Recreational Water Quality in Western Malaysia: A Case Study of Kuala Woh

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(Received 23rd August, 2006, revised 29th November, 2006)

Summary: The pollution level of recreational water in Western Malaysia has been investigated. Kuala Woh, a famous recreational spot in Perak was taken as a case study, which covered a time period from September 2003 to April 2004. The samples were analyzed for ammonia nitrogen, chemical oxygen demand (COD), biological oxygen demand (BOD) and heavy metals. The range of quality parameters of the samples were: temperature (20.49 °C – 58.19 °C), pH (7.10 – 8.26), conductivity (5.4 – 267.7 μS/ cm), turbidity (0.01- 1.01 NTU), total dissolved solid (89-149 mg/ L), COD (2.1-11.0 mg/ L), BOD (1.0- 4.3 mg/ L), ammonia nitrogen (0.03- 0.18 mg/ L) and sulphur (0.55- 56.98 mg/ L). Although the study was limited, the results were encouraging. Most of the quality parameters with the exception of the hot patches at the recreational site followed the levels adopted by the Interim National Water Quality Standards (INWQS) for Malaysia. On the basis of the INWQS values, the Kuala Woh recreational water can be categorized as Class IIB and considered safe for recreational purposes. The high sulfur contents and elevated temperature at the hot patches, however, may be harmful in the case of a direct body contact.

Introduction

Recreational water refers to that natural water that is used for primary and secondary contact activities. Primary contact includes swimming, windsurfing and water-skiing, whereas secondary contact activities include boating and fishing. Recreational use is normally defined as any activity involving the intentional immersion (e.g., swimming) or incidental immersion (e.g., water-skiing) of the body including the head, in natural water. Natural water is any marine, estuarine or fresh body of water as well as any artificially constructed flow-through impoundment using untreated natural water.

Health hazards, associated with direct contact, with water include infections transmitted by pathogenic microorganisms, injuries and illnesses due to physical and chemical properties of water. Water used for recreational purposes should be sufficiently free from these hazards to ensure that there is negligible risk for the health and safety of the user.

Water, used for recreational purposes, should be sufficiently free from microbiological, physical and chemical hazards to ensure that there is negligible risk to the health and safety of the user. (a) The evaluation of risk of disease or harm from microbiological, physical, or chemical hazards is based on a number of factors. These include: environmental health assessment, epidemiological evidence, indicator organism limits, and the presence of pathogens. The decision to post a warning to the users of a particular recreational area or to close the area for public use, is based on an assessment of existing hazards using available information on the factors listed above.

An appropriate environmental health assessment should pay special attention to pollution sources like inadequately treated sewage, fecal matter, or chemical substances entering the water from a discharge or a spill, outfalls including urban storm water, agriculture waste or runoff as well as physical hazards. Additional factors like seasonal variability of hazards, density of bathers, water temperature, the frequency of change or circulation of the water, changes in water depth, the fluctuation of water quality with rainfall (wet and dry conditions) and the occurrence of algal blooms have to be taken into consideration. Epidemiological

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evidence requires an established surveillance for bather illness or injuries, which can be achieved by comprehensive epidemiological studies or by formal and informal reporting from physicians and hospital emergency department. An indicator organism or organisms should be chosen for routine monitoring of recreational water quality [1].

The choice of indicator organism and of enumeration procedures is determined by the nature of water (whether water is marine, fresh or estuarine), the presence of turbidity, and local experience of monitoring particular organism. Tests for pathogenic organisms may be carried out when there are reports of illnesses of specific etiology. When there is suspected illness of undetermined cause or when levels of an indicator organism demonstrate a continuous suspected hazard, the tests may help to determine the source of contamination (e.g., sewage pollution, agriculture or urban runoff, bather origin).

Recreational water may be contaminated by direct human contact and by waterborne pollutants from external sources. Many epidemiological studies have identified gastrointestinal and upper respiratory illnesses in bathers that were the result of such contamination [2]. The ideal indicator of fecal contamination of recreational water would be one of the enteric pathogens. However, since these are usually present at low levels and are irregularly distributed, even during disease outbreaks, they are difficult to isolate and quantify [3].

Moreover, the absence of one pathogen does not necessarily ensure that other enteric pathogens are also absent. In addition, testing for every possible (a) waterborne disease-causing microorganism, would be prohibitively expensive in terms of both time and money. For these reasons, it is a common practice to monitor the other more plentiful, but non-pathogenic bacteria, present in human and animal feces.

The presence of elevated numbers of these bacteria, in an aquatic environment, is indicative of fecal contamination and the possible presence of enteric pathogens. In the past, the most widely used indicator of recreational quality was total coliforms. However, because this group does not conform to most of the required characteristics, it is now considered unsuitable [4]. The increasing use of surface water, in Malaysia, for body contact recreational purposes and the larger number of industrial and municipal wastewater sources entering surface water, call for investigation into recreational water quality. Research data on recreational water quality in Western Peninsular Malaysia is rare, thus the present work was undertaken. As initial investigation, Kuala Woh recreational park was taken as a case study.

Kuala Woh recreational park is a famous picnic spot in the Perak state. The park is about 15 kilometers from Tapah, a small town on the North-South highway. The water stream at Kuala Woh is a major attraction for visitors to Cameron Highlands and most of the visitors make a brief stop here before proceeding to the highlands. The source of water in the stream is a combination of springs and seepage from the surrounding natural forest. The Kuala Woh stream passes through a small residential area upstream the recreational park. The recreational park is extensively used for bathing by visitors of all ages. In the park premises, there are some hot patches in the stream with temperature well above the rest of the stream water.

The water seepage from these hot patches makes the stream water comfortably warm. Recently, the local administration has fixed some warning signs on the site near the hot patches. Apparently, the stream has no sign of any kind of aquatic life. The current work was undertaken to study the pollution level of the Kuala Woh stream water and make an assessment of its possible impact on human health.

Results and Discussion

The results of on-site measurements are presented in Table-1. The range of values obtained during the two sampling seasons is given separately. The NTU refers to Nephelometric Turbidity Units. The laboratory measurements are shown in Table-2. The units adopted are shown in the relevant columns individually.

Metals concentrations measured in the samples are presented in Table-3. Table-4 gives the Interim National Water Quality Standards (INWQS), adopted by the Department of Environment, Government of Malaysia (DOE document, 1986).

Table- 1: On-site measurement of quality parameters.

	Sampling Period	
Parameter	Jan 03-Nov 03.	Dec 03-July 04
pH	7.17-8.05	7.10-8.26
Temperature (°C)	22.33-55.00	20.49-58.19
Conductivity (µS/cm)	16.8-241.7	5.4-267.7
Turbidity (NTU)	0.01-2.00	0.01-1.00
Dissolved Oxygen (mg/ L)	2.01-9.22	1.94-9.20
Total Dissolved Solid (mg/ L)	89-161	104-154

Table- 2: Water quality parameters measured in the laboratory.

	Sampling Period	
Parameter	Jan 03-Nov 03.	Dec 03-July 04
Ammonia-Nitrogen (mg/ L)	0.05 – 0.20	0.00 – 0.18
Total Suspended Solid (mg/ L)	1.1 - 3.1	1.3 – 3.7
Chemical Oxygen Demand (mg/ L)	2.2 – 13.5	2.1 – 11.0
Biological Oxygen Demand (mg/ L)	0.5 – 5.7	1.0 – 4.3

Table-3: Metals concentration range (ppm or mg/ L) in water samples.

	Sampling period[1]	
Parameters	Jan 03-Nov 03	Dec 03-July 04
Magnesium (Mg)	1.00 – 7.14	0.55 – 6.50
Cadmium (Cd)	0.12 – 0.25	0.10 – 0.24
Nickel (Ni)	0.22– 0.60	0.18 – 0.55
Chromium (Cr)	0.05 – 0.70	0.07 – 0.65
Zinc (Zn)	0.04 – 0.50	0.05 – 0.55
Lead (Pb)	0.30 – 0.80	0.33 – 0. 77

The corresponding values (ppm) for the hot water spring in the recreational park are: magnesium (23.44), nickel (10.76), zinc (12.33), lead (0.78), and sulphur (56.98).

Table- 4: Interim National Water Quality Standards.

		Classes					
Parameters[2]	units	I	IIA	IIB	III	IV	V
Temperature	°C	-	normal	-	normal	-	-
pH		6.5-8.5	6.0-9.0	6.0-9.0	5.0-9.0	5.0-9.0	-
Conductivity	µS/ cm	1000	1000	-	-	6000	-
TDS	mg/ L	500	1000	-	-	4000	-
TSS	mg/ L	25	50	50	150	300	300
Turbidity	NTU	5	50	50	-	-	-
DO	mg/ L	7	5 - 7	5 - 7	3 - 5	<3	<1
COD	mg/ L	10	25	25	50	100	>100
BOD	mg/ L	1	3	3	6	12	>12
AN	mg/ L	0.1	0.3	0.3	0.9	2.7	>2.7

[1] Class I- water body of excellent quality, class IIA- water body of good quality, class IIB- water for recreational use with body contact, class III- extensive treatment required, class IV- irrigation purposes, class V- none of the above.

[2] TDS-total dissolved solids, TSS-total suspended solids, DO-dissolved oxygen, COD-chemical oxygen demand, BOD-biochemical oxygen demand, AN-ammonia nitrogen.

This table has been reproduced here for ready reference. From the tables, the pH of the samples is found to be in the range of 7.10-8.26 throughout the studies. These values are almost close to neutral solution (pH = 7) and fall in water quality class I on the Interim National Water Quality Standard (INWQS) for Malaysia issued by the Department of Environment [5]. The range of temperature at Kuala Woh is 20.49 °C – 58.19 °C. The extreme figures in Table-1 are the values observed at the hot patches, where hot water continuously flows into the stream. The conductivity values measured on the spot are in the range of 5.4-267.7µS/ cm. These values again follow the water quality of class-I. At certain points, the conductivity is relatively high due to high temperature. This was particularly the case at the hot patches. The ranges of turbidity values obtained from Kuala Woh are in the range of 0.01-2.00 NTU. The turbidity is also affected by the presence of total suspended solids. The observed values of dissolved oxygen at Kuala Woh are in the range of 1.94-9.22 mg/ L.

The dissolved oxygen normally depends on the temperature and as expected, was observed to decrease with the increasing temperature [6]. The lowest values of dissolved oxygen were observed at the hot water springs in the park area. The total dissolved solid measured on the site in the stream was 89-161mg/ L. Data from the laboratory experiments are shown in Table-2.

The amount of ammonia nitrogen was below 0.20 mg/ L. The values change randomly and do not follow any particular pattern. Total suspended solid recorded was in the range of 1.1-3.7 mg/ L. As shown in Table-2, the COD measured in the laboratory was 2.1-13.5 mg/ L, which follows water quality class IIA. The BOD was in the range 0.5-5.7 mg/ L, which meets the requirements for water quality class III. The concentration levels of certain metals, measured with the atomic absorption spectrometer, are shown in Table-4. The hot water spring was found to have abnormally high concentration (up to 56.98 ppm) of sulfur. The hot patches were also found to have elevated values (up to 23.44 ppm) of magnesium as well as zinc (12.33 ppm). Enhanced extraction of these metals from the soil, due to increased solubility in water at high temperature, seemed the probable reason.

Experimental

The experimental work was undertaken in two stages. In the first stage, onsite measurement of certain parameters was done with the portable instrument "Hydrolab". The equipment offers a reliable and convenient method for the measurement of temperature, pH, salinity, conductivity, turbidity,

dissolved oxygen (DO) and total dissolved solids (TDS). The onsite measurements were repeated several times, at regular time interval, to see any seasonal change in water quality or a remarkable impact of weather conditions. The measurements were mostly performed during daylight. Three onsite measuring stations were selected in the park area, one station upstream and the other down stream. The instrument was calibrated before every measurement.

Ambient climate conditions were recorded at the time of measurement of quality parameters. The second stage of experimental work involved laboratory measurement of additional parameters, like biological oxygen demand (BOD), chemical oxygen demand (COD), ammonia nitrogen and total suspended solids (TSS).

Water samples were collected in black color, clean polyethylene bottles with screw caps, stored in an icebox and transferred to the laboratory. Samples were collected from the park area, upstream the park, and down stream the park location. Within the recreational park, samples were collected from three stations. Multiple sampling stations were aimed at investigating the human impact on the stream water quality. The samples were collected during daytime, mostly on a shiny day. Care was taken to collect the representative samples. In the laboratory, the samples were stored at 4 °C in the refrigerator [7]. In the sample collection, preservation and preparation for analysis, known standard procedures were adopted [8]. For chemical analysis, analytical grade reagents were used without any further purification. All equipments used were properly calibrated prior to experimental measurement of the recorded parameters. The COD was determined with a COD reactor (model 45600).

The COD reactor is a dry-bath incubator that directly gives the reading of COD in the samples. In the COD test, the oxygen equivalent of the organic matter that can be oxidized is measured by using a strong chemical oxidizing agent in an acidic medium. Potassium dichromate has been found to be excellent for this purpose [9]. Typically, a 100 ml sample was homogenized for 30 seconds in a blender. The COD reactor was preheated to 150 °C and the sample vial was heated through the COD reactor for two hours. A catalyst (oftenly silver sulfate) is required to aid the oxidation of certain classes of organic compounds, which are otherwise hard to decompose. Since some organic compounds interfere with the test, care has been taken to eliminate or account for this factor in the final results. The BOD was measured with a "BODTrak" apparatus. An appropriate sample volume was placed in an ambered BOD bottle with ample amount of air left above the sample. The bottle was then connected to a pressure sensor where pressure drop could be measured as a result of the bacterial consumption of dissolved oxygen. The readings were obtained directly from the apparatus as mg/ L of BOD using graphical display. The lithium hydroxide crystals in a sealed cup were used to remove carbon dioxide produced during the experiment [10]. Metals concentration in the samples was determined with Atomic Absorption Spectrophotometer (AAS, model JIS K-102-1993). The results obtained are presented in Table-3.

Conclusion

The quality of Kuala Woh recreational water was compared to the national quality standards. Most of the quality parameters were within the limits required for recreational water quality. The BOD was on the higher side, which could be considered an indication of higher bacterial counts. The temperature of the hot patches / hot springs at the recreational park was much higher than the requirements. The limited data collected here show the water quality to be suitable for recreational purposes, though the hot patches pose a threat of physical injury to the visitors. Seasonal variation in the quality parameters was not appreciable. No substantial impact of weather condition on the quality parameters was observed.

Acknowledgments

Financial support and laboratory facilities provided by the University Technology PETRONAS, Bandar Seri Iskander, Malaysia, are gratefully acknowledged.

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