JOWRM

Journal of Water Resources Management

Journal homepage: https://journal.water.gov.my

e-ISSN: 2811-3578

Klang River System Water Quality Modelling and Improvement for the River Of Life (ROL)

Wai Sam Wong[1,a], Chow Hock Lim[2,b] , Nik Mohd. Kamel Nik Hassan[1,c *]

[1]Dr. Nik & Associates Sdn. Bhd, 53300 Kuala Lumpur, Malaysia
[2]Department of Irrigation and Drainage, 50626 Kuala Lumpur, Malaysia

Email: [a]wong@drnik.com.my , [b]chow@iahr.com.my , [c]nikkamel@drnik.com.my

Received 10 September 2023; Accepted 20 November 2023; Available online 25 December 2023.

Abstract: The water quality of the Klang river system has declined due to pollution sources like sewerage cffluent, industrial effluent, untreated discharge from restaurants, wastes and cfflucnts from wet markets and commercial outlets, and large quantities of solid wastes (litter and rubbish) etc. One of the main objectives in the River of Life (RoL) project is to improve the water quality to Class IIB especially along the 10.7 km of rivers within the river beautification stretches of Gombak river and Klang river.

In order to proposc any improvement to the river water quality, a comprehensive water quality modelling was carried out for the river system with the existing conditions through a process of thorough data collection of pollution sources, analysis of river flows during various seasons (return flows are significant during low flows), model calibration and verification, etc. With the calibrated model setup, various structural measures were tested and evaluated for their effectiveness before the optimum solution was adopted. The proposal also has recommended various non-structural measures to complement the structural measures.

Keywords: Source Controls, Water Quality Modelling and Improvement

1. Introduction

In general, the present water quality of most stretches of the rivers in the River of Life (RoL) area as shown in Figure 1 is of Class III and IV in the National Water Quality Standards (NWQS). The high sediment and solid waste loads as well as BOD and ammoniacal nitrogen loads in the Klang river and its tributaries have rendered these urban waterways unsuitable for body contact and recreational activities, besides causing adverse impacts on the ecological health of the rivers. One of the main objectives within the Greater Kuala Lumpur River of Life (RoL) project is to enhance, rehabilitate and preserve the Klang river and its tributaries to achieve water quality Class IIB (suitable for body-contact recreational usage) by year 2020.

This paper is to present the water quality modelling work that has been carried out toanalyse the existing water quality conditions along the Klang river system as well as touse the model to evaluate various measures and options to improve the river water quality to the desired levels.

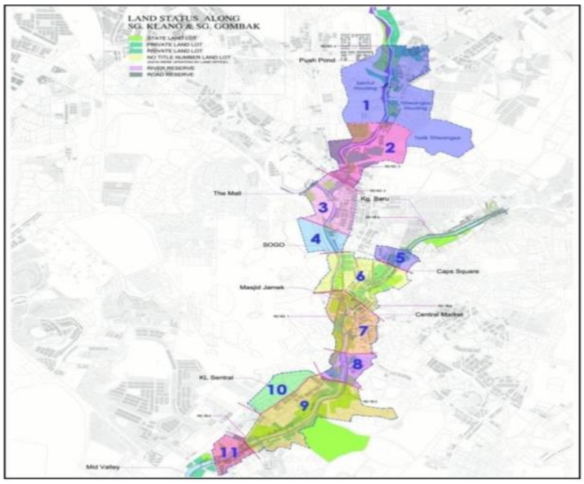

Figure 1. Location Plan of River of Life (RoL) Project.

**Corresponding author: wong@drnik.com.my*

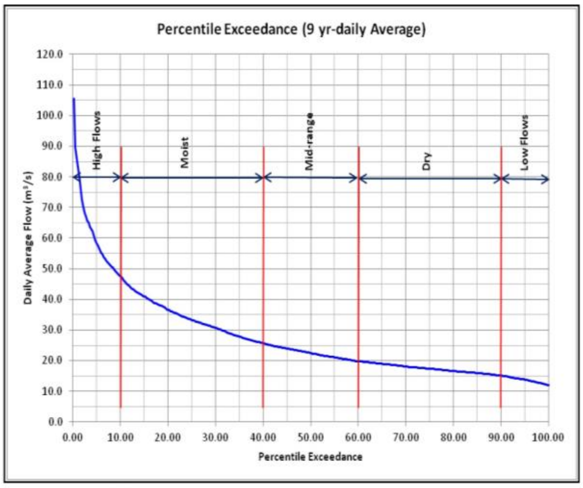

Figure 2. Plot of discharge against percentile exceedance at Klang river, Mid-Valley

WATER QUALITY MODELLING

InfoWorks RS was used to model the water quality for this project. The critical water- quality parameters that are modelled include Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH, Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH;3N) and Total Suspended Solids (TSS) so that they also can be used to calculate the Water Quality Index (WQI) based on the Department of Environment Malaysia Water Classification (DOE, 2012). The point source pollution has the greatest impact to river water quality in the project area and considerable effort was focused on point source pollution estimation and reduction. It is envisaged that non-point pollution will be reduced in tandem with the effort to reduce point source pollution and therefore is of lesser importance at this point in time.

Data Collection and Calibration

Extensive effort had been put in to collect point source pollutant samples throughout the project area for various types of contributors including discharge measurement, interview with the operators, water bills, etc. besides other secondary data from the sewerage treatment plants and regulated industrials. With the data collected from various sources, the water-quality model was calibrated with the observed water-quality data during low flows from the Department of Environment (DOE) in 2008 and 2009 and verified using the DOE 2010 and 2011 data. With the model calibration and verification, the resulting point source loadings based on the types contributed from the catchment area upstream of Klang river at Mid-Valley are shown in Table 1.

Type	BOD (kg/day)	COD (kg/day)	TSS (kg/day)	NH_3N (kg/day)
STP + Sewage	5,662	19,909	9,277	4,779
Food	2,959	13,707	3,129	94
Institutional	1,543	8,181	2,994	386
Industry	742	6,954	1,023	53
Workshops	453	3,881	2,023	40
Wet Market	419	1,141	660	29
Commercial	240	1,370	73	4
Squatters	237	1,766	916	122
Carwash	200	797	562	13
Residential	138	676	87	14
Landfill	42	215	92	1

valley.

Existing River Water Quality

Under the 90™ percentile low-flow and the calibrated pollutant loads, the concentrations of the pollutant parameters at key locations along the river system are listed in Table 2 and the WQI are indicated in Figure 3. To achieve the Class [IB water quality, great effort is required to reduce all the point source effluents to the minimum. From the above evaluation and analysis, it is found that while the existing condition of Klang river at Mid-Valley has a WQI of 54%, the target is to achieve minimum WQI of 76.5% for Class II water quality.

Location	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	NH_3N (mg/l)
Gombak River– At Upstream of Batu River Confluence	3.5	15.7	40.1	1.8
Gombak Rvier – At Upstream of Klang River Confluence	9.1	44.8	53.1	4.2
Klang River – At Downstream of SMART Barrage	11.2	44.9	36.8	5.8
Klang River – At Upstream of Gombak Confluence	12.4	52.1	46.2	5.0
Klang River – At Mid-Valley	9.7	45.2	50.6	4.3

Table 2. 90 Percentile Low-Flow Pollutant Concentrations at Various Key Locations

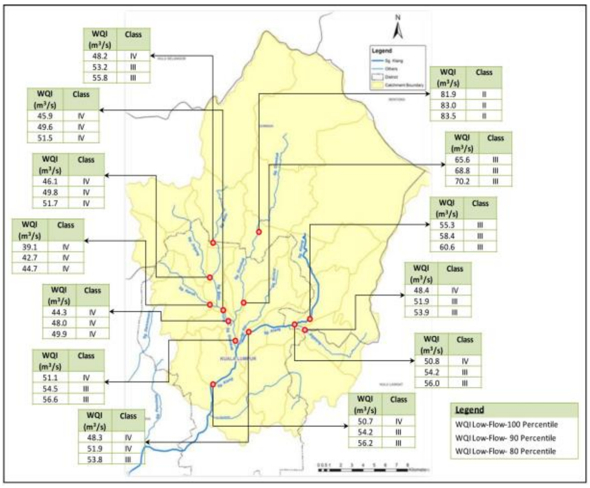

Figure 3. WQI at key locations during different low-flow conditions

There are twelve key initiatives formulated in the inception of the RoL to improve the water quality and to reduce the sedimentation, rubbish and debris in the river system. The key initiatives are being implemented by various government agencies and involve works such as upgrading and expanding the existing and new sewerage facilities and treatment plants with effluent discharges to meet Standard A; treatment of wastewater for wet markets; installation of FOG traps, GPT and River Water Treatment Plants (RWTP); monitoring and enforcement; establishment of erosion control and sedimentation ponds, upgrading of rubbish disposal system, relocation of squatters, public outreach programs, etc. The structural measures of the key initiatives were modelled based on the same low-flow conditions and found that the WQI in Klang river at Mid-Valley can be improved from 54% to 66%. The WQI for the river system are as given in Figure 4. As can be observed, all the stretches of the river system within the city centre are still Class 111.

One of the main reasons is the effluent discharge limit allowed for Sewerage Treatment Plants (STP) in the RoL areas is set to Standard A Category 1 as in the EQ(S)R 2009. From the analysis of the existing pollution loads, sewage contributes as much as 45% of BOD and 86% of NH:;N. The performance of these STP systems is crucial in determining the water quality of the Klang river system as sewage effluent forms the main load input into the system for point source. During dry weather, about a third of the river flow is composed of discharges from the return flows of various pollution sources. Thus, at the most, the dilution factor available for all discharges from STPs is three. Even if the STP effluent discharge meets the Standard A Category 1 river discharge limits, the dilution required in order to meet Class IIB river water quality ranges from 5 to 34 times, depending on the type of pollutants as listed in Table 3. Thus, with only three times dilution available for the Klang river system during dry weather, it is not possible to meet Class IIB river water quality for this river system without further treatment to remove the extra BOD, COD and nutrients. Other main factors that aggravate the river water quality are sullage water from eatery areas and restaurants as well as the wastewater from the workshops and SMI (Small & Medium Industries) that discharge directly into the river system without any treatment.

Parameter	Unit	EQ(S)R 2009 (Std A Cat 1)	NWQS Class II	Dilution Required to Meet Class II
BOD	mg/L	20	3	7x
COD	mg/L	120	25	5x
TSS	mg/L	50	50	0x
NH_3N	mg/L	10.0	0.3	34x

Table 3. Comparison of EQ(S)R 2009 Standard A Category 1 Levels with NWQS Class IIB Levels

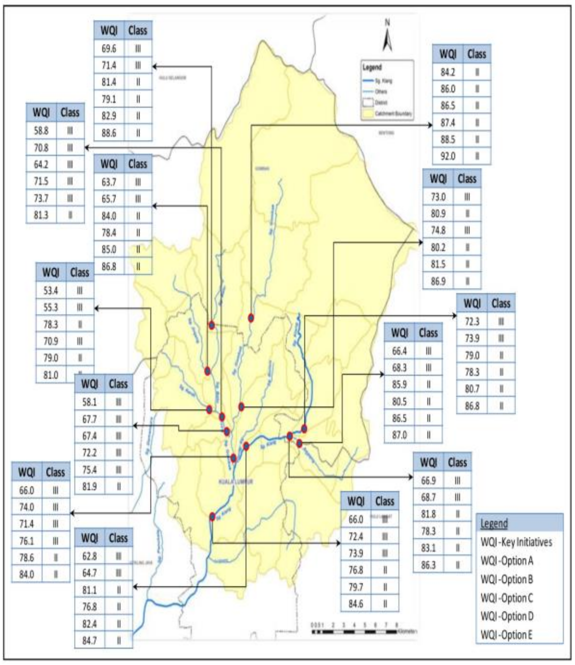

Figure 4. WQI at key locations with Key Initiatives and Proposed Options

WATER QUALITY IMPROVEMENT

The conceivable measures can be generally categorised as non-structural and structural measures. Among the examples for non-structural measures are :-

- Load prevention and reduction at source normally this can be achievedthrough awareness, education, legislation, enforcement, as well as bettertechnologies, housekeeping and waste management.

- Relocation of major polluters this measure is to identify major polluters whose effluents are very costly to be further treated and need to be relocated away to other catchment that has much higher flows available for dilution. Among the examples for structural measures are :-

- Treatment of all point source pollutants to achieve the required standard or in meeting the river system's TMDL (Total Maximum Daily Load).

- Diversion of effluent discharges from STPs to other catchments when the effluent cannot meet the required standard of the river system's TMDL.

- Intercepting flows at the drainage outlets with combined sewer overflow (CSO)so that during low-flow, the sullage and effluent discharges from point sources can be diverted to the treatment plants for treatment.

- Dilution of river pollution concentrations through the release of clean water from reservoirs and lakes during low-flow conditions to meet the desired standard.

After evaluated the above options, the most feasible structural measures to be adopted to improve the water quality in the RoL area are treatment of all point sources at source through pre-treatment and connection to the centralised sewerage treatment system. The non-structural measures through load reduction will be emphasised and will be an added bonus to the structural measures implemented and for its long-term sustainability. The adopted measures for the RoL are in line with the system used in advanced countries that has been proven to be effective.

Proposed Options and Recommendations

Hence, to achieve the RoL objectives, five options on top of the 12 Key Initiatives have been proposed for model analysis to improve the river water quality. The options are as given below:

- Option A- The effluents of the 2 Regional STPs at Bunus and Jinjang to be upgraded to Class IIB

- Option B- All STPs' effluents maintained at Std. A Cat.1 + 80% trade waste to betreated

- Option C- The effluents of the 2 Regional STPs to be upgraded to BOD =7.5, COD =50, TSS =50 & NH3N = 2 & the rest of the STPs to be upgraded to Std. A Cat. 1 + 60% trade waste to be treated

- Option D- The effluents of the 2 Regional STPs to be upgraded to BOD =7.5, COD = 50, TSS = 50 &

NH3N = 2 & the rest of the STPs upgraded to Std. A Cat. 1 + 80% trade waste to be treated

- Option E- The effluents of the 2 Regional STPs to be upgraded to Class IIB + the rest of the STPs to be upgraded to BOD =5, COD = 60, TSS = 50 & NH3N=2 + 80% trade waste to be treated

Figure 4 shows the WQI at key locations along the river system for the 5 options. Although Option E provides the best river water quality, the cost involved is very high and to require the STP effluents to meet Class IIB is technically very difficult with the limited space available for the plants. The more pragmatic option to be adopted is Option C where it can provide a reasonable good water quality and requires reasonable budget to be implemented. In the above endeavour, it is to be emphasised that besides all the measures proposed in Option C, an equally important list of tasks that need to be carried out to finally achieve the longterm sustainability of RoL project are as follows:

- Relocation of all the remaining squatters.
- Septic tank and private plant effluents as well as individual treatment units from situations should be connected to nearby sewerage system for further treatment.
- Relocation of all road side stalls that involve the usage of water for food preparation and washing to designated food courts that have proper pre-treatment facilities and connections to nearby sewerage system.
- All the remaining wet markets should be installed with proper pre-treatment facilities and connection to a nearby sewerage system;
- All the small and medium industries as well as workshops that produce a significant amount of effluents but do not fall under the jurisdiction of DOE should be regulated by local councils and should have pre-treatment facilities before discharging into nearby sewerage system;
- Laundrettes, car wash centres, restaurants, food courts and other businesses in the commercial areas that have significant sullage and effluent discharges shouldhave pre-treatment facilities and connection to a nearby sewerage system;
- All illegal by-pass connections from residents' kitchens and wash areas to the adjacent drainage systems should be rectified. This can be carried out through awareness campaign for the owners and enforcement by the local authorities;
- At all the construction sites, full implementation of the erosion and sediment control plan should be enforced to control the TSS level to the required level;
- Implementation of the storm water management plan by local councils for thewhole RoL areas;
- Promoting awareness in good housekeeping and cleanliness as well as prohibiting activities and storages that can generate high pollutants runoff when exposed to rainstorm; and
- Non-structural measures such as stringent enforcement, public awareness and educations, capacity buildings, amendments to certain regulations, legislation and institutional arrangement, etc.

CONCLUSIONS

Water quality modelling requires extensive data collections and analyses, model calibration and verification as well as the river flow conditions in order for the proposed improvement measures to be evaluated effectively. The RoL project is one of the great efforts by the Government of Malaysia to improve the deteriorating river water quality in the city of Kuala Lumpur. Many structural measures that incur high costs have been proposed and are being implemented to achieve the project objectives, especially on the centralisation and upgrading works for the existing sewerage systems as well as many other efforts highlighted above including operation and maintenance of the said measures. Since the poor quality of river water is solely caused by human activities, equally important are the non-structural measures such as public awareness, education, capacity building, enforcement, legislation, regulation, etc. to ensure the long term sustainability of the systems implemented, more so for Kuala Lumpur city where the population is still increasing.

ADKNOWLEDGEMENT

The authors would like to thank Jabatan Pengairan dan Saliran Malaysia, under The Study on Water Quality Improvement and Hydrological Assessment for the Klang River System for allowing this paper to be presented. The authors would also like to express their gratitude to all the team members from Dr. Nik & Associates Sdn. Bhd. who were involved in the study.

REFERRENCE

[1] Caboolture ~~ Shire Council, Queensland, Australia (2005) "Environmental Management Plan & Trade Waste Policy"

[2] Department of Environment, Malaysia (2012), "Malaysia Environmental Quality Report"

[3] Department of Irrigation and Drainage, Malaysia (2002), "Klang River Basin Environmental Improvement and Flood Mitigation Project", prepared by Dr. Nik & Associates Sdn. Bhd. in association with DHI and SMEC.

[4] Department of Irrigation and Drainage, Malaysia (2012) "Study on Water Quality Improvement and Hydrological Assessment for the Klang River" prepared by Dr. Nik & Associates Sdn. Bhd.

[5] Environmental Protection Agency, United States (1995) "Technical Guidance Manual for Developing Total Maximum Daily Loads"

[6] Environmental Protection Agency, Ireland (1997) "Wastewater Treatment Manual — Primary, Secondary and Tertiary Treatment"

[7] Environmental Quality (Sewage) Regulation (2009) Malaysia