Assessment of microorganism pollution of Selangor River, Malaysia

Faridah Othman [1], Md. SadekUddin Chowdhury[1], and Nobumitsu Sakai [2]

***Abstract*—** In concern with sanitary state of water bodies used for drinking water supply, recreational activities and harvesting seafood due to a potential contamination by pathogenic bacteria, microbial pollution in aquatic environments is one of the crucial issues. Rapid development and urbanization may contribute the microbial pollution in the Selangor River, Malaysia. This study focused on the evaluation of microorganism pollution in the Selangor River watershed. Water samples were collected along the Selangor River and its tributary and determined total coliform and Escherichia coli (*E.coli*). According to the findings of this study, the highest of *E.coli* was found in the urban area (Rawang sub basin) followed by industry, residential and agricultural area respectively. The results of the present investigation revealed that, the Selangor river water at Rawang sub basin was greatly affected by microorganism due to point and non-point sources of pollution. Therefore, holistic countermeasure for microorganism pollution control is necessary for both point and non-point sources.

***Keywords*—** Selangor River; Coliform; *E.coli*; water quality.

I. Introduction

PATHOGENIC bacteria in water sources are risk to human health and microbial study is essential. Although at the origin of numerous outbreaks of gastrointestinal diseases and public health concerns, microbial contamination is rarely considered [1], it was reported that a lack of studies concerning waterborne diseases correlated with extreme events such as droughts and floods [2]. Despite a regulatory framework, microbial quality is often a source of impairment of the compliance of drinking water supply [3], Furthermore, climate change would be amplified microbial pollution of water quality which requires more regular basis studies [4], [5]. The goals of river water quality monitoring consist in directly targeting the sources of contamination, by using simple and quick indicators but are mainly focused on parameters such as faecal bacteria (*E. coli* or *Enterococci*). Enteric viruses, that play a major role in waterborne diseases, are rarely investigated due to the detection limits of commonly applied methods [6], [7]. Coliforms are bacteria that are always present in the digestive tracts of animal, including humans and are found in their wastes. Total coliform include bacteria that are found in the soil, in water that has been influenced by surface water. *E. coli* is the major species in the fecal group coliform group. Consequently, *E. coli* is considered to be the species of coliform bacteria that is the best indicator of fecal pollution and the possible presence of pathogens [8]. Therefore, the presence of coliform bacteria indicates that other pathogenic organisms of fecal origin may be present.

According to Interim National Water Quality Standards (INWQS), the total coliform and *E. coli* presence are high and harmful for outer body contact.

Microbial contamination in to the water is often of faecal nature related to humans such as water sewage treatment plants, combined sewage overflow, non-collective sewage systems, domesticated animals (manure spreading, pit stock overflow), or wildlife. The main origins of microbial contamination of natural aquatic resources are the point source such as discharges of water treatment plants, decontamination stations, hospitals, industries. Correlation between pathogens concentrations and urban activities is well documented e.g.,[9],[10]; and non-point sources are also considered. The abundance and importance of pathogens in water depend on factors such as the contamination level, pathogens' persistence in water bodies, biological reservoirs (including aquatic plants and sediments) and the ability of pathogens to be transported [11]. The land use management practices and the size of the watershed also influence the survival of microorganisms [12]-[14]. This study focused on the evaluation of microbial water quality pollution in Selangor river watershed because of its importance as approximately 60% of water consumption in Selangor and Kuala Lumpur is sourced from the Selangor River [15].

II. Materials And Methods

A. Description of Study Area

Selangor river basin is located within the state of Selangor. The catchment area is about 2200 km^2 - covering approximately 25% of Selangor state. The main tributary of the Selangor River starts at the border between the states of Selangor and Pahang at an elevation of 1700m. The Selangor River flows in a southwesterly direction traversing a total distance of about 110 km before discharging into the Straits of Malacca at the town of Kuala Selangor. Among the main tributaries are Sungai Batang Kali, Sungai Serendah, Sungai

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Buloh, Sungai Kerling, Sungai Sembah, Sg Kundang and Sungai Rawang. The map of Selangor river basin is shown in Fig. 1 below. Half of the basin area is still covered by natural forest and another 22% by agricultural activities.

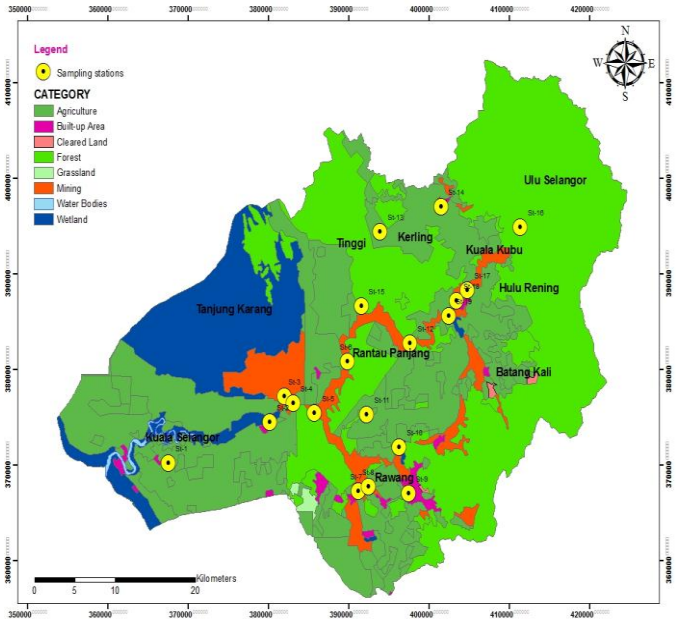

Fig. 1. Land use and sampling stations at Selangor River Basin.

B. Sampling

Sampling was conducted in 17th December 2013. Nineteen river water samples were collected from the selected sampling stations along the Selangor river watershed as shown in Fig.1. The selected sampling stations (St) representing the surrounding areas of the Selangor river basin. St-4, 5, 6, 7, 8, 9 and 11 are located in Rawang sub basin. Rawang sub basin is the mostly populated, urbanized and industry area. St-1 is located at a most downstream site close to the estuary.

C. In-Situ Analysis

The chemical and physical variables of the river were measured directly at each sampling station. These included temperature, dissolved oxygen (DO), conductivity, pH, and turbidity. All the samples collected from the field were kept in cool room at a temperature below 4°C to reduce all the activities and metabolism of the organisms in the water. *In-situ* parameters was measured by handheld multipara meter instrument (YSI, Inc. USA) and turbidity meter 2100P (HACH, Inc. USA). The equipment's were calibrated prior to use based on the manufacturer's directions.

D. Laboratory Analysis

Microbiological test were carried out at no later than 24 hours from the sampling by following the MPN method [16]. Autoclaved distilled water was prepared for dilution of the water samples. The medium (Colilert®) was added to each 120ml Shrink-Banded Vessels without sodium thiosulfate containing sample and the bottles were sealed and shaken to dissolve the medium. Each bottle was then poured into a 97-Well Quanti-Tray/2000 and sealed with a Quanti-tray sealer. The trays were incubated at 36 ^{0}C for 24 hours, and the number of positive well was counted which stands for those which emit fluorescence in UV light for *E. coli* and which are colorized yellowish in visible light for total coliform The number of positive wells was converted into a most-probable number (MPN) using an IDEXX-supplied calculation sheet. In addition, Biochemical Oxygen Demand (BOD), and Ammonical Nitrogen (NH_3-N) were also analyzed by standard methods.

III. Results and Discussion

In situ result from this study are summarize in Table (I). The range of water temperature along the Selangor river watershed was 27.10 ^{0}C to 31.80 ^{0}C. The DO at the upstream of Selangor River was good but downstream was low. The lowest DO was detected at St-8 and highest was at St-14. Less values of DO may be due to low flow of stream and incoming wastewater from the surrounding area. The lowest pH was detected at St-3. Due to peat land surrounding area of Air Hitam River at St-3 the pH value was low. The area of peat swamp is known by low water pH values and has extreme acidic environment [17]. The maximum value of conductivity was recorded at St-8 (188 µS/cm) and the minimum was recorded at St-14 (26 µS/cm). The highest and lowest turbidity was detected at St-5 and St-1 respectively. Comparison with National Water Quality Standards for Malaysia[18] showed that in all sampling stations the temperature were in the normal range, pH was in class IIA, electric conductivity was in class I, dissolved oxygen was in class III, and Turbidity was in class IIB. It was reported that levels of coliforms had close relationships with pH, temperature, suspended solid, organic and inorganic nutrients in water [19].

TABLE I
IN-SITU ANALYSIS RESULTS.

Station	TEMP (^{o}C)	DO (mg/l)	pH (-)	Conductivity (µS/cm)	Turbidity (NTU)
St-1	27.10	4.02	5.08	184	6.10
St-2	27.10	4.96	6.08	72	73.00
St-3	28.10	3.72	3.81	54	87.80
St-4	28.40	4.90	6.13	74	68.60
St-5	28.30	4.19	6.33	121	211.00
St-6	30.10	6.26	6.16	42	23.50
St-7	29.30	3.59	6.25	147	60.70
St-8	30.10	3.51	6.51	188	25.20
St-9	29.60	4.66	6.46	125	51.70
St-10	31.00	6.54	6.33	70	61.20
St-11	31.80	5.55	6.19	117	17.30
St-12	29.20	7.05	6.21	49	33.70
St-13	29.60	6.05	5.86	30	9.20
St-14	28.70	7.20	6.16	26	7.20
St-15	31.60	6.39	5.45	31	10.10
St-16	28.60	7.18	6.35	28	9.40
St-17	28.60	6.41	6.07	29	17.20
St-18	29.30	7.10	6.24	37	10.30
St-19	29.50	6.27	6.09	54	14.00

Total bacteria and *E. coli* were detected and given in Fig.2. The number of total coliform at all stations was in the range of $5.4x10^2$ MPN/100ml to $6.4x10^5$ MPN/100ml. The number of fecal coliform (FC) or *E. coli*, was between from to$1.4x10^2$ MPN/100ml to 1.0 x 10^6 MPN/100ml. The number of *E. coli* was generally low at the upstream of the Selangor river basin, but in some of the stations of the middle stream it was extremely high.

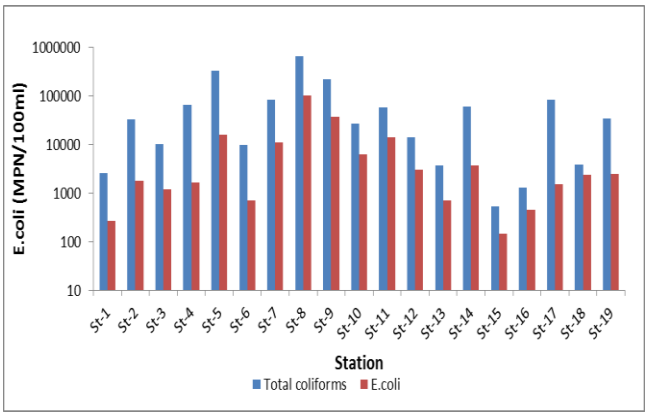

Fig. 2. Variation of total coliform and *E. coli*; among the sampling stations.

The highest number of total coliform (6.48 x 10^5 MPN/100ml) and *E. coli* (1.00 x 10^5 MPN/100ml) were observed in the St-8. Fig.2 shows that the *E.coli* results widely varied among the sampling stations. The *E.coli* number was significantly high at St-5, St-7, St-8, St-9 and St-11. The maximum number of *E.coli* was detected at St-8 (1.00 x 10^6 MPN/100ml). St-5, St-7, St-8, St-9 and St-11 are located at Rawang sub basin (Fig. 1) which represents the main river for urban wastewater discharge, effluents from septic tank and industrial effluent within Rawang industrial areas. The reasons of such high *E.coli* may be due to the direct discharge of wastewater from septic tank, STP and industrial wastewater to the river from the surrounding area. The lowest *E.coli* was detected at St-16 as it is located upstream of Selangor River and very close to Selangor dam.

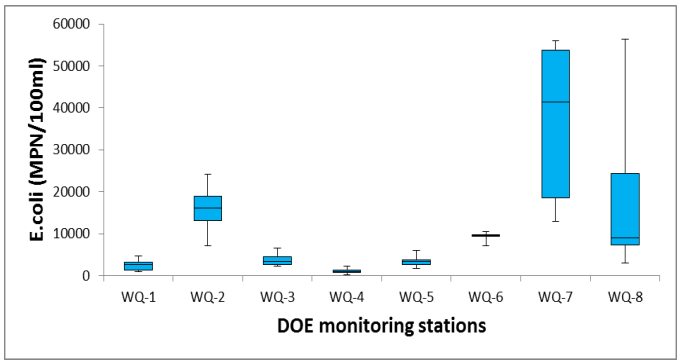

Fig. 3. Box–whisker plots of DOE *E.coli* data from the year 2005 to 2010(Source: DOE,Malaysia).

Department of Environment (DOE) water quality monitoring network in the Selangor Basin includes 9 manual sampling stations, and three of them (WQ-6, WQ-7 and WQ-8) are located in Rawang sub basin of the Selangor river basin. *E.coli* data from the year 2005 to 2010 of eight DOE water quality monitoring stations were available for analysis. The analysis (Fig. 3) shows that *E.coli* results widely varied among the monitoring stations, the number of *E.coli* was significantly high at monitoring stations WQ-2, WQ-6, WQ-7 and WQ-8. The annual average maximum number of *E.coli* (5.64x10^4 MPN/100ml) was detected at DOE monitoring station WQ-9. Box–whisker plots (Fig.3) shows that *E.coli* were extremely high at WQ-2, WQ-6, WQ-7 and WQ-8 which are located in the Rawang sub basin of Selangor River basin

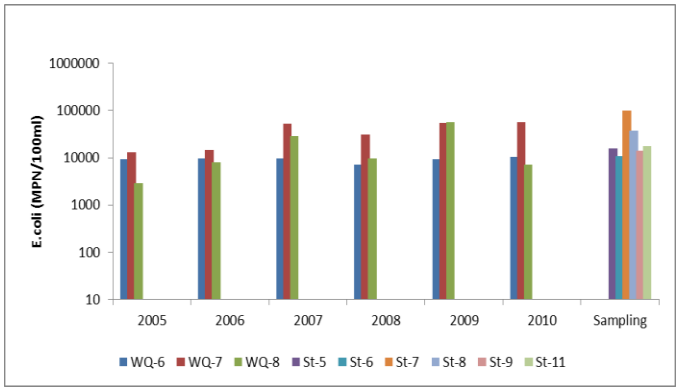

Fig. 4. Comparisons of *E.coli* results between DOE monitoring station and sampling of Rawang sub basin of Selangor watershed.

The number of *E.coli* exceeded the limit of NWQS at all three DOE monitoring stations at Rawang sub basin and shows an increasing trend of *E.coli*. In particular, the number of *E.coli* in WQ-8 was the highest from the year 2005 to 2010. In the year 2007 the numbers of *E.coli* was 5.22 x 10^4 MPN/100ml and increased $5.43x10^4$ MPN/100ml and $5.59x10^4$ MPN/100ml in the year 2009 and 2010 respectively. The present study also showed a similar trend of *E.coli* in Rawang sub basin of the Selangor basin.

In, comparison with the DOE historical data, it is clear that Rawang sub basin was greatly affected by microorganism due to point and non-point sources of pollution such as effluents from septic tank including industrial effluent which has no disinfection process and/or fertilizer spread to agricultural land.

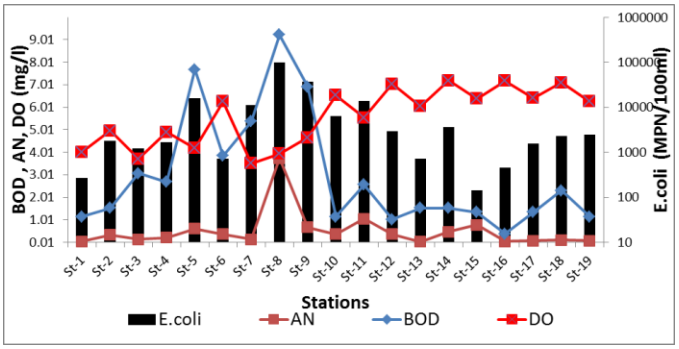

Fig. 5. Comparison of the *E.coli*, BOD, DO and NH_3-N.

Fig. 5 shows observed water quality in each sampling station. BOD result showed that St-5, 8 and 9 were in class-IV, St-3, 6 and 7 were in class-III and all others stations were in class-II according to DOE water quality index classification. The maximum BOD value was detected at St-8 (9.23 mg/l). It

was suggested that the high BOD and number of *E.coli* were found in the urban area (*i.e* Rawang sub basin of the Selangor river basin), whereas low values were found in rural area (*i.e* mostly forested area of the Selangor River basin). Ammoniacal nitrogen (NH_3-N) was also high at the Rawang sub basin. In contrast, DO was recorded low where the BOD and number of *E.coli* showed high. According to DOE water quality index classification, St-8 was categorized as class-V, St-11 was categorized as class-IV, while St-1, 16, 17, 18 and 19 were categorized as class-I and all other stations are in class-III.

Thus, BOD, DO, NH_3-N and *E. coli* were interdependent. If there was a large quantity of organic waste in the water supply, there would be enormous number of bacteria as the high nutrient concentration led to growth of microorganisms. Accordingly, the degradation of organic matters and respiration of bacteria decreased dissolved oxygen concentration in water body, and BOD increased as it is a parameter of the oxygen consumed by the microorganisms. In addition, the DO reduction would lead to low nitrification rate in water body as DO is a key factor for nitrification-denitrification process of nitrogen.

IV. CONCLUSION

This study showed that urban area was greatly contaminated by the excessive number of total coliform and *E. coli*. The presence of the contamination was due to the existence of many sewage discharges along the river, which carried effluents from septic tank including industrial effluent which has no disinfection process. The results of this study indicated that the main sources of pollution of the Selangor river basin were obviously from anthropogenic activities such as industrial wastes and effluents, slaughter house or abattoirs, agricultural activities and landfills. In particular, it was clear that the most polluted area by both point and non-point sources pollutions were Rawang sub-basin where a large amount of urban wastewater as well as industrial effluent was discharged. Therefore, immediate action to address the water issues in this Rawang sub-basin is considered to be extremely important. The output of this study could be an environmental reference for water pollution control and assist for the formulation of policies towards sustainable water management. Further studies are necessary to identify the exact pollution sources and simulate the water pollution to clearly reveal its reason as well as to assess the future scenario.

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