 stations schematically shown in Figure 1. The stations are located at segments within the boundary of the IIUM, as this was the main area of interest. Sample collection was done between 50 – 250 meters spatial interval, with a main-stem length of about 3 kilometers. Sampling for the tributary began at 3°15'37.92"N, 101°44'21.45"E, whereas for the main-stem, the first sample was collected at 3°15'18.10"N, 101°44'29.29"E. Samples were analyzed for total suspended solids (TSS), biochemical oxygen demand (BOD_5) and ammoniacal nitrogen (NH_3-N). To represent high flow conditions, samples were collected during or after a rainfall event. Preservation and storage were done in accordance with standards stipulated by the [4]. Hydraulic properties (depth, width, velocity) were measured on-site to derive the riverine flowrate.

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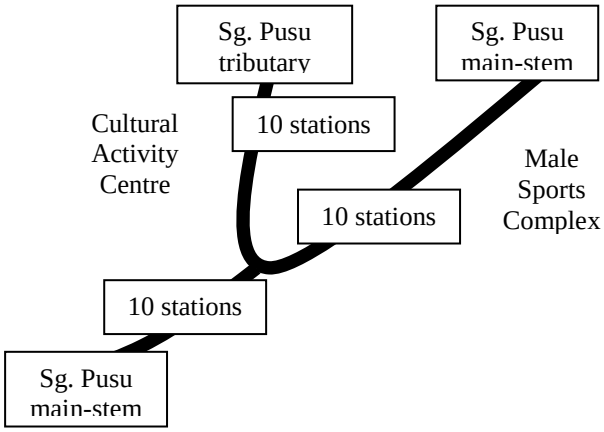

Fig. 1: Schematic of Sampling Stations

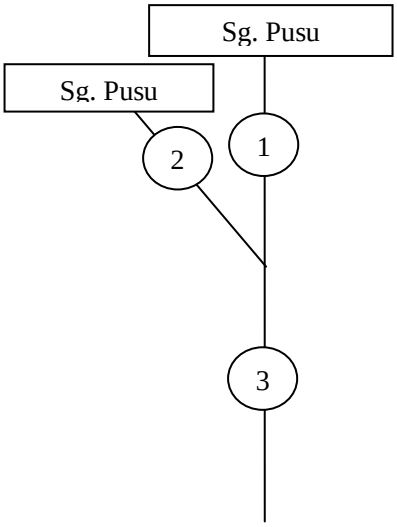

Fig. 2: Sg. Pusu QUAL2K Stream Reach System

The US EPA QUAL2K model was utilized to characterize water quality conditions and derive in-stream loading. The stream reach system is as shown in Figure 2 with an elemental resolution of 0.1 km (100 meters).

Event Mean Concentration (EMC) values from [5] were used in the model based on the designated land-uses. Discrepancies between observed and actual results were then rationalized via model calibration [6].

RESULTS AND DISCUSSION

Referring to Table 1, the high flow monitoring results showed elevated SS levels on the upstream reaches of the main-stem to be at 740 mg/L and 950 mg/L. The most significant contribution appears to originate from developmental activities taking place upstream, outside of the campus boundaries. Some decrement was observable downstream mainly due to weirs which acts as a barrier to sediment transport. That being the case, weirs are designed to regulate flow rather than assist sediment removal [2]. Thus, SS contamination was still observable on the downstream reaches. This is reflected in the monitoring results at L5, where the SS levels increased to 270 mg/L before hovering to between 110 – 140 mg/L. A sudden increase was observed in SS at L10 due to turbulence after a weir.

Table 1: Sg. Pusu main-stem

River	Sampling Locations	TSS (mg/L)
Sg. Pusu main-stem (pre-confluence)	L1	740
	L2	950
	L3	10
	L4	170
	L5	270
	L6	310
	L7	110
	L8	110
	L9	140
	L10	1790

Referring to Table 2, initially, the sand-mining activities appear to exhibit minimal impact towards the upper reaches (L1). This was mainly due the presence of two ponds that function to remove some of the SS. Despite this, elevation in SS levels was again observed at the middle segments to between 50 – 120 mg/L. This illustrated that SS presence was still significant. Water features on the main-stem may have disrupted the bottom sediments causing re-suspension. The heightened flow momentum during rainfall also negates settling.

Referring to Table 3, the post-confluence monitoring results showed the values were quite elevated, remaining within the Class III region of the NWQS, particularly on the upper reaches; between 120 -1,500 mg/L. Again, the weirs appear to have assisted SS removal as the values dwindle down to between 20 – 70 mg/L mid-stream. That being the case, the presence of suspended matter was still significant and was insufficient to dilute the SS loading from the incoming tributary. Future remediation measures therefore, need not only inculcate mitigation of sources on the main-stem but on the sub-catchments as well.

Table 2: Sg. Pusu tributary

River	Sampling Locations	TSS (mg/L)
Sg. Pusu tributary	L1	20
	L2	100
	L3	140
	L4	40
	L5	50
	L6	120
	L7	10
	L8	10
	L9	80
	L10	80

Table 3: Sg. Pusu main-stem (post-confluence)

River	Sampling Locations	TSS (mg/L)
Sg. Pusu main-stem (post-confluence)	L1	1500
	L2	800
	L3	260
	L4	120
	L5	70
	L6	30
	L7	20
	L8	40
	L9	10
	L10	80

Referring to Figure 3, the modeling exercise using QUAL2K showed that even at 90% load reduction, the Class II denotation would barely be achieved. This translates to an approximate load reduction from 3,204 kg/hr to 320 kg/hr.

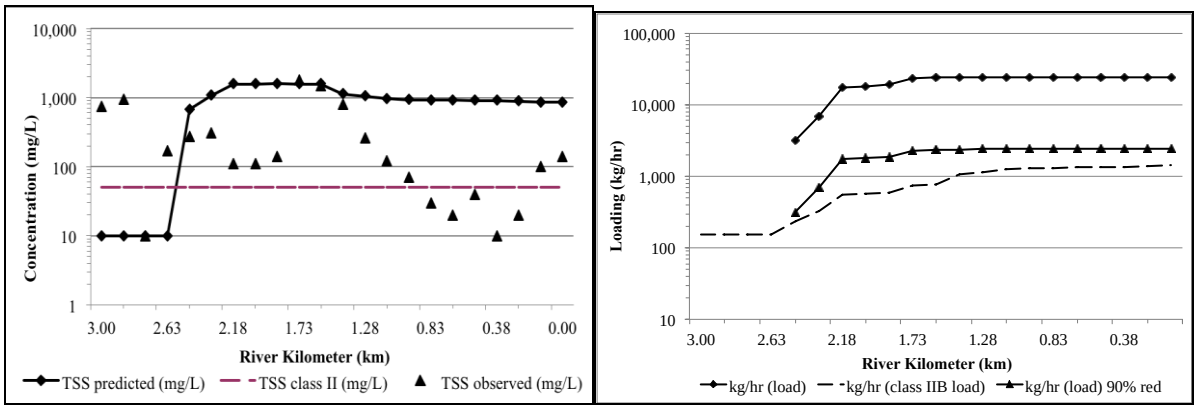

Fig. 3: TSS Spatial Concentration Trend (left) and Loading Trend (right) on main-stem of Sg. Pusu

The BOD_5 modeling results (shown in **Figure 4)**, also denotes a disturbing trend, where elevated organic levels (exceeding Class IV/V) was observed particularly on the middle segment of the river. The upper segments did not show significantly high organic levels. The heightened BOD_5 levels at the mid-segment were indicative of organic pollution contribution, likely to be originating from the surrounding commercial activities such as cafes and restaurants. Surface organic depositions carried by runoff may also have contributed to this condition. In addition, treated sewage effluent discharged to the perimeter drains also enters the water column. To achieve a Class II denotation, the current in-stream value of 136 kg/hr has to be reduced to at least 14 kg/hr.

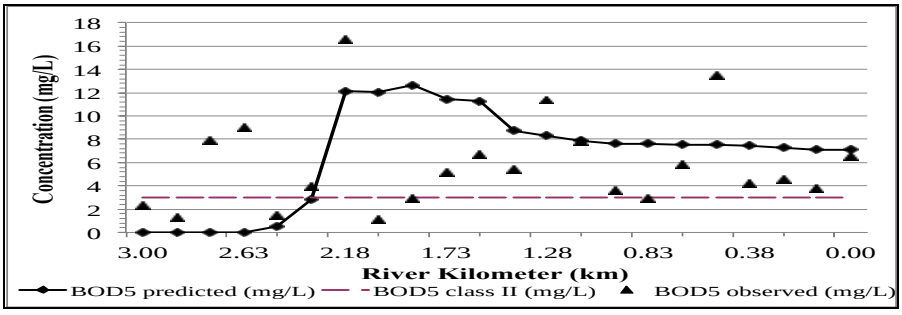

Fig. 4: BOD_5 Spatial Concentration Trend on main-stem of Sg. Pusu

Adding to this point, were the ammoniacal nitrogen (NH_3-N) results as shown in Figure 5. The elevated constituent concentration was in excess of 1.5 mg/L in the middle segment of river, which is beyond the desired threshold for most sensitive and tolerant species [7]. Coupled with the elevated SS results shown previously, it can be concluded that Sg. Pusu would not be able to support fish life of economic value or most ornamental fish species [8]. The NH_3-N loading analysis further showed that a decrement to about 7.4 kg/hr needs to be achieved compared to the current 50 kg/hr for a Class II denotation to be plausible under high flow conditions.

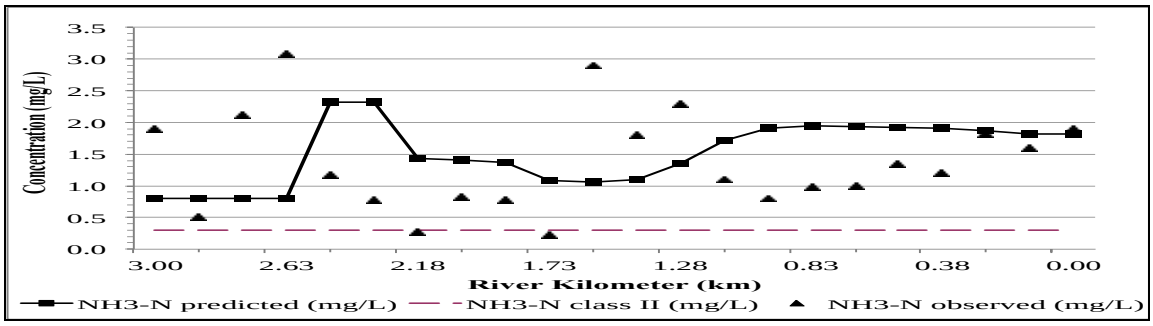

Fig. 5: NH_3-N Spatial Concentration Trend on main-stem of Sg. Pusu

Conclusions:

Sg. Pusu, particularly the reaches that flows through the university, is severely contaminated by SS transported by rainfall. The SS load originates from two main anthropogenic activities namely; sand-mining and development taking place on the upper reaches outside of the campus boundaries. Besides this, there are also organic contributions prevalent in the water column, indicated by the elevated levels of BOD_5 and NH_3-N. In order to achieve Class II denotation, a load reduction of at least 2,880 kg/hr has to be achieved TSS, 122 kg/hr for BOD_5 and 43 kg/hr for NH_3-N. It is likely that the organics originated from activities occurring within the university itself as opposed to contribution from developmental or sand-mining activities. The contribution is likely to be point-source in nature and not entirely due to the runoff. Remediation measures must not only inculcate SS removal but also need to mitigate BOD_5 and NH_3-N as well.

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