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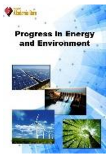

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Original Article

The impact of sewage treatment plant loading to river basin during Movement Control Order

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Abstract

Environment quality is essential aspects of life on earth, any changes in the quality have a significant impact on human beings. The implementation unprecedented Movement Control Order (MCO), which halted social, economic, and other activities except essential services contributed to opportunities for the earth to rejuvenate itself and build a better blue sky, peaceful wildlife, controlled noise pollution, and improved environmental features. Although the unprecedented Movement Control Order (MCO) due to COVID-19 pandemic posed some adverse effects on the environment, but there are also some benefits on the environment. One of the significant positive effects by the MCO is that the environment had rejuvenated during this period, especially significant water quality improvement. Many reports worldwide, including Malaysia, had reported that the environment including water quality had shown signification improvement. With controlled activities, MCO recognized contributed to river water quality rejuvenation amidst one of the main essential service sewage treatment plant operating at its fullest capacity. Amidst of various river pollution sources, Sewage Treatment Plant (STP) effluent discharge loading was identified as one of the main water resource polluters, and the MCO phenomenon turn raises the question of whether the STP effluent discharge loading onto river resources is the main culprit to the river pollution. This is a new challenge for water resources management to examine the impact of sewage treatment effluent discharge loading on water resource pollution loading in Malaysia. This study investigates the influence of sewerage treatment plant effluent loading from the Kuala Lumpur sewerage catchment to the Klang River basin within the Kuala Lumpur City Centre. The river's natural self-carrying loading was investigated to evaluate the influence of sewerage effluent loading on the selected river basin. The STPs within the study area were identified and segregated based on its tributary river basin. The individual STP's Biological Oxygen Demand (BOD) and Suspended Solid (SS) average effluent discharge loading of the year 2020 analyzed against the study River's BOD and SS average self-loading of the year 2020. The STP and River loading were analyzed to investigate the fraction of STP effluent discharge loading against River loading in the study river basin during MCO.

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1 Introduction

The world had been gripped over the years 2020 and 2021 by a Pandemic that was identified as a new Coronavirus Disease 2019 (COVID-19) [1]. About 3 billion people are affected by MCO or lockdown globally [1]. The earliest COVID-19 cases detected in Malaysia is on January 25, 2020 [2]. Since then, the number of cases is increasing, even though there was some reduction from July to September 2020. The situation becomes out of control again from April to July 2021 even though the Malaysian government had taken several control measures [3]. With infections rising rapidly worldwide and no vaccine yet formulated during the first wave period, most nations had called for immediate and widespread lockdowns or MCO to curb the virus' spread [2], and the battle is still ongoing till July 2021. The Malaysian government similarly had enforced the MCO to control the COVID-19 outbreak from contagious. The five enforcement levels of MCO are Movement Control Order (MCO) (March 18, 2020 – May 3, 2020), Conditional Movement Control Order (CMCO) (May 4, 2020 – June 9, 2020), Recovery Movement Control Order (RMCO) (June 10, 2020 – December 31, 2020) and Enhanced Movement Control Order (EMCO) (January 1, 2021 – July 1, 2021). Each state switch between MCO, CMCO, RMCO, EMCO, and semi-EMCO depending on the COVID-19 condition in each state.

Initially the Covid-19 is a big problem for this planet, as there still no proper treatment or vaccine developed initially, in relation the other related problems created by this pandemic is becoming another pressing issues to the world and Malaysia. The movement control order or lockdown effects entwined with many humanitarian and political effects such as decreased access to health care, lack of sufficient medical facility, uncontrollable public mobility, unemployment, migrants' crisis, starvation and prevailing poverty, psychological effects on people and the world is learning to cope with this new repercussion [4].

1.1 MCO effects on environment

One of the biggest questions during this pandemic is 'does the COVID-19 pandemic contribute positively to the environment?'. The positive aspect is related to reduced human activity in the environment, and the negative aspect is related consequences of reduced human activities. Apart from sufferings of entire country and globe due to the pandemic especially the people by all sort of social level, economic and psychologic effects in day-today life, the pandemic either directly or indirectly had contributed positively and negatively to environment. The negative affects by the Covid-19 are sudden spike in use of personal protective equipment (PPE) like face mask, face shield, hand gloves, gowns, and others, and their chaotic disposal increases environmental burden [5]. Positive effects of Covid-19 toward environment are improvement of air and water quality, reduction of noise and restoration of ecology [6]. The environment impact of COVID-19 pandemic during MCO summarised in Fig. 1 [7].

One of the important environmental, the water resources quality which is severely polluted due to urbanization and modernization, had blessing in disguise that the rivers are cleaner and more transparent than before MCO implementations [8].

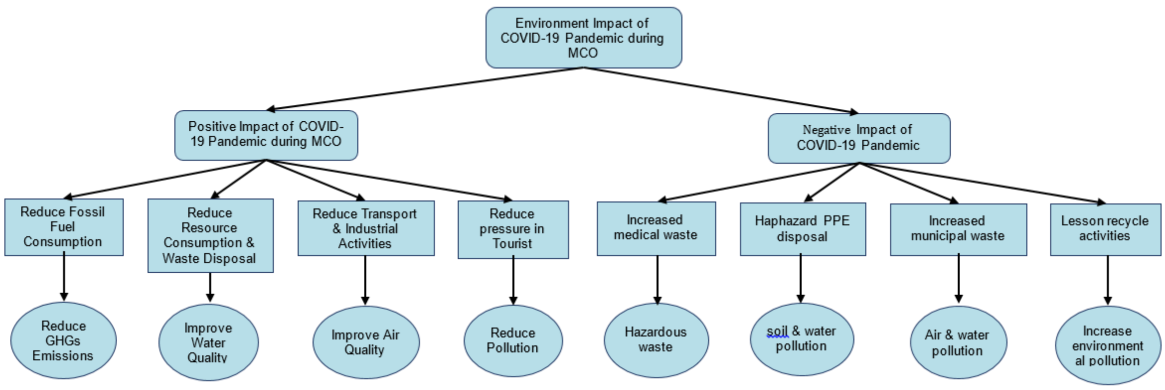

Fig. 1 The environment impact of COVID-19 pandemic during MCO in Malaysia.

1.2 Water quality during MCO

Before COVID-19, water pollution is one of the biggest challenges for many countries, especially developing countries. Poor river water quality severely affect the water supply to the communities. During MCO, enormous changes have happened to the polluted rivers all over the country.

A study using river monitoring stations, there was an improvement of 28 % in water quality during MCO [9]. The rivers that showed the improvement are Sungai Batang Sadong, Sungai Kelantan, Sungai Kuantan, and Sungai Besut [9]. Table 1 illustrates the studies on water quality during pandemic COVID-19 in Malaysia. The WQI study in Putrajaya Lake and showed a significant increase in the WQI from 24 % to 94 % during the MCO period [10]. The Sg. Melaka, which is in the Centre of the Melaka City and renowned for its water pollution, becomes the town's talk for its cleaner water during the MCO period [11]. The Sg. Melaka reported 'greener' during the MCO period [12]. The same goes for the Sg. Kim Kim, infamous for having chemical waste pollution from factories in Johor Baharu and become the country's talk a few years ago. The river is clearer when the factories ceased operation during the MCO. The Sg. Klang recorded Class III WQI (90 %) during MCO, compared to 46 % before MCO, and a total of 43 % less solid waste was removed while Sewage Treatment Plants operated as usual during the MCO [11]. Fig. 2 and Fig. 3 illustrates the comparison between before and after MCO of Sg. Gisir, Kuala Lumpur, and drainage Taman Teratai Mewah, Kuala Lumpur. It is clearly showing that the river is clearer during the MCO period.

Table 1 Studies on water quality during COVID-19 pandemic in Malaysia.

Study	Key Results	Reference
Rivers of Klang, Penang, Putrajaya Lake for Water quality index (WQI)	Increase in Putrajaya Lake WQI from 24 % to 94 % (Class 1 river).	[10]
Water quality index (WQI)	Rivers were clearer during MCO: Sg. Btg Sadong, Sg. Kuantan, Sg. Pahang, Sg. Johor, Sg. Besut, Sg. Kim Kim, Sg. Gombak, Sg. Klang, Sg. Melaka, Sg. Gisir etc.	[11]
Water quality index (WQI)	Improvement in WQI in 29 water monitoring statons (28 % WQI improved). Rivers showing improved water quality are Sg. Batang Sadong, Sg. Besut, Sg. Kelantan, Sg. Linggi, Sg. Johor, Sg. Muar etc.	[9]
Sungai Melaka visibility	The visibility is ‘greener’ and cleaner. The water can be visible at several locations and drastic reduction in rubbish in the river.	[12]
Sungai Pinang visibility	Water has been noticeably clearer and cleaner.	[13]
Environmental quality report 2016	Estimated pollution load from sewage sources for BOD loading is 49% and SS loading is 38%	[14]
Environmental quality report 2017	Estimated pollution load from sewage sources for BOD loading is 49% and SS loading is 39%	[15]
Environmental quality report 2018	Estimated pollution load from sewage sources for BOD loading is 37% and SS loading is 36%	[16]
Environmental quality report 2019	Estimated pollution load from sewage sources for BOD loading is 51% and SS loading is 29%	[17]
Environmental quality report 2020	Estimated pollution load from sewage sources for BOD loading is 59% and SS loading is 34%	[22]
State of River Klang River 2015	The biggest pollution source estimated about 80% from sewage and STP effluent discharge.	[23]

Fig. 2 Sungai Gisir (a) before MCO in March 2020 and (b) during MCO.

Fig. 3 Drainage water quality before and during MCO Taman Teratai Mewah, Kuala Lumpur.

1.3. Sewage treatment effluent discharge

There are many studies suggested that the sewage effluent discharge is one of the main pollution point source to the river resources [18-20]. Although the sewage treatment plant's effluent discharge complies with its statutory requirement under Department of Environment's (DOE) 2009 Environmental Quality Sewage Regulation (EQSR), but its overall loading capacity toward river's carrying capacity is alleged to be substantial to river's carrying capacity [21]. River constitute natural self-carrying loading, and shoulders various loading source that flown into the river in a mixed developed area. Fig. 4 and Fig. 5 illustrate main five focused type of pollution sources identified [22], manufacturing industries, agricultural-based industries, sewage treatment plants, pig farming and wet markets. The sewage pollution loading identified as the biggest loading contributor among the five focused type pollution loading with 54% and 34% for Biological Oxygen Demand (BOD) and Suspended Solid (SS) respectively.

The implementation unprecedented MCO, which halted social, economic, and other activities except essential services contributed opportunities for environment to rejuvenate itself. MCO recognized as well contributed to river water quality rejuvenation amidst one of the main essential service sewage treatment plant operations are operating at its fullest capacity. Amidst of various pollution sources, Sewage Treatment Plant (STP) effluent discharge loading was identified as one of the main water resource polluters, and the MCO phenomenon turn raises the question whether the STP effluent discharge loading onto river resources is the main culprit to the river resource pollutions. This is a new challenge for water resources management to examine the impact of sewage treatment effluent discharge loading onto water resource pollution loading in Malaysia. With all other activities stopped, the MCO had provided the right avenue to investigate and analyse actual STP effluent discharge loading against the river loading with only the sewage point source discharging into the river.

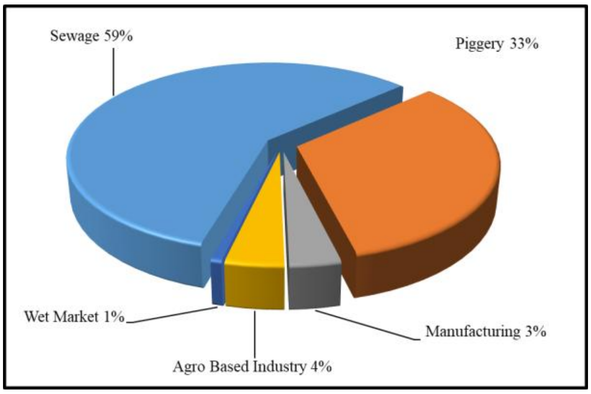

Fig. 4 BOD pollution load 2020.

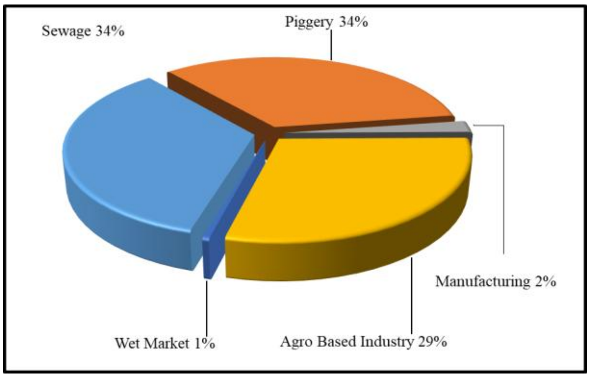

Fig. 5 SS pollution load 2020.

This paper explores influence of sewerage treatment effluent loading and its effects on a selective river basin during the MCO. The selected river basin for the study is Sungai Klang (Klang River) basin in Federal Territory Kuala Lumpur. This study investigates the influence of sewerage effluent loading from the Kuala Lumpur sewerage catchment to the Klang River basin within the Kuala Lumpur City Centre.

2 Methodology

This section presents the research methodology in conducting this study to interpret effects of MCO towards STP effluent discharge loading onto river loading during the MCO 2020. The study only covers the main river and tributary rivers from its origin till exit Point of Klang River from FTKL to Selangor State at southwestern limit FTKL border. The main river network that spread across the Federal Territory of Kuala Lumpur (FTKL), Klang River basin selected for this study. The main rivers and its main tributaries rivers that spread across in study area identified. The tracing of tributary river origin not limited within the FTKL boundary but across the boundary FTKL into part of Selangor. The river flow data sought and the selected river point sampled for river water quality analysis. The STPs located within river basin from its origin identified, including the STPs located in parts of Selangor till exit point of study and segregated based its tributary river basin. The STP's average effluent discharge capacity and effluent discharge quality for year 2020 extracted for analysis. All STPs within the catchment basin, invariable of its process type and size is included to capture actual discharge capacity conditions. During the strict MCO period, in lieu government's instruction to stop all commercial and industrial premises activities including outdoor activities, assumed all other point source and non-point source polluters discharging "No Discharge' except for STPs effluent discharge. As all citizens were behind closed doors in their houses, the STPs that serving its sewerage catchment were receiving sewage inflow volume as usual per before MCO period.

The flow volume capacity and water quality analysis data for both river and STP effluent discharge analysed for River self-loading and cumulative STP effluent discharge loading. This study concentrates on Biological Oxygen Demand (BOD) and Suspended Solid (SS) water quality parameter for loading evaluation. For both the Klang River self-loading and STP effluent discharge loading is calculated from flow capacity measurement data and water quality concentration data. The BOD and SS loading for River and STPs effluent discharge calculated separately and analysed.

$$\text{Loading/day (kg/day)} = \frac{\text{average flow (m}^3\text{/day)} \times \text{BOD/SS concentration (mg/l)}}{1000} \tag{1}$$

The STP effluent discharge loading calculated based on average daily STP flow capacity and average effluent quality concentration by individual BOD and SS parameter. Then the STPs loading data by individual STP loading concentration was calculated by Branch river basin. As the STPs was listed by its location from river origin till downstream, the BOD and SS loading cumulated one by one from the most upstream STP till downstream. The mix concentration calculated from immediate upstream and downstream plant and the cumulative goes on.

$$\text{Mix concentration} = \frac{V1 \times C1 + V2 \times C2}{V1 + V2} \tag{2}$$

where:
$V1$ = volume STP 1 (upstream STP)
$V2$ = volume STP 2 (downstream STP)
$C1$ = concentration STP 1
$C2$ = concentration STP 2

River self-carrying loading derived from average daily river volume and river water analysis for BOD and SS concentrations. The examined loading data further analysed for STP effluent loading fraction against the River self-loading.

$$\text{River loading (kg/day)} = \frac{\text{river flow (m}^3\text{/day)} \times \text{BOD/SS concentration (mg/l)}}{1000} \tag{3}$$

In general, the study consists of five main phases. In first phase, the general information river pollution that one of key environmental issue during MCO and operating industries during 1st level MCO were explained. In second phase, River selected as study area, then investigation of the overall River basin including its tributaries, river basin’s geometric information and land use within study area boundary. The investigation also includes identifications of STP tabulations within the study area (Objective 1). Then in third phase to examine the flow capacity and water quality of the selected River and identified STPs within the study river basin. For the both River and STP effluent discharge, water quality analysis assessments done for BOD and SS parameter during the study period MCO level 1 period in 2020 (Objective 2). For the fourth phase, the River self-carrying loading and STP’s cumulative effluent discharge loading into River calculated from the flow capacity and water quality analysis. This to examine pollution loading by the STP effluent discharge loading into River (Objective 3). Then in the last phase, the Klang River loading data is used as important data in formulation of better strategies and way forward options in Integrated River Basin Management (Objective 4). The results from this study is reviewed how to establish and emulated similar BOD and SS loading fraction against the river self-carrying loading for other pollutant source. By establishing the loadings by each pollutant source, then the actual highest pollutant source can be identified for a more comprehensive river basin management plan. Based on the results from the study a mathematical modelling developed to derive similar individual pollutant loading against the river self-carrying loading. The fraction of each pollutant loading reviewed for the river basin management action. The model appraised with other pollutant loading river data for verification. Other similar river with multiple source pollutant loading study selected to verify the model. The data filled into the model to calculate the total river pollutant loading. The highest pollutant loading source against the river self-loading identified for way forward river basin management. This study outcome expected to give an oversight on STP effluent discharge effects to river and assist comprehensive action plans for river basin management. The research methodology briefly illustrated in flowchart in Fig. 6.

3. Results and discussion

Study river catchment is located in the most developed and populated area in Malaysia which encompasses the Federal Territory of Kuala Lumpur and part of the state of Selangor. It is approximately 120 km in length and the Klang river basin is about 1,288 km2 includes heart of Kuala Lumpur (Fig. 7). The upper catchment of the Klang River and its creeks at the Gombak and Batu Rivers are surrounded with well-maintained forests including Klang Gates Quartz Ridge in Gombak, Selangor bordering state of Pahang. The Klang River basin notable that spread across the Kuala Lumpur City Centre. Klang River has 11 main streams and sub streams but for this study only seven main Klang River tributaries branches deliberated of which include Gombak River, Batu River, Jinjang River, Keruh River, Bunus River, Ampang River and Kerayong River. The Fig. 7 shows the overall Klang River basin complete with its tributary networks with the study area boundary circled in red.

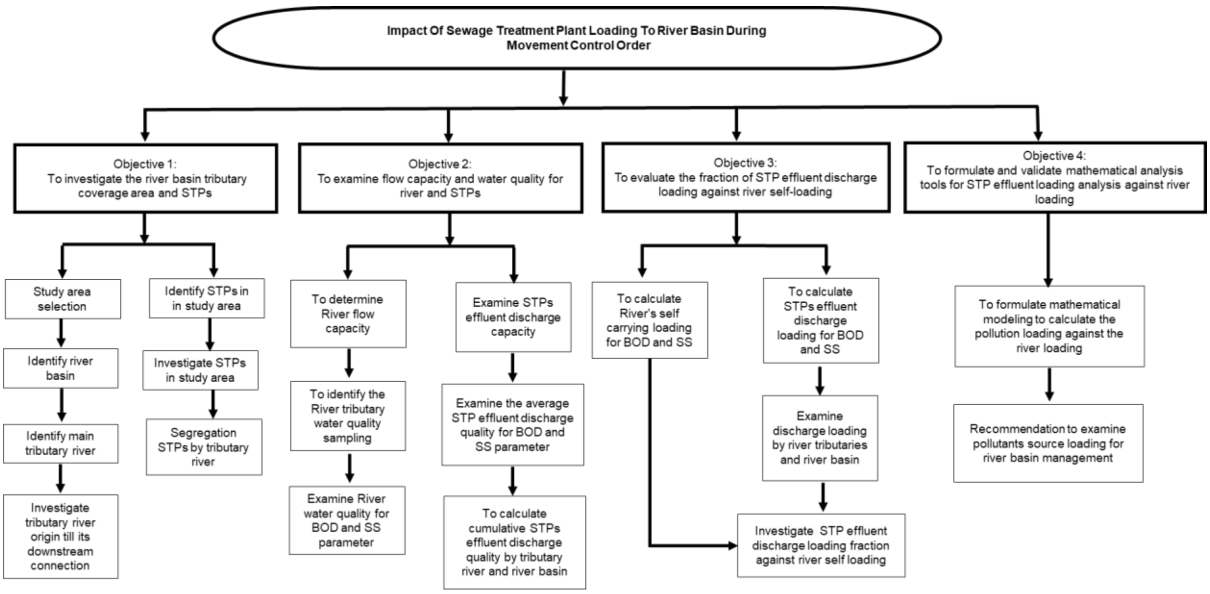

Fig. 6 Experiment flowchart.

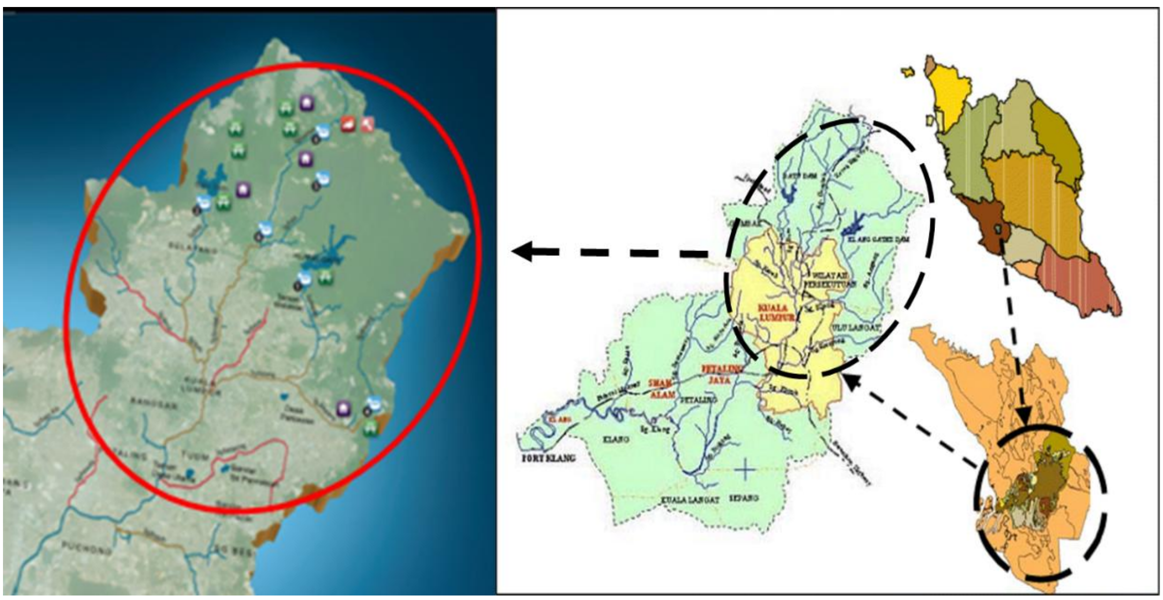

Fig. 7 Klang River catchment and its main tributaries.

The main tributary river and sub-tributary referred as Branch and Sub-branch respectively and arranged in sequence from upstream to downstream to ease study review as shown in Fig. 8 and Fig. 9.

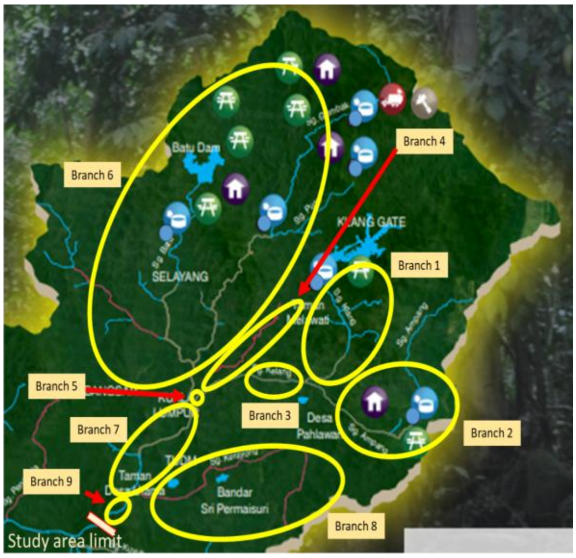

Fig. 8 Study river basin-Branch

Fig. 9 Gombak River with Sub-branch

The STPs that spread out within the study area identified and each identified STPs investigated on its effluent discharge route to trace its receiving tributary river to segregate the STPs according to its effluent receiving Branch river basin. The number of STPs spread with the Branch river basin varies depending localized sewerage catchment developments within the Branch river basin area. The zero number of STP signifies there is no STP within the Branch river basin due to either the area serve by individual septic tank (IST) or the areas located within the large connected sewerage catchment that served by Regional Sewage Treatment Plant (RSTP). The total number of STPs identified located with the study area is 316 STPs and summarised in Table 2.

3.1 STP effluent discharge flow capacity, water quality and loading

To investigate STPs effluent loading to river, two main data STP's effluent discharge volume and its effluent discharge concentration into river tabulated. Each individual STP's average effluent discharge volume and treated effluent quality tabulated and accumulated based its discharge tributary Branch River, summarised in Table 2. Noticeable number of STPs in Branch River does not dictate or influence the total cumulative PE, cumulative flow data and cumulative effluent discharge quality. The cumulative STP's effluent discharge volume and STP's treated effluent discharge quality data for BOD and SS by Branch River basin, analysed to calculate total cumulative STP effluent discharge loading for BOD and SS, summarised in Table 2.

3.2 River flow capacity, water quality and loading

The daily average river flow data for year 2020 from seven river monitoring station located within the study area obtained for river analysis flow analysis. The river flow monitoring station are first, located at confluence of Ampang River and upper section of Klang River (Confluence). Second, located at Jalan Tun Razak of Bunus River (JTR), in middle of city center. The third located at Taman Ceupacs of Keroh River (Ceupacs). The fourth located Jln Chendurah of Batu River. The fifth located at Jln Sultan Ismail of Gombak River. The sixth located at Jambatan Tun Perak of Klang River. The seventh located at cross section of Klang River at Jalan Klang lama (JKL). The JKL station is the most downstream monitoring station that situated at the end limit of study area. The total flow volume at JKL river monitoring station represent accumulations of flow from all tributaries, sub-tributaries and streams that directly or indirectly discharges into the Klang River. The selected average river flow data summarized in Table 3. During the 1st lockdown in early year 2020, as there still uncertainty on effects of Covid-19 and with limited resources due to strictest MCO implementation, sampling of river samples is a challenge. Due to unprecedented constraints, only four river point were sampled during the 1st MCO period and this enable four river self-loading analysis. The four river loading analysis summarized in Table 3. Figure 10 is actual visual of the Klang River water sample which taken during the 1st MCO period at Pantai Dalam, Kuala Lumpur.

Fig. 10 Klang River sample visual.

Table 2 Branch River basin with STPs, Cumulated flow, effluent discharge quality and Loading.

Branch	Main River	No STPs	Cumulative PE	Cumulative flow m3/day	BOD (mg/l)	SS (mg/l)	Loading BOD kg/day	Loading SS kg/day
1	Klang	32	217,715	48,985.88	15.5	23.3	757.20	1,140.62
2	Ampang	35	201,335	45,300.38	20.1	26.0	909.76	1,176.55
3	Klang	0	Nil	Nil	Nil	Nil	Nil	Nil
4	Bunus	4	480,442	108,099.45	2.9	3.7	309.52	401.65
5	Klang	0	Nil	Nil	Nil	Nil	Nil	Nil
6a	Batu	33	149,002	33,525.45	16.5	28.5	552.40	954.40
6b	Jinjang	38	264,099	59,422.28	23.5	35.0	1,394.26	2,082.06
6c	Batu	11	12,491	2,810.48	14.4	27.4	40.34	77.13
6d	Keruh	49	406,785	91,526.63	9.4	15.0	859.37	1,374.50
6e	Batu	0	Nil	Nil	Nil	Nil	Nil	Nil
6f	Gombak	14	82,350	18528.75	8.5	12.2	157.53	225.94
6g	Gombak	24	73,712	16585.20	14.3	20.9	237.73	347.27
7	Klang	0	Nil	Nil	Nil	Nil	Nil	Nil
8	Kerayong	74	749,308	168,594.30	21.7	27.2	3,655.01	4,586.46
9	Klang	2	1,425,229	320,676.53	4.2	7.4	1,358.37	2,371.54
	Total STP	316	4,062,468	914,055.32	**11.2**	**16.1**	10,231.49	14,738.12

Table 3 Branch River basin with STPs, Cumulated flow, effluent discharge quality and Loading.

River name	**Location**	**Flow measurement**	**Concentration (mg/l)**		**Loading (kg/day)**	
		(m3/day)	**BOD**	**SS**	**BOD**	**SS**
Sungai Klang	Sg.Klang Sg Ampang confluence	737,960.02	16	60	11,807.36	44,277.60
Sungai Bunus	Jalan Tun Razak	355,318.57	10	136	3,553.19	48,323.33
Sungai Keroh	Taman Cuepacs	3,188,366.19	10	24	31,883.66	76,520.79
Sungai Klang	Jln Klang Lama	9,521,015.56	6	20	57,126.09	190,420.31

3.3 Analysis of STP effluent loading to River

The STPs effluent loading on river by Branch River from Table 2 and Table 3 summarized in Table 4. The STPs BOD and SS loading on river in study are ranges from 3% to 18% for BOD and 2% to 8% for SS. The lowest loading percentage is Branch River 6d, Keroh River. The STP in the Keroh River catchments only contribute 3% BOD and 2% SS loading on to the Keroh River. High river flow volume in Keroh River directly contributing to the lower pollution loading to the river. Assumed the Keroh River catchment of had exceptional high rain volume compared with other River tributaries that contributed higher river flow volume and thus cause the STP effluent discharge BOD and SS loading lowest compared with other river tributaries. The downstream Branch 9, Klang River is the most important monitoring station for the study of which represent cumulative STPs discharge loading to the Klang River. The overall STPs in whole Klang River catchment including tributaries from Gombak and Ampang area contributes 18% BOD and 8% SS loading on to Klang River. Although all the 316 STP area spread across the whole catchment, assumed that all STPs effluent channelled to the monitoring station for the STP effluent discharge loading analysis. The total STPs in the study catchment contribute 18% BOD loading and 8% SS loading to the Klang River.

3.4 Mathematical model for river basin management

Management of water resources is important in ensuring water resource development, management and conservation carried out in line with environmental sustainable development plan.

As the river self-loading is measurable, the investigations of each type of pollutant loading is essential to identify the real or the actual big pollutant that contributing to river pollution. A simple specific mathematical modelling developed to ease tabulation and collation of all pollutant loading source both unregulated sewage effluent discharge and non-sewage discharge loading to the river basin. The identified pollutant sources such as privately owned STPs, ISTs, Communal septic tanks(CST), domestic sullage, squatters, commercial sullage, food stalls and eateries sullage, flood retention and detention pond discharges, agricultural activities, tourism activities, farming, poultry, regulated wet markets, unregulated markets, partial wet market, sand washing, construction site, industries, workshops, carwash, and other pollution sources relisted for development of mathematical loading modelling. The pollutant's BOD and SS or other parameter's concentration examined in term of milligram per liter (mg/l) as per depicted in Eq. (4). The pollutant source volume measured in term of meter cubic per day (m^3/day) as depicted in Eq. (5). If there is more than one same type pollutant that locates separately with the river basin, the cumulative concentration calculated as per depicted in Eq. (6). Then from the cumulative concentration, the pollutant source loading calculated as depicted in Eq. (7). If there is multiple pollutant type, each pollutant type examined its quality BOD and SS concentration, flow volume measured and its pollutant loading analyzed as depicted in Eq. (8) and (8.1).

Table 4 Summary of STP effluent loading on River by Branch River.

Branch	Main River	No STPs	STP Loading			River Loading			% of STP Loading on to River	
			Cumulative flow m3/day	BOD Kg/day	SS Kg/day	Flow measurement (m3/day)	BOD Kg/day	SS Kg/day	BOD	SS
Confluence	Klang	67	94,286.25	1,666.96	2,317.17	737,960.02	11,807.36	44,277.60	14%	5%
4	Bunus	4	108,099.45	309.52	466.73	355,318.57	3,553.19	48,323.33	9%	3%
6d	Keroh	49	91,526.63	859.37	1,374.50	3,188,366.19	31,883.66	76,520.79	3%	2%
9	Klang	316	914,055.32	10,231.49	14,738.12	9,521,015.56	57,126.09	190,420.31	18%	8%

1. Pollutant concentration BOD and SS examine $= aC$ mg/l (4)

2. Pollutant source volume meaure $= aV$ m^3/day (5)

where:
a = type of pollutant source
C = pollutant concentration
V = flow volume

3. Mix concentration (mg/l) $= \dfrac{aV_i \times aC_i + aV_{ii} \times aC_{ii}}{aV_i + aV_{ii}}$ (6)

where
aV_i = volume of pollutant source a, upstream source a
aV_{ii} = volume of pollutant source a, downstream source a
aC_i = pollution concentration source a, upstream source a
aC_{ii} = pollution concentration source a, downstream source a
If there is more same pollution source type separately, the concentration added according to number of sources.

4. Pollution loading/day $(\text{Kg/day}) = \dfrac{aV\left(\text{m}^3/\text{day}\right) \times aC \text{ concentration (mg/l)}}{1000}$ (7)

5. Multiple pollution type loading (kg/day), each type of pollution source listed for cumulative pollution loading analysis.

$$\begin{aligned}\text{Pollution Loading} = {} & (\text{public STP-a}) + (\text{privately owned STPs-b}) + (\text{ISTs-c}) \\ & + (\text{Communal septic tanks-c}) + (\text{domestic sullage-d}) + (\text{squatters-e}) \\ & + (\text{commercial sullage-f}) + (\text{food stalls and eateries sullage-g}) \\ & + (\text{flood retention and detention pond discharges-h}) \\ & + (\text{agricultural activities-i}) + (\text{tourism activities-j}) + (\text{farming, poultry-k}) \\ & + (\text{regulated wet markets-l}) + (\text{unregulated markets-m}) \\ & + (\text{partial wet market-n}) + (\text{sand washing-o}) \\ & + (\text{construction site-p}) + (\text{industries-q}) + (\text{workshops-r}) \\ & + (\text{carwash-s}) + (\text{and other pollution sources-t}) + \ldots\ldots\end{aligned} \tag{8}$$

$$\text{Pollution loading} = \frac{aV \times aC}{1000} + \frac{bV \times bC}{1000} + \frac{cV \times cC}{1000} + \cdots + \frac{xV \times xC}{1000} + \cdots \tag{8.1}$$

Then river self-loading examined by measuring the total river volume that flow is a day multiply with river water quality concentration for BOD and SS. The River self-loading analyzed.

$$\text{River self-loading } (\text{kg/day}) = \frac{riverV\left(\text{m}^3/\text{day}\right) \times riverC\,(\text{mg/l})}{1000} \tag{9}$$

The Pollution loading by the pollution sources against the River loading?

$$(\text{if only one pollution source}) \tag{10}$$

$$= \frac{\text{Pollution loading } (\text{kg/day})}{\text{River self-loading } (\text{kg/day})} \times 100$$

When there is multiple pollutant source, cumulative loading of each individual pollutant type derived and examine as shown in Eq. (11) and Eq. (11.1).

$$\text{Accumulative loading} = \frac{(\text{public STP}) + (\text{private STP}) + (\text{IST}) + (\text{CST}) + (\text{domestic sullage}) + \cdots}{\dfrac{river\text{V}\left(m^3 / \text{day}\right) \times river\text{C}(\text{mg/l})}{1000}} \tag{11}$$

$$= \frac{\dfrac{(aV \times aC)}{1000} + \dfrac{(bV \times bC)}{1000} + \dfrac{(cV \times cC)}{1000} + \dfrac{(dV \times dC)}{1000} + \cdots}{\dfrac{river\text{V}\left(m^3 / \text{day}\right) \times river\text{C}(\text{mg/l})}{1000}} \tag{11.1}$$

where

V = pollutant volume
C = pollutant concentration
*river*V = River volume
*river*C = River pollution concentration
alphabet = different type of pollutant source

Some of the pollutant type not easily to be classified and examined its loadings due to nature of discharge complexity. A mechanism need to be identified to measure and examine the loadings by individual type, otherwise a comprehensive river basin management plan could not be formulated. The discharge pattern from each premises examined of its discharge quality, quantity and its collective loading to the river. With detailed various pollutant loading source established, will ease the action plan for better river basin management.

4 Conclusions

This study aimed to identify the STP effluent discharge loading to river during the MCO period. There many studies reported that more than half of the river pollution is by STP effluent loading. While all activities had been stopped or halted except essential service including sewerage services during the MCO, this study investigate actual fraction of STP effluent loading to river. The study concludes that STPs effluent discharge loading to the Klang River basin within Kuala Lumpur City Center constitute of 18% BOD loading and 8% SS loading. The Klang River basin results, of which constitute mixed development with residential, commercial, industrial and others can be taken as benchmark for matured developed area. For an all-inclusive river basin management, a comprehensive and thorough study suggested via mathematical modelling examine the actual source of the balance loading of 82% BOD and 92% SS loading in the river.

Based on the above conclusions, an all-inclusive comprehensive river basin management plan recommended to identify the balance gap loading.

i. The other pollution sources which is estimated 122 in numbers (Luas, 2016) to be investigated technically to identify the actual loading compositions by each pollutants to establish actual loadings by each pollutants.
ii. Among the pollutant sources that identified for detail investigation are privately owned STPs, ISTs, Communal septic tanks, domestic sullage, squatters, commercial sullage, food stalls and eateries sullage, flood retention and detention pond discharges, agricultural activities, tourism activities, farming, poultry, regulated wet markets, unregulated markets, partial wet market, sand washing, construction site, industries, workshops, carwash, and other pollution sources.
iii. The type of pollution sources reclassified, investigated and analyzed for its loading to rivers.
iv. All point source and non-point source drivers work as team in providing required data for the establishing its pollution loading for river basin management.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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