Prediction on Water Quality of Point-Source Pollution for Lunchoo River, Malaysia

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Abstract

The growth in urbanization, industrialization and irrigated agriculture are imposing growing demands and pressure on water resources. As a case in point, Lunchoo River, Malaysia was considered on of the contributing factor to water quality deterioration with regional consequences on the aquatic ecosystem. Moreover, it also deemed to affect the health of the downstream sub-basin user group. Influenced by tidal, restricted exchange between estuaries and the open sea allows rapid change in salinity, temperature, nutrients and sediment load. Therefore, a balance is vital between development and a good quality of life. In the present study, limitation on point source pollutant and low flow conditions are investigated. An understanding of the existing river and waste stream characteristic is necessary to determine the background level of pollutant. In addition, output generated from this study is an important key towards an optimal management of water resources. Results showed that in making prediction of water quality for Lunchoo River, it is essential to characterize the volume and properties of the river and wastewater stream. Moreover, both hydraulic and constituent flow rate fluctuated greatly in most part of the experimental field.

Keywords: Low flow, Point-source pollutant, Water quality

1. Introduction

In general, source of pollution can be categorized in two types, point source pollution and non point source pollution. Point source pollution is a single identify localized source. Point sources are relatively easy to identify, quantify and control. Point sources of water pollution include discharge from municipal sewage treatment plant and industrial plant (Peavy et al., 1985).

Generally, in focusing on point-source pollution, the most potential pollutants are industrial discharge (Krenkel & Novotny, 1980). Point-source pollutants in surface water and groundwater were usually found in a plume that has the highest concentrations. To indicate this situation, domestic sewage and industrial wastes act as point-source as they are generally collected by a network of pipes and channels and conveyed to a single point of discharge into receiving water (Masters, 1998). Figure 1 shows the main point-source pollutants of Lunchoo River catchments boundary.

Municipal point sources are the result of community sewage treatment systems. At the sewage treatment plant, wastewater is treated to remove solid and organic matter, disinfected to kill bacteria and viruses, and then often discharged to a surface water (Vigil, 1996). Not all solids and organic matter are removed during treatment, resulting in degraded receiving water quality, due to a reduction in dissolved oxygen. Nutrients such as phosphorus that are not removed during treatment can cause overgrowth of algae and other organisms, also leading to lower dissolved oxygen. Many toxic substances can pass through conventional municipal treatment systems.

Industrial point sources are the result of industries using water in their production processes, and then treating the water prior to discharge. Some of the industries requiring process waters include pulp and paper mills, food processors, electronic equipment manufacturers, rare metal manufacturers, textile manufacturers, pharmaceutical manufacturers, forest product producers, leather tanners, and chemical manufacturers (Vigil, 1996).

Information on low-flow statistic of stream is essential for the development and management of surface-water resources (Novotny, 2003). Such information is useful to calculate stream design-flow for water quality standard. In actual fact, wastewater effluent dominated pollution typically violates chemical criteria during low stream flow (Spellman, 2004). In general, flow and water quality are important in predicting the pollutant load within the water bodies (Abdul Ghani et al., 2009). In managing water quality it is important to determine aggregate of point and non point source pollution loads in order to set maximum allowable loads from each source that contribute to pollution of a river. Chang et al. (2001) stated that it is essential to assess the water quality condition of the river even though the information and data availability is limited and there are various classification methods that have been used for estimating the changing status and usability of surface water in river basin.

Lunchoo River located approximately at 1° 29'N and 103° 50'E of Mukim Plentong, Johor Bahru, Malaysia. The length is around 5km and has a surface area of 7.5 kilometres square. Existing activities along the river contributed to the water quality deterioration with regional consequences of aquatic ecosystem. The main aim of this study was to investigate the point-source pollution and to predict pollution data within Lunchoo River waterways. The current study also means to provide some useful information for mitigation measures in reducing pollution. The more specific objectives of this study were; a) to address in general the type and point-source pollution within the river basin, b) to predict the impact towards contamination of certain constituents on point-source pollution using mass balance analysis, and c) to provide strategy and formulation of an action plan to improve river water quality. The study focused on point-source pollutant using low flow design criteria. Due to time constrain, only certain parameters of water quality was investigated using mass balance. The catchments are divided into three parts; Atman Perindustrian Seri Plentong, Kota Puteri and Jalan Bukit 1, 2, 3 and Bukit Lunchoo (Figure 2).

2. Materials and Methods

In order to understand the important criteria of the area of concern, several considerations, assumptions and adjustment of previous data were adapted. In this section, a general approach that has been used to analyze the data was given. A hydrological based low-flow frequency were determined using annual series of minimum n-day (number of consecutive days) daily mean low flows and fitted into a log-Pearson Type III. The minimum 7 d flow that would be expected to occur every 10 years was generally accepted as the standard design flow. To calculate the design of rainfall intensity (log Pearson Type III), the following equations were used;

$$\log x = \log x + K\sigma_{\log x} \tag{1}$$

$$\overline{\log x} = \frac{\sum (\log x_i)}{n} \tag{2}$$

$$\sum_{i}^{n} \log Q - avg(\log Q))^{2}$$
⁽³⁾

$$\sigma_{\log x} = \sqrt{\frac{\sum (\log x - \overline{\log x})^2}{n - 1}}$$
(4)

$$\int_{n}^{3x} \sqrt{n-1} \frac{n-1}{\log x - \log x}$$

$$C_{5} = \frac{n \sum (\log x - \log x)}{(n-1)(n-2)(\sigma_{\log x})^{3}}$$
(5)

where x is the flood discharge value of some specified probability, $\overline{\log x}$ is the average of the log x discharge values, K is a frequency factor, and σ is the standard deviation of the log x values. The frequency factor K is a function of the skewness coefficient, C_s , where n is the number of entries, x the flood of some specified probability and $\sigma_{\log x}$ is the standard deviation. Therefore, analysis on low flow discharge design can be determined by using Rational Equation:

Where, Q is the design of flood discharge, c is the runoff coefficient, i is rainfall intensity and A drainage area.

2.1 River Quality

The Department of Environment (DOE) used Water Quality Index (WQI) to evaluate the status of the river water quality. The WQI serves as the basis for environment assessment of a watercourse in relation to pollution load categorization and designation of classes of beneficial uses as provided for under the National Water Quality Standards for Malaysia (NWQS). It consists of six (6) parameters - Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH3N), Suspended Solids (SS) and pH. This WQI is defined as:

$$WQI = (0.22* SIDO) + (0.19*SIBOD) + 0.16*SICOD) + (0.15*SIAN) + (0.16*SISS) + (0.12*SIPH)$$
(7)

2.2 River Concentration and Loads

The concentration and load were related through flow rate Q (Novotny, 2003). It is defined as;

$$W = K_u C Q \tag{8}$$

where K_u is a conversion constant that depends on the unit of W, C and Q. If W unit is equal to $g.s^{-1}$, Q as $m^3.s^{-1}$ and C as $mg.L^{-1}$ or $g.m^{-3}$, then K_u constant is equal to 1. If W unit is lb.d⁻¹, Q as $ft^3.s^{-1}$ and C as $mg.L^{-1}$, then the K_u value will be 5.39.

2.3 Waste Stream Characteristic

When a wastewater characterization study is required, pertinent data are often unavailable. When this is the case, population equivalent or unit capita loading is used to estimate total waste loading (Parker *et al.*, 2008):

2.4 Mass Balance Analysis

This analysis is one of the most useful tools available to the water engineer; it enables the modeling of a process in which a change in nature of a solution occurs. Metcalf and Eddy (1991) have described the mass balance concept in Mathematical equation:

$$d (Mass)/dt = C_r Q_r + C_{ww} Q_{ww} + C_x Q_x - K_s C_{stream} V - C_{stream} Q_{out}$$
(10)

Where C_r is a concentration of river, C_{ww} is a concentration of a wastewater, C_{stream} is a concentration of final effluent, V is volume of stream, while Ks is the settling rate constant for water constituent.

3. Results and discussions

Using a 10 years data, the results for minimum 7 d average flow rate was tabulated (Table 1) and by using log-Pearson Type III method, the distribution frequency was analyzed (Table 2). A value of 6.7 mm.d⁻¹ (Table 3) was observed corresponds to the design rainfall intensity for the 10 year period and the results for low flow discharge were illustrated in Table 4. It is notable that the average minimum 7 d rainfall intensity was fluctuating, with year 2009 having the lowest value (0.36mm).

3.1 Water Quality Index (WQI)

Water Quality Index (WQI) provides a convenient means of summarizing large numbers of water quality data in regularly sampled water bodies (House & Newsome, 1989). Water samples taken from sampling stations were analyzed to compute the WQI based on the six main parameters; BOD, COD, AN, DO, SS and pH. During low tide, the WQI for Lunchoo River was depicted as 53.6 (Class III) which was classified as polluted river.

3.2 Waste stream

The BOD and SS population equivalent (PE) in each sub-catchment were determined based on identified industrial processes (Rendell, 1999). Typical value for practical calculation was assumed to be 54 g of BOD per 24 h. For SS, standard capita per unit load was used as 90 g.capita⁻¹.d⁻¹ (Hann, 1972). During operational period, the Class II of the Interim National Water Quality Standards for Malaysia (INWQS) was used for the BOD and SS comparison. As represented in Table 6, the BOD analysis for Taman Perindustrian Seri Plentong was below the target value (0.83 mg.L⁻¹) and in the case of Taman Perindustrian Kota Puteri, it was 0.3 mg.L⁻¹. However, for Jalan Bukit 1, 2, 3 and Bukit Lunchoo, the BOD (Table 7) were above the standard value (2 mg.L⁻¹). The SS analysis for Taman Perindustrian Seri Plentong showed 30 mg.L⁻¹, whereas for industrial area at Jalan Bukit 1, 2, 3 and Bukit Lunchoo, it was 44 mg.L⁻¹.

For industrials within the area of Lunchoo River which does not meet the discharge standard of Class II (INWQS), it was suggested that the pollution should be reduced and transported to the receiving waters (Metcalf & Eddy, 2003). An extended aeration (EA) system containing a tank was proposed for this reason. Extended aeration is the most commonly used treatment system in small developments and the technology best understood by operators. In an extended aeration (EA) system, wastewater from industry is brought into a biological basin where is degraded by naturally occurring bacteria. After an "extended" period of time, typically 24 h of detention time, the mixed liquor (ML) is sent to a clarifier where it is allowed to settle. Secondary effluent (SE) is drawn off the clarifier and the settled biomass is returned to the head of the plant. The major advantages of an EA system are the relatively low capital cost combined with the extensive operational knowledge associated with these systems (Metcalf & Eddy, 2003).

3.3 Mass Balance Analysis

In order to determine the flow rate from wastewater treatment plant, an assumption of 20,000 residents from that area was multiplied with an average water consumption of 400 L.capita⁻¹.d⁻¹. Thus, the effluent flow rate was calculated and determined as $1.09 \text{ m}^3.\text{s}^{-1}$. The result for mass loading of BOD and SS was represented in Table 8. The final concentration was measured using a mass balance analysis which gave a value of 0.219 and 0.97 mg L⁻¹ for BOD and SS, respectively (Table 9 and 10). Both concentrations fulfilled the INWQS (Class I) requirement.

Metcalf and Eddy reported that an extended aeration, with a hydraulic detention time (HRT) of 18 to 36 h is sufficient for complete removal of pollutant. Accordingly, a HRT of 18 h was selected for the current operational study and the results showed that the effluent discharged from this process achieved the required standard (Table 11). Table 12(a), 12(b) and 12(c) illustrate the SS profile in the treatment system.

4. Conclusion

In summary, in order to make prediction of water quality for Lunchoo River, emphasis should be given to the characterization of volume and properties of the river, including wastewater stream. Nevertheless, it is a great challenge since both hydraulic and constituent flow-rates fluctuates in the most of the industrial processes. These problems can be overcome by minimizing the judiciously limiting analysis for constituent of concern.

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Table 1. Minimum 7 d rainfall intensity

No.	Year	Rainfall Intensity (mm)
1	2000	4.57
2	2001	3.79
3	2002	3.5
4	2003	1.93
5	2004	2.57
6	2005	3.07
7	2006	2.97
8	2007	3.43
9	2008	4.33
10	2009	0.36

Table 2. Distribution frequency using log-Pearson Type III method

No	Year	Xi	Log X _i	(Log X _i)-(Log Xrt)	$(\text{Log } X_i \text{-} \text{Log } Xrt)^3$
1	2000	4.57	0.659916	0.24330	0.01440333
2	2001	3.79	0.578639	0.16203	0.00425388
3	2002	3.5	0.544068	0.12745	0.00207065
4	2003	1.93	0.285557	-0.13105	-0.00225077
5	2004	2.57	0.409933	-0.00667	-0.00000029
6	2005	3.07	0.487138	0.07052	0.000350836
7	2006	2.97	0.472756	0.05614	0.000177004
8	2007	3.43	0.535294	0.11868	0.001671804
9	2008	4.33	0.636488	0.21987	0.010630379
10	2009	0.36	-0.443697	-0.86030	-0.63673702
	Total		4.166	0.000	-0.605
Lo	g X _{rt} =0.41	7	S	1=0.32139	$C_s = -0.08141$

Table 3. Design of rainfall intensity

Period	Probability	Log X _{rt}	Cs	G	
2	50	0.42	-0.08	0.0138	
5	20	0.42	-0.08	0.8371	
10	10	0.42	-0.08	1.2738	
25	4	0.42	-0.08	1.7233	
50	2	0.42	-0.08	2.0108	
100	1	0.42	-0.08	2.2657	

Table 4. Low flow discharge

Intensity (m/s)	Area (m ²)	Runoff Coefficient	Low
7.75348E-08	7500000	1	

Table 5. Water Quality Index (WQI) during low tide

Sampling	DO%	BOD	COD	SS	pH	NH3-N	DO	BOD	COD	A
Point							SI	SI	SI	3
W1	7.1	19	74	22	7.4	0.2	0	36	29	8
W2	7.5	12	58	43	6.6	1.1	0	55	39	4
W3	7.3	8	35	40	6.5	0.5	0	69	58	6
W4	7.5	12	48	51	6.7	0.2	0	55	47	8
W5	7.3	5	16	43	5.8	0.4	Ō			
W6	7.5	8	29	13	6.7	0.7	0			
W7	7.8	4	26	20	6.7	0.7	0			
W8	4.7	15	67	6	2.4					
AVERAGE	7.1	10.2		_			4			

Table 6.			.ong	
No			Total	Flowrate,
			BOD	Q (L/day)
		/s)	Load	
			(mg/day)	
	_	0.172	10800000	14860800
		0.172	2700000	14860800
		0.172	27000000	14860800
	.3.5	0.172	13500000	14860800
	8.1	0.172	8100000	14860800
	10.8	0.172	10800000	14860800
	13.5	0.172	13500000	14860800

No	Indust rial Area	ID	Conce ntratio n (mg/L)	Target Concentrat ion (Class II, INWOS)	Status t Concent	arget ration	Percen tage Differe nt	Expected reducing Total BOD Load (mg/day)	New Total BOD Load (mg/day)	Flowrate, Q (L/day)	Expecte d Concent ration (mg/L)
8		SL093	3.18	2	higher	1.18	37.07	12009600	20390400	10195200	2.00
9		SL094	0.53	2	ok	-	-	-	5400000	10195200	0.53
10		SL095	0.79	2	ok	-	-	-	8100000	10195200	0.79
11		SL096	0.11	2	ok	-	-	-	1080000	10195200	0.11
12		SL097	0.26	2	ok	-	-	-	2700000	10195200	0.26
13		SL098	0.11	2	ok	-	-	-	1080000	10195200	0.11
14		SL099	0.53	2	ok	-	-	-	5400000	10195200	0.53
15		SL100	0.26	2	ok	-	-	-	2700000	10195200	0.26
16		SL101	0.11	2	ok	-	-	-	1080000	10195200	0.11
17		SL102	0.11	2	ok	-	-	-	1080000	10195200	0.11
18	Jalan	SL103	1.06	2	ok	-	-	-	10800000	10195200	1.06
19	Bukit	SL104	0.79	2	ok	-	-	-	8100000	10195200	0.79
20	1, 2, 3	SL105	1.06	2	ok	-	-	-	10800000	10195200	1.06
21	anu Dukit	SL106	0.26	2	ok	-	-	-	2700000	10195200	0.26
22	Lunch	SL107	3.71	2	higher	1.71	46.06	17409600	20390400	10195200	2.00
23		SL108	4.24	2	higher	2.24	52.80	22809600	20390400	10195200	2.00
24	00	SL109	0.53	2	ok	-	-	-	5400000	10195200	0.53
25		SL110	0.42	2	ok	-	-	-	4320000	10195200	0.42
26		SL111	0.26	2	ok	-	-	-	2700000	10195200	0.26
27		SL112	0.26	2	ok	-	-	-	2700000	10195200	0.26
28		SL113	3.18	2	higher	1.18	37.07	12009600	20390400	10195200	2.00
29		SL114	0.79	2	ok	-	-	-	8100000	10195200	0.79
30		SL115	0.53	2	ok	-	-	-	5400000	10195200	0.53
31		SL116	0.16	2	ok	-	-	-	1620000	10195200	0.16
32		SL117	3.18	2	higher	1.18	37.07	12009600	20390400	10195200	2.00
33		SL118	0.11	2	ok	-	-	-	1080000	10195200	0.11

Table 7. BOD profile in Jalan Bukit 1, 2, 3 and Bukit Lunchoo

Table 8. Mass loading of BOD and SS effluent

Place	BOD Concentration (mg/l)	SS Concentration (mg/l)	Q (m ³ /s)	M _{BOD(IN)} (mg/s)	M _{BOD(IN)} (kg/day)	M _{SS(IN)} (mg/s)	M _{SS(IN)} (kg/day)
River	11	48	0.58	6380	551.23	27770.4	2399.36
ww	135	225	0.093	12555	1084.75	20925	1807.92
T.S.P	0.83	30	0.172	142.8571429	12.34	5074.372	438.43
JLN123&BKTL	1.02	44	0.118	120.4326923	10.41	5177.5931	447.34
K.P	0.30	39	0.129	38.492.64706	3.33	5005.6713	432.49
			•		1662.06		5525.54

Table 9. BOD in Lunchoo River effluent

Min (kg/day)	K _s	Area (m ²)	Depth river, m	Volume, V (m ³)	Qout (m ³ /s)	Qout (m ³ /day)	K _s X Volume (m ³ /day)	(Ks X Volume)+(Q out)	C _{lunchoo} (kg/m ³)	C _{luncho} o (mg/L)
1662.06	0.5	7.5 x 10 ⁶	2	1500000 0	1.09	94313. 60	7500000	7594313.60	0.0002	0.219

Table 10. SS in Lunchoo River effluent

Min (kg/day)	K _s	Area (m ²)	Depth river (m)	Volume V (m ³)	Qout (m ³ /s)	Qout (m ³ /day)	K _s X Volume (m ³ /day)	(Ks X Volume)+(Qout)	C _{lunchoo} (kg/m ³)	C _{lunchoo} (mg/L)
5525.54	0.5	7.5 x 10 ⁶	1.5	112500 00	1.09	94313.6 0	5625000	5719313.6 0	0.0009 7	0.97

			Type of		-	HR	T			Iffluent	Cin		BOD Existin	ng	Concentration		BO	D Full De	sign	
No.	Industrial Area	ID	Type of SIP	PE	Q in (m ³ d)	dumtion	dava	Volume (m ³)	K	Analysis (C_)	(gim3)	Q _{in} C _{in}	Q	Q _{ee} C _{ee}	mal	kCV	$Q_{in}C_{in}$	Removal	Quut	Cour
					(//	duration	days	()		(g/m ³)	(g/m3)	(g/d)	(m ³ /d)	(g/d)	mgi	(g/d)	(g/d)	(%)	(m ³ /d)	(g/m^3)
8		SL093	EA	600	10195.2	18h	0.75	7646.4	0.5	1.02	3.18	32400	10195.2	10405.38	5.75	21994.615	32400	44.76	5631.909	1.85
22	JLNBKT1,2,3	SL107	EA	700	10195.2	18h	0.75	7646.4	0.5	1.02	3.71	37800	10195.2	10405.38	7.17	27394.615	37800	48.26	5275.378	1.97
23	& Bkt.	SL108	EA	800	10195.2	18h	0.75	7646.4	0.5	1.02	4.24	43200	10195.2	10405.38	8.58	32794.615	43200	50.60	5036.261	2.07
28	Lunchoo	SL113	EA	600	10195.2	18h	0.75	7646.4	0.5	1.02	3.18	32400	10195.2	10405.38	5.75	21994.615	32400	44.76	5631.909	1.85
32		SL117	EA	600	10195.2	18h	0.75	7646.4	0.5	1.02	3.18	32400	10195.2	10405.38	5.75	21994.615	32400	44.76	5631.909	1.85

Table 11. BOD in industrial area at Jalan Bukit 1, 2, 3 and Bukit Lunchoo

Table 12(a). SS in industrial area at Taman Perindustrian Seri Plentong

						HR	I			Effluent	Cin	S	S Existing		Concentration		SS F	full Desig	n	
No.	Industrial Area	D	Type of STP	PE	Q in (m ³ /d)	duration	days	Volume (m ³)	K	Analysis	(a/m3)	Q _{in} C _{in}	Q _{out}	Q _{out} C _{out}	wal	kCV	Q _{in} C _{in}	Removal	Q	Cout
					((/		(g/m ³)	(g/m5)	(g/d)	(m ³ /d)	(g/d)	mg/1	(g/d)	(g/d)	(%)	(m ³ /d)	(g/m^3)
3	Tmn Perindustrian	SL003	EA	7696	14860.8	18h	0.75	11145.6	0.5	30	47	692603.3	14860.8	438425.7	45.61	254177.53	692603.3	-2.18	15185.21	28.87
7	Seri Plentong	SL007	EA	58	14860.8	18h	0.75	11145.6	0.5	30	58	865754.1	14860.8	438425.7	76.68	427328.347	865754.1	24.03	11290.32	38.83

Table 12(b). SS in industrial area at Taman Perindustrian Kota Puteri

	Industrial Area		Type of STP	FE	Q in (m ³ /d)	HRT				Effluent	Cin	BOD Existing		Concentration	BOD Full Design					
No.		ID				duration	days	Volume (m ³)	K	Analysis (C _{ou}) (g/m ³)	(g/m3)	Q _{is} C _{is}	Q _{out}	Q.,C.,	mg/l	kCV	QinCin	Removal	Q	Cour
												(g/d)	(m³/d)	(g/d)		(g/d)	(g/d)	(%)	(m ³ /d)	(g/m^3)
35		SL009	EA	14429	11145.6	18h	0.75	8359.2	0.5	39	116.5	1298631.1	11145.6	434678.4	207	863952.73	1298631.1	43.63	6282.5	69.19
51		SL025	EA	5772	11145.6	18h	0.75	8359.2	0.5	39	46.6	519452.5	11145.6	434678.4	20	84774.05	519452.5	-129.78	25610.5	16.97
52		SL026	EA	21644	11145.6	18h	0.75	8359.2	0.5	39	174.8	1947946.7	11145.6	434678.4	362	1513268.29	1947946.7	51.73	5380.2	80.79
55		SL029	EA	28858	11145.6	18h	0.75	8359.2	0.5	39	233.0	2597262.3	11145.6	434678.4	517	2162583.86	2597262.3	54.96	5019.7	86.59
57		\$L031	EA	17315	11145.6	18h	0.75	8359.2	0.5	39	139.8	1558357.4	11145.6	434678.4	269	1123678.96	1558357.4	47.99	5796.4	74.99
58		SL032 EA	EA	21644	11145.6	18h	0.75	8359.2	0.5	39	174.8	1947946.7	11145.6	434678.4	362	1513268.29	1947946 .7	51.73	5380.2	80.79
63		SL037	EA	5772	11145.6	18h	0.75	8359.2	0.5	39	46.6	519452.5	11145.6	434678.4	20	84774.05	519452.5	-129.78	25610.5	16.9 7
78		SL052	EA	14429	11145.6	18h	0.75	8359.2	0.5	39	116.5	1298631.1	11145.6	434678.4	207	863952.73	1298631.1	43.63	6282.5	69.19
79		\$L053	EA	5772	11145.6	18h	0.75	8359.2	0.5	39	46.6	519452.5	11145.6	434678.4	20	84774.05	519452.5	-129.78	25610.5	16.97
80	Tmn. Perindustrian Kota Puteri	SL054	EA	17315	11145.6	18h	0.75	8359.2	0.5	39	139.8	1558357.4	11145.6	434678.4	269	1123678.96	1558357.4	47.99	5796.4	74.99
81		SL055	EA	7215	11145.6	18h	0.75	8359.2	0.5	39	58.3	649315.6	11145.6	434678.4	51	214637.16	649315.6	-13.44	12644.0	34.38
89		SL063	EA	17315	11145.6	18h	0.75	8359.2	0.5	39	139.8	1558357.4	11145.6	434678.4	269	1123678.96	1558357.4	47.99	5796.4	74.99
93		SL067	EA	14429	11145.6	18h	0.75	8359.2	0.5	39	116.5	1298631.1	11145.6	434678.4	207	863952.73	1298631.1	43.63	6282.5	69.19
95	-	SL069	EA	6493	11145.6	18h	0.75	8359.2	0.5	39	52.4	584384.0	11145.6	434678.4	36	149705.61	584384.0	-46.38	16315.3	26.64
105		SL079	EA	5772	11145.6	18h	0.75	8359.2	0.5	39	46.6	519452.5	11145.6	434678.4	20	84774.05	519452.5	-129.78	25610.5	16.97
106		SL080	EA	28858	11145.6	18h	0.75	8359.2	0.5	39	233.0	2597262.3	11145.6	434678.4	517	2162583.86	2597262.3	54.96	5019.7	86.59
109		SL083	EA	36073	11145.6	18h	0.75	8359.2	0.5	39	291.3	3246577.8	11145.6	434678.4	673	2811899.42	3246577.8	56.70	4825.7	90.08
114		SL088	EA	11543	11145.6	18h	0.75	8359.2	0.5	39	93.2	1038904.9	11145.6	434678.4	145	604226.50	1038904.9	35.52	7186.4	60.49
116		SL090	EA	10100	11145.6	18h	0.75	8359.2	0.5	39	81.6	909041.8	11145.6	434678.4	113	474363.39	909041.8	28.14	8009.5	54.27

No.	Industrial Area	ID	_			HRT				Effluent	Cin	SS Existing			Concentration	SS Full Design				
			Type of STP	PE	Q in (m ³ /d)	duration	ı daya	Volume (m ³)	K	Analysis (C _{ou}) (g/m ³)	(g/m3)	Q _{in} C _{in}	Que	QC	mg/l	kCV	$Q_{ia}C_{ia}$	Removal	Q	Cent
					((g/d)	(m ³ /d)	(g/d)		(g/d)	(g/d)	(%)	(m ⁸ /d)	(g/m^{δ})
8		SL093	EA	5297	10195.2	18h	0.75	7646.4	0.5	44	47	476726.9	10195.2	447344.0	7.69	29382.8807	476726.9	-508.42	62030.1	7.21
22	Jalan Bukit 1, 2 ,3 and Bukit Lunchoo	SL107	EA	10594	10195.2	18h	0.75	7646.4	0.5	44	94	953453.9	10195.2	447344.0	132.38	506109.806	953453.9	29.35	7202.5	62.11
23		SL108	EA	13242	10195.2	18h	0.75	7646.4	0.5	44	117	1191817.3	10195.2	447344.0	194.73	744473.269	1191817.3	39.97	6120.5	73.09
28		SL113	EA	5297	10195.2	18h	0.75	7646.4	0.5	44	47	476726.9	10195.2	447344.0	7.69	29382.8807	476726.9	-508.42	62030.1	7.21
30		\$L115	EA	66212	10195.2	18h	0.75	7646.4	0.5	44	584	5959086.6	10195.2	447344.0	1441.66	5511742.52	5959086.6	59.46	4133.5	108.22
32		SL117	EA	5297	10195.2	18h	0.75	7646.4	0.5	44	47	476726.9	10195.2	447344.0	7.69	29382.8807	476726.9	-508.42	62030.1	7.21

Table 12(c). SS in industrial area at Jalan Bukit 1, 2, 3 and Bukit Lunchoo



Figure 1. Main point source pollutants for Lunchoo River



Figure 2. Sub-catchments for Lunchoo river basin