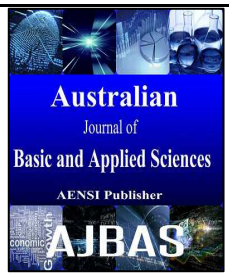
ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com



Recreational Water Quality Assessment at Selected Waterfalls in Selangor, Malaysia

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ARTICLE INFO

Article history:
Received 10 January 2016
Accepted 15 February 2016
Available online 28 February 2016

Keywords:
Recreational water, water quality index, waterfall

ABSTRACT

Background: Recreational Water Illness is illnesses that are spread by having contact with contaminated water. Based on the study done by (Sapian *et al*., 2012), they found out that Lubuk Yu, one of the famous recreational area in Malaysia pose dangerous threat to humans. **Objective:** The study was carried out in order to analyze the physico-chemical water parameters, to compare the water quality between weekend and weekdays, to compare the water quality between selected waterfalls. **Result:** The result for physical parameters found out that only two parameters exceed the standards which are dissolved oxygen and biological oxygen demand with readings of 2.62mg/L and 5.67mg/L. No biological parameters exceed standard and chemical parameters which exceeds readings were boron (1.64mg/L), manganese (2.08mg/L), cadmium (0.021mg/L) and barium (7.96mg/L). Comparison between weekdays and weekends found out that total dissolved solid (18.2mg/L), conductivity (33.8mg/L), salinity (0.12mg/L), suspended solid (16.33mg/L) and pH (8.31) for physical parameters higher during weekend. For biological parameters, total coliform is higher during weekends (1754.98 counts). While Chromium (0.072mg/L), Nickel (0.027mg/L), Zinc (0.29mg/L), Nitrogen (0.10m/L), Barium (9.53mg/L) and Fluoride (0.33mg/L) for chemical parameters. Comparisons between waterfalls found out that Sungai Tua is the most contaminated streams between the five selected waterfalls (WQI=67.39) which slightly polluted. **Conclusion:** The result indicates that there is likely potential adverse health effect that is associated with the exposure of the chemicals in recreational water. However, further study should be performed in order to calculate specific hazard index and hazard quotient of the chemical for the specific organs in human bodies.

To Cite This Article: Nurhidayah Sabri, Abdul Raof Mohd Ali, Ahmad Razali Ishak, Siti Nurshahida Nazli, Nurhidayah Ab. Rahim and Syarifah Masyitah Habib Dzulkarnain., Recreational Water Quality Assessment at Selected Waterfalls in Selangor, Malaysia. ***Aust. J. Basic & Appl. Sci.,*** *10(7): 14-20, 2016*

INTRODUCTION

Water is very important for drinking sources and also sanitary. Thus, water quality should be monitored from time to time to ensure the water is safe for human use. Under Environmental Quality Act 1974, water parameter and standard should be complied. In order to maintain environmental health impact from human activity such as agriculture, the frequent monitoring program on water bodies should be done strictly. Recreational area is one of the main factors that cause death as according to study that had been done across the world. Furthermore, according to the Centre for Disease Control and Prevention (CDC), recreational area such as swimming and other water related activities are good medium to get the physical activities that is crucial for a healthy life. Millions of people had enjoyed oceans, lakes, river, pools and spas each year. Thus it is important to be aware of ways to prevent water related adverse health events and recreational water illnesses (RWIs). Recreational waters in the tropics and subtropics pose special hazards, not just from some of the local aquatic or amphibious predators such as crocodiles, but also from a number of tropical diseases. First and foremost is schistosomiasis or bilharzia, a disease caused by parasitic worms. The parasites can lodge as adults in people's veins around the intestines and liver, or around the bladder. Children and adolescents are

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particularly vulnerable to schistosomiasis as they frequently play or bathe in unsafe water in hot tropical climates (WHO, 16 October 2003). There are three exposure routes of pollutant to enter the human's body which are through absorption, ingestion, inhalation and injection. However, for this case, the routes are more to absorption and ingestion. Absorption is through the skin while ingestion will undergo unintentionally when we are swimming. This is especially for those who can't swim (drowning). In Malaysia, there is no strict specific rules and regulation for recreational water quality standard. Besides, Based on the study done by M Sapian *et al*. (2012), they found out that Lubuk Yu, one of the famous recreational areas in Malaysia pose dangerous threat to humans. 153 people were exposed to this outbreak, 85 (55.5%) were professional rescuers from various government agencies and 68 (44.5%) were villagers. Recreational water standard is crucial as we use the water especially for swimming and we made direct contact with it. Thus, we exposed to the risk that posed by the water. The study aim is to conduct water quality assessment for physical, chemical and biological parameters at Kanching, Sungai Congkak and Ulu Yam. The assessment will be done for both peak and normal hour. The data obtained will be used to identify the water quality status of the selected recreational water.

MATERIALS AND METHOD

Study Area and Sampling Locations:

The study area for this study is covering the state of Selangor where 5 rivers were selected based on their location and intensity of visitors. The most famous waterfalls were selected for the study which is Sungai Gabai, Sungai Sendat, Sungai Congkak, Sungai Tua and Sungai Kanching. In addition, Sungai Gabai was found out to have a case of leptospirosis. Furthermore, both private management and government managed waterfalls were selected for the study.

Table 1: Sampling Locations and Coordinate.

Waterfalls	Sampling Point	Sampling Coordinate
Sungai Gabai	1. Upstream	3°10'3.97"N, 101°54'38.63"E
	2. Midstream	3°9'59.97"N, 101°54'38.16"E
	3. Downstream	3°9'55.47"N, 101°54'38.26"E
Sungai Congkak	1. Upstream	3°12'33.45"N, 101°50'36.33"E
	2. Midstream	3°12'33.24"N, 101°50'36.40"E
	3. Downstream	3°12'33.07"N, 101°50'36.31"E
Sungai Tua	1. Upstream	3°19'55.18"N, 101°42'10.39"E
	2. Midstream	3°19'54.44"N, 101°42'9.96"E
	3. Downstream	3°19'53.74"N, 101°42'9.56"E
Sungai Sendat	1. Upstream	3°24'12.33"N, 101°41'1.42"E
	2. Midstream	3°24'12.39"N, 101°41'1.29"E
	3. Downstream	3°24'12.42"N, 101°41'1.14"E
Sungai Kanching	1. Upstream	3°17'56.87"N, 101°36'41.93"E
	2. Midstream	3°17'55.77"N, 101°36'42.33"E
	3. Downstream	3°17'53.83"N, 101°36'42.55"E

Sampling Collection:

For this study, five sampling will be chose for each of the recreational places. The samples will be measured and sampling along the recreational water body. Three sampling point were selected. First sample were taken at upstream of the river, second is at the midstream of the river and the last point is at the downstream of the river. The samples will be taken during weekdays and weekend, which means that every river will have 6 samples collected and there are total 30 samples, will be collected for 5 recreational places.

RESULTS AND DISCUSSION

Physico-chemical water parameters:

Table 2: Physical Properties in Selected Waterfalls.

Parameter	Mean ± Standard deviation	Interim Water Quality Standard Class II(B)	National Drinking Water Quality Standard
pH	7.97 ± 0.94	6.5 - 9.0	6.5 - 9.0
DO	2.62 ± 0.96	5-7	-
Temperature	24.06 ± 0.53	-	-
TDS	15.71 ± 5.59	-	1500
Salinity	0.11 ± 0.038	-	-
Conductivity	28.66 ± 11.67	-	-
Turbidity	5.58 ± 2.32	-	1000
SS	12.66 ± 7.46	50mg/L	-
COD	13.83 ± 8.94	25mg/L	-
BOD	5.271 ± 1.28	3mg/L	-

The result for physical parameters found out that there are only two parameters exceeded the standards of Interim Water Quality Standard class II(B) which are dissolved oxygen and biological oxygen demand.

Table 3: Concentration of Total Coliform and E.coli in Selected Waterfalls.

Parameter	Mean ± Standard deviation	Interim Water Quality Standard Class II(B)
Total Coliform	1597.49 ± 826.99	5000
E.coli	190.3 ± 58.47	400

However, for the biological, there are no parameters that exceed Interim Water Quality Standard.

Table 4: Chemical Properties in Selected Waterfalls.

Parameter	Mean ± Standard deviation	National Drinking Water Quality Standard
Chromium	7.97 ± 0.94	0.05
Copper	2.62 ± 0.96	1
Nickel	24.06 ± 0.53	0.02
Total Chromium	15.71 ± 5.59	0.05
Zinc	0.11 ± 0.038	3
Silver	28.66 ± 11.67	0.05
Aluminum	5.58 ± 2.32	0.2
Boron	12.66 ± 7.46	0.5
Iron	13.83 ± 8.94	0.3
Manganese	5.271 ± 1.28	0.1
Fluoride	15.71 ± 5.59	0.4 - 0.6
Cobalt	0.11 ± 0.038	-
Barium	28.66 ± 11.67	0.7
Nitrogen	5.58 ± 2.32	1.5
Cadmium	12.66 ± 7.46	0.03
Sulphide	13.83 ± 8.94	-
Nitrate	5.271 ± 1.28	10

Lastly, for the chemical parameters, it was compare with Drinking Water Quality Standard. The result obtained is that the chemical parameters that exceed the standards are boron, manganese, cadmium and barium. The high readings of BOD may be due to the fact that, some waste such as organic waste being thrown in the water body. As during each of recreational activities, we tend to bring along foods and beverages. Thus the foods usually were thrown into the river after we eat. Besides that, we also tend to wash the utensils that we brought along especially for those who picnic in the recreational area (Force). As there is low maintenance service at most of the recreational area in Malaysia, the garbage was thrown along the riverside where there is no rubbish collector as relation to the low maintenance service in the recreational area. Thus the organic waste may be channel into the water especially through surface runoff when there is precipitation (rain) and also through scavenger. A research done had found out that high rainfall and subsequent high surface runoff introduce high concentrations of nitrate-nitrogen and fecal streptococci into the lower reaches of Keaahala and Kaneohe streams. High concentrations of fecal streptococci also occur in waters overlying a clam bed during high stream flows, suggesting that a potential public health hazard may exist during the rainy period. (Quan, Young, Burbank Jr, & Lau, 1970). Biological parameters are quite low as the high water flow prevents the growth of the both bacteria. As the water collection was done near the waterfalls, thus the flow of water is high. As a research carried out, it is found out that water flow can influence physiological processes including photosynthesis and respiration by affecting the diffusion boundary layers around the organism. This in turn affects the associated ability of dissolved gases. (Dennison & Barnes, 1988). For the chemical properties, mostly there are only a small readings of chemicals found out at the recreational area. However, for the parameters of boron, manganese, fluoride, sulphide and nitrate they had shown a quite amount of readings where most of them is more than 1 mg/L. As for fluoride and sulphide, it may be due to that the chemicals are produced from the usage of soap and shampoo and also toothpaste at the recreational area. This is enhance when the visitor consist of families whose tends to bring along the chemical substances to the recreational area. This is according to survey; most of the chemicals were bringing by family. This is because the men usually only swimming without bringing any soap or shampoo and also toothpaste.

For comparison of weekends and weekdays, the data was test by using Levene and Mann-Whitney test. The significance physical parameters between the two periods of time are total dissolved solid, conductivity, salinity, suspended solid and pH, where all the physical parameters are higher during weekend as compared to weekdays. While for biological parameters, only Total Coliform has significance different and it is also higher during weekends as compare to weekdays. There are 9 chemicals parameters that were found out to have significance difference between weekdays and weekends. 6 of them showing higher readings during weekends and the other 3 are higher during

weekdays. The 6 parameters are Chromium, Nickel, Zinc, Nitrogen, Barium and Fluoride for chemical parameters. The 3 parameters that are higher during weekdays are Total Chromium, Boron and Cobalt. It is found out that the number of visitors is double during weekends when compare to the weekdays. In addition, some of places such as Gabai, Sendat have their visitors number tripled. This may be due to the scenic value of the streams as both Gabai and Sendat have their waterfall easier to reach compare to the other streams. The means value shows that the readings are higher during weekends when compare to weekdays. This may be caused by the fact that the human's activities are increase during weekends that alter the water quality during the weekends. As according to Jarmie Bartram *et al*, the effects of human activities on water quality are both widespread and varied in the degree to which they disrupt the ecosystem and/or restrict water use (Ballance, 1996). For total dissolved solid, suspended solid the increase of those parameters during weekends also may be caused by the vigorous activities done by the visitor's prior swimming in the streams. As according to my observation, the visitor prefer to jump around and playing sliding at the upstream area where it lead to the change of water properties. This may cause re-suspend sediments (Kerr). In fact, addition of turbidity level, associated with suspended solid also reduces the penetration of sunlight (Appleby & Scarratt, 1989). This in turn reduces photosynthetic activity (Arruda, Marzolf, & Faulk, 1983). As for the biological parameters, when the numbers of visitors increase, the flow of water in the swimming area is slowed down. This is because the visitors will become obstacle, thus can dispersive and slow down the flow rate of the water. This, in turn, can provide a medium for the growth of bacteria (Dennison & Barnes, 1988). Furthermore, the chemicals of fluoride, boron the source are the chemicals that brings along by the visitors to the streams which are the toothpaste, soap and also shampoo. The products is made up of the chemical substances and when they were used, it is introduce into the water, thus lead to a high readings during weekends when compare to weekdays (WHO, 1998). The numbers of visitors affect the concentration of the chemicals in the water. This is supported with the observation that as number of families increase, the number of chemicals also increases. This is enhance when the visitor consist of families whose tends to bring along the chemical substances to the recreational area.

Comparison between Weekdays and Weekends:

Table 5: Parameters which have significant difference on measurement between weekdays and weekends ($p < 0.05$).

Parameter	Weekdays/ weekends	Mean ± Standard deviation
TDS	Weekdays	13.22 ± 4.06
	Weekends	18.2 ± 5.91
Conductivity	Weekdays	23.53 ± 9.71
	Weekends	33.8 ± 11.47
SS	Weekdays	9.0 ± 4.15
	Weekends	16.33± 8.32
Salinity	Weekdays	0.09 ± 0.02
	Weekends	0.12 ± 0.04
pH	Weekdays	7.62 ± 0.62
	Weekends	8.31 ± 1.10
Total Coliform	Weekdays	1440.0 ± 772.50
	Weekends	1754.98 ± 875.65
Chromium	Weekdays	0.02 ± 0.02
	Weekends	0.072 ± 0.019
Nickel	Weekdays	0.0071 ± 0.007
	Weekends	0.027 ± 0.008
Total Chromium	Weekdays	0.040 ± 0.038
	Weekends	0.016 ± 0.008
Zinc	Weekdays	0.17 ± 0.17
	Weekends	0.29 ± 0.17
Boron	Weekdays	2.87 ± 3.35
	Weekends	0.42 ± 0.30
Nitrogen	Weekdays	0.045 ± 0.074
	Weekends	0.10 ± 0.066
Barium	Weekdays	6.4 ± 2.74
	Weekends	9.53 ± 4.27
Fluoride	Weekdays	0.29 ± 0.36
	Weekends	0.33 ± 0.23
Cobalt	Weekdays	0.087 ± 0.069
	Weekends	0.0092 ± 0.0057

Comparison of Water Quality between Waterfalls:

Table 6: Water Quality Index Scale.

Water Quality Index Scale	
0 – 59	Polluted
60 – 80	Slightly polluted
81 - 100	Clean

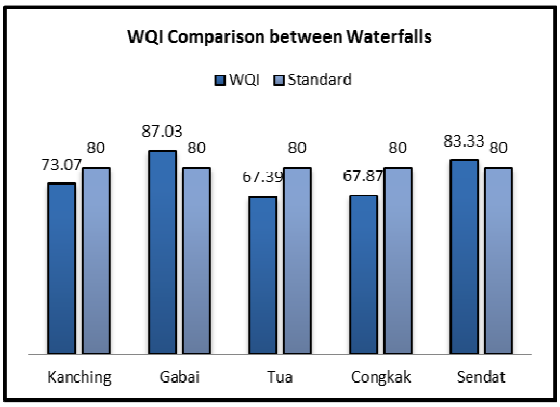

Fig. 1: Water Quality Index of Selected Waterfalls.

Comparisons between waterfalls found out that Sungai Tua is the most contaminated streams between the 5 selected waterfalls (WQI=67.39) which slightly polluted. Water Quality Index (WQI) was also calculated for each of the waterfalls under the study. The highest WQI obtained is 87.03 which is from Gabai and followed by 83.3 from Sendat. Both waterfalls are indicated as clean based on the WQI obtained. While the lowest WQI obtained is from Tua with 67.4 which indicated slightly polluted. The other two streams which are Congkak and Kanching was also fall in the slightly polluted category. The fact that Gabai and Sendat has a higher flow rate compare to the other three waterfalls. The condition of the waterfalls at the both streams lead to the higher flow rate of water between the places. This allows the water to circulate faster and prevent the sedimentation of the contaminants in the water. Thus, it can maintain the water quality to be in a good state. Besides that, the good maintenance from the Department of Occupational Safety and Health at Gabai and Forestry and Wildlife Department at Sendat also help to maintain the cleanliness of the streams. This can be seen by the view that there is proper waste disposal at the streams as compare to the other stream. This can prevent the contamination of the streams through surface runoff during rainy day.

Conclusion:

The physical, biological and chemicals parameters had exceeded the standard limits for the Malaysian Interim Water Quality Standard Class IIB and Drinking Water Quality Standard. Thus, null hypothesis is accepted. For physical, the mean of DO and BOD is exceeding the standards which are 2.62mg/L and 5.67mg/L respectively. Next, the recreational water quality is good on weekdays when compared to weekends, suggesting that the water quality is poor on weekends. Thus, the null hypothesis is again accepted. Besides that, for the sampling locations comparison, it is found out that the worst water quality collected is from the downstream. However, it is found out that certain midstream locations also found out to produce a bad water quality. As for comparison between waterfalls, it is found out that Gabai falls is the cleanest waterfalls. This is further proved from the calculation of the Water Quality Index where the WQI for Gabai fall is 87.03 which indicate that it is clean followed by Sendat Fall with 83.33 WQI reading. While for the rest three the WQI obtained indicated that they are slightly polluted. Lastly, it is found out that from the result it indicates that there is likely potential adverse health effect that is associated with the exposure of the chemicals in recreational water. However, further study should be performed in order to calculate the specific HQ of the chemical for the specific target organs in the human bodies. Thus, the third hypothesis is accepted.

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