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The Relau River Water Quality Analysis at the National Forest Reserve, Merapoh, Pahang

[1,2]Kalaivani Nadarajah, [1]Noorliyana Rashid and [2]Yang Farina
[1]School of Biosciences and Biotechnology,
[2]ALIR Faculty of Science and Technology, Universiti Kebangsaan Malaysia,
43600 Bangi, Selangor, Malaysia

Abstract: This study was conducted to determine the water quality of the Relau River which is situated within the National Forest Reserve at Merapoh, Pahang. The study was conducted at three stations and water sampling was conducted three times i.e., in October, November and December 2011. The parameters analysed were the temperature, turbidity, Total Suspended Solid (TSS), pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), total coliforms and faecal coliforms. In addition to total and faecal coliform, the presence of *Leptospira* as an additional biological parameter was included due to an increase in the incidence of *Leptospira* presence in water bodies reported over the recent years. According to the Interim Water Quality Standards for Malaysia (INWQS), the values for all parameters in Relau River, except for the BOD were classified between Class I and Class II. Based on BOD values, the river was categorised as a Class III. The one way Analysis of Variance (ANOVA) with confidence level of 95% shows that all water quality parameters measured exhibited no significant differences between the three sampling stations.

Key words: Water quality, INWQS, Malaysia, National Forest Reserve, Relau River

INTRODUCTION

Water plays a vital role in human livelihood, well-being and quality of life. It is also important in sustaining and ensuring the survival of ecosystems. Water quality refers to the water sample composition and it directly affects virtually all water uses (Najah *et al*., 2009). Many of human activities such as recreational activities like swimming and boating, municipal, industrial, agricultural uses such as irrigation and livestock drinking water, watering, private water supplies, waste disposal and general aesthetics all are affected by the physical, chemical, biological and microbiological conditions that is present in water sources and in subsurface aquifers (Park and Lee, 2002; Roger *et al*., 2012). Low water quality in any water source or shed will result in a reduction in the desired uses of the water and if further deterioration of this water body occurs, it will result in it being regarded as not safe for consumption or uses that may result in harmful outcome to human and other living organisms.

Malaysia is a developing country that is moving towards its vision 2020. With development comes the price and impact on the environment especially water quality (Al-Shami *et al*., 2011). Industrial and domestic waste that is being dumped into rivers and other water sources is beginning to impact the overall water quality surrounding human activity and living. Deteriorating water quality will have its harmful effects on human health and thus has become an issue that is gaining much public attention and sensitivity. The effect is not only felt by human via ill health reasons but also in the aquatic systems where the living organisms within the water bodies are affected by the deterioration. In the water quality studies conducted by Baroni *et al*. (2007), showed that nearly 70% of surface water was used in agriculture field which means that without water, our agricultural activities would be affected and this directly will affect the countries livelihood as Malaysia is still very much dependent on its agricultural produce.

The domestic and industrial water supply in Malaysia comes from rivers, lakes and underground water. As a main source of water, the river is a complex ecosystem where no two rivers are identical physically or biologically (Chiras, 2001). Erosion, oxygenation, absorption and various other activities which are a commonality in river bodies continue to happen exhibiting more of an negative outcome then one that is positive which would ensure a healthy ecosystem (Bilotta *et al*., 2012). The increase in population and widespread pollution has resulted in the rivers in Malaysia being threatened as a sustainable water source for its people

Corresponding Author: Kalaivani Nadarajah, School of Biosciences and Biotechnology,
ALIR Faculty of Science and Technology, Universiti Kebangsaan Malaysia,
43600 Bangi, Selangor, Malaysia

(Hamirdin, 2000). Therefore, it is important that water quality analysis is conducted periodically to ensure that the water quality in rivers that supply water to Malaysians is safe for consumption and will not be detrimental to the inhabitants of these water bodies.

There are many rivers and streams that can be found within the National Forest Reserve in Merapoh, Pahang. However, the Relau River was selected for this study as it was one of the main rivers in this area which is known for good fishing, a great picnic and recreational location as well as the main water supply to the lodging/chalets at the National Forest Reserve, Merapoh and the surrounding villagers. In addition the Relau River is not one of the designated rivers for monitoring on a regular basis by the Pahang State Department of Environment. Therefore, in this study, the water quality of the Relau River was obtained for the first time so as to provide the Department with a record on water quality for this river and to ensure that proper quality monitoring will ensue in future for this river due to it being an important tourists destination. The Department needs to be vigilant as the Relau River can be contaminated by waste from the chalets in the area and the recreational activities of tourists camping in the vicinity. As such the main objective of this study is to determine the quality of water in the Relau River according to the Interim National Water Quality Standards (INWQS).

MATERIALS AND METHODS

Study sites and experimental design: Three locations for sampling were determined along the Relau River (Fig. 1). Station 1 is upstream of the river and is at a location called Lata Serigala. This is a major tourists and recreational destination. In addition to high human traffic, this area does have wild animals and elephant dung was seen along the trail. Station 2 is located at the junction between the Relau and Negeram River. The Negeram River is contaminated by waste material from palm oil mills located nearby. In addition, station 2 is where the canteen, public toilets and chalets are located. Station 3 is where the Kelah Fish Sanctuary is located and is a popular tourist destination.

The parameters that were studied are the temperature, turbidity, Total Suspended Solids (TSS), pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), total coliform and faecal coliform. Sampling was conducted on the 9 October 2011, 6 November 2011 and 8 December 2011. The water sample was taken once in the morning at 8 am and another at 12 noon. Each sampling contained 1 L of water sample. Water samples collected was stored as recommended by APHA (1998). Physicochemical parameters were measured *in situ* and *ex situ*. A YSI multi-parameter 556MPS was used to measure dissolved oxygen and temperature while the pH was measured using

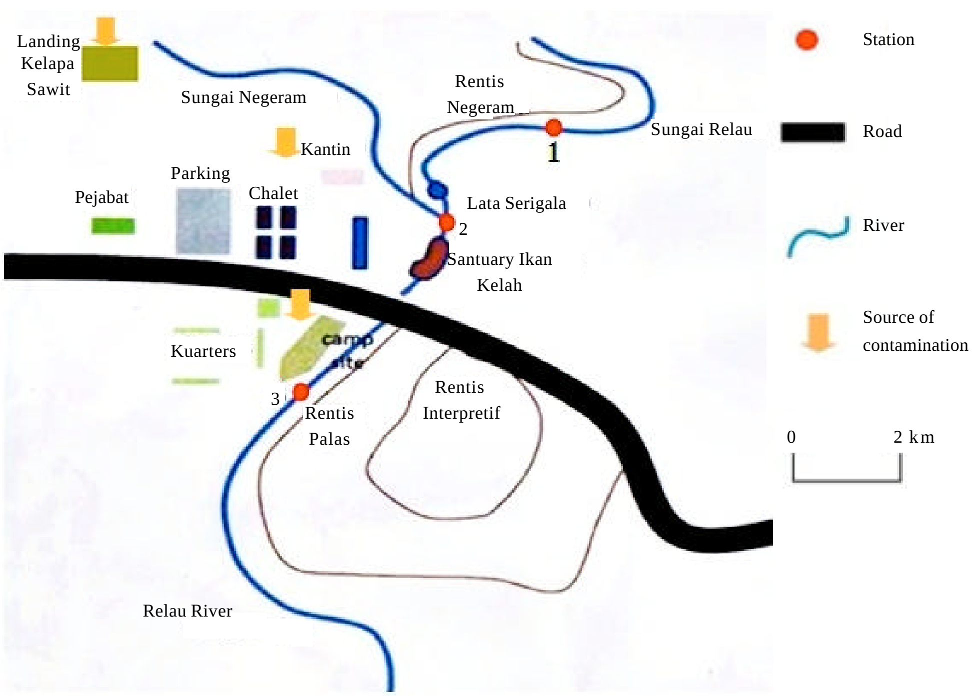

Fig. 1: Map of the Relau River located within National Forest Reserve, Map source: Ranger Station Taman Negara Merapoh, Pahang

a pH meter. Water turbidity was measured by means of a turbidimeter HACH 2100P (Jenkins *et al*., 2011). The BOD and TSS values were determined *ex situ* where the TSS values were obtained via the gravimetric method (APHA, 1998) and the BOD values were obtained by means of the 5-day BOD test. The membrane filtration method was used to determine total coliform and faecal coliform values where water samples were filtered through a 0.25 micron filter. Total coliform was identified and confirmed on M-Endo LES and BGBB. Identification and confirmation of faecal coliform was conducted on lauryl sulphate and Eosin Methylene Blue agar (EMB) (An *et al*., 2002).

Detection of *Leptospira*: The presence of *Leptospira* was determined via membrane filtration followed by culturing on EMJH agar. In addition, colonies isolated were grown in EMJH broth to validate presence and quantify the bacterial presence. Inoculated agar and broth were incubated in the dark at 20°C for 3-5 weeks. In the event of *Leptospira* presence the solid medium would be murky and produce a 1.5 cm condense layer below the surface of the medium (Adler and de la Pena Moctezuma, 2010). In the liquid medium, the presence of this organism may be detected by the formation of a ring on the surface of the broth (Kaboosi *et al*., 2010). A microscopic method of identification follows these procedures.

Statistical analysis: Statistical analysis that has been used was one way-Analysis of Variance (ANOVA) with $\alpha = 0.05$ and confidence level at 95%. Data obtained was analysed using the minitab programme and Microsoft Excel. The purpose of this test was to determine the presence of significant differences among water quality parameters with each sampling stations and period of sampling.

RESULTS

The results obtained from this study was statistically analysed and the results obtained were compared to the values stated in the Interim National Water Quality Standards (INWQS).

Physical parameters

Temperature: The results show that the temperature varies from 23.87-24.21°C in all three stations studied. This places the Relau River in the Class I category of a water body as in INWQS (Fig. 2a). The analysis of ANOVA shows no significant difference in the temperature values obtained from these stations. There seemed to be a decline in temperature measured from October to December with the lowest recorded in December ($p = 0.84869$).

pH: The min pH values observed in the three stations were in the range of 6.22-6.45. These readings place the River in Class II (Fig. 2b). When analysed statistically there was no significant difference observed in all readings obtained over the duration of the three months and in all three stations ($p = 0.84970$).

Turbidity: The turbidity values obtained in all three stations were in the range of 4.50-7.75 NTU and again placing the River in the Class I category (Fig. 2c). There was no significant difference observed in all three station readings ($p>0.05$). The values obtained from all three stations over the three sampling times showed a difference. There was no significant difference observed in all stations in October. In November the value was similar in station 2 and 3 while in December the highest value (in all months) was observed in station 3 ($p = 0.24888$).

Total suspended solids (TSS): Total suspended solids in the three locations studied ranged from 30.20-45.83 mg L^{-1} placing the River in Class I category (Fig. 2d). The differences between the three locations at each sampling time was statistically insignificant for the months of October and November with a small degree of difference observed in station 3 in the month of December ($p = 0.15362$).

Chemical parameters

Dissolved oxygen (DO): The minimum dissolved oxygen values obtained in the three locations studied were in the range of 13.67-16.76 mg L^{-1} with no significant difference ($p = 0.14245$) in all three locations over the three sampling periods (Class I) (Fig. 2e).

Biochemical oxygen demand (BOD): The BOD profiles in the three stations were similar to the DO profiles observed. The readings obtained for BOD were in the range of 7.03-8.77 mg L^{-1} placing it in the Class III category of rivers (Fig. 2f) with no significant differences ($p = 0.32276$) observed in all three stations and periods.

Biological parameters: Three different parameters were observed for biological analysis of water quality which are the total coliform, faecal coliform and the presence of *Leptospira* sp. in water.

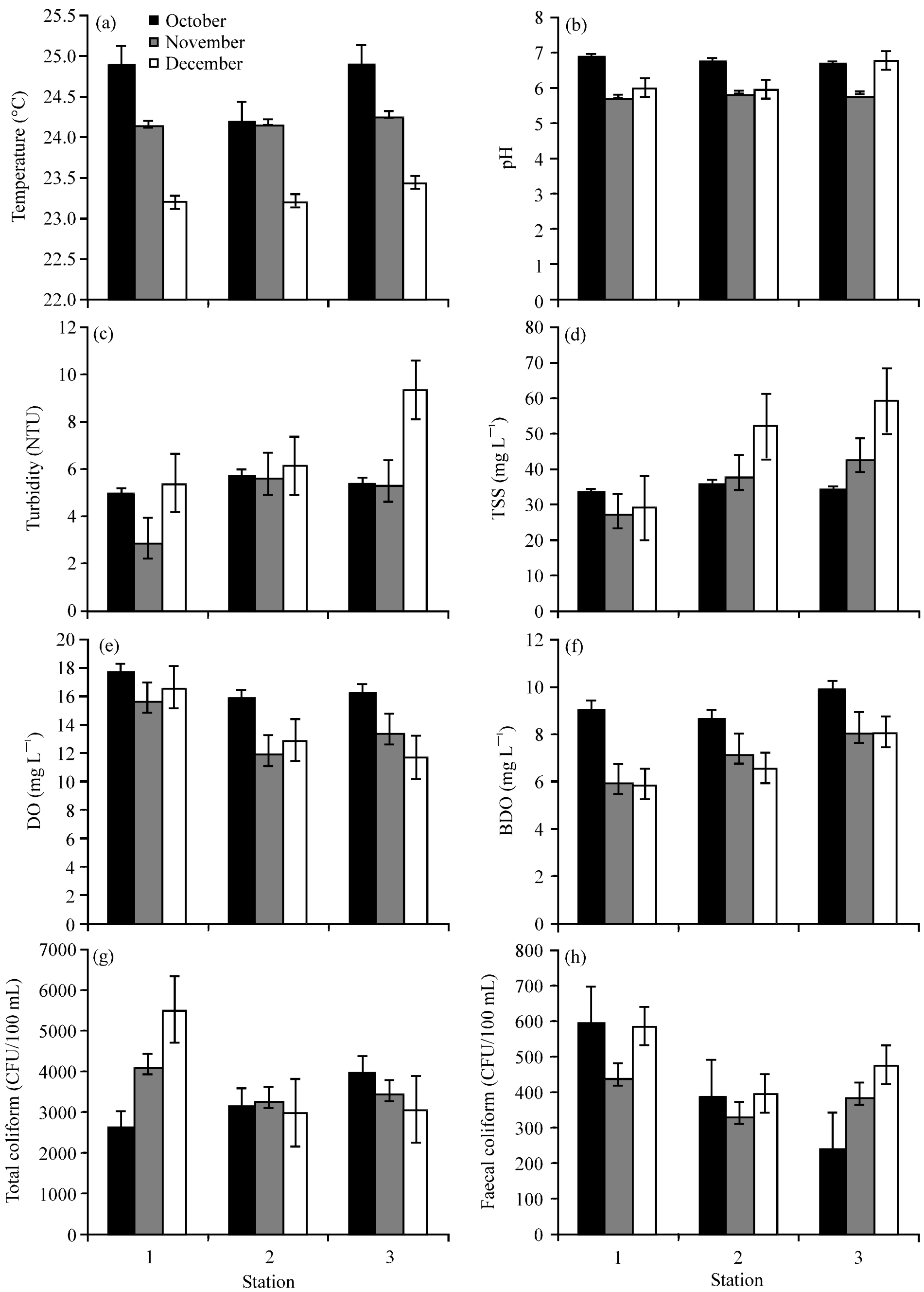

Fig. 2(a-h): Physical, chemical and biological factors assayed at the Relau River, Values obtained were compared against the INWQS to determine class and water quality of the river, (a) Temperature (b) pH, (c) Turbidity, (d) Total suspended solid (TSS), (e) Dissolved oxygen (DO), (f) Biological oxygen demand (BOD), (g) Total coliform and (h) Faecal coliform, The standard error bar provides the range of readings obtained through triplicate analysis of water samples at these stations and months, CFU: Colony forming unit, NTU: Nephelometric turbidity unit

Total coliform: The Gram negative rod shaped facultative anaerobe organism is used as a biological indicator to suggest the possible contamination by pathogens. The water samples were analysed and the min coliform values obtained were 3182-4121 CFU/100 mL which places the water body in Class I (Fig. 2g). Station I seemed to show

Table 1: Values recorded in comparison to INWQS

	Values recorded					
Parameter	Station 1	Station 2	Station 3	INWQS scale	Class	Safety level (if safe for human consumption or activity)
Temperature	24.09	23.87	24.21	-	I	Safe for human consumption
pH	6.23	6.22	6.45	6.5-8.5	IIB	Recreational use with body contact
Turbidity	4.50	5.69	7.75	5.0	I	Safe for human consumption
TSS	30.20	42.37	45.83	25.0	I	Safe for human consumption
DO	16.76	13.67	13.89	7.0	I	Safe for human consumption
BOD	7.03	7.55	8.77	1.0	III	Recreational use with body contact
Total coliform	4121.00	3182.00	3545.00	100.0	I	Recreational use with body contact
Faecal coliform	543.00	247.00	372.00	10.0	IIA	Recreational use with body contact
Leptospira sp.	-	-	-	-	-	-

an increase in readings from October to December while Stations 2 and 3 showed a more consistent value ($p = 0.47105$) over the three month observation period.

Faecal coliform: Faecal coliform is used as an indicator of faecal contamination in material assayed (Ashbolt, 2004). The min faecal coliform measured between 247-543 CFU/100 mL (Class II) (Fig. 2h). No significant difference was obtained in all stations readings. The highest readings were obtained in Station I for months of November and December 2011 ($p = 0.07816$).

***Leptospira*:** Though, *Leptospira* is not used most often as an indicator for biological water quality, this organism was added into our analysis as there was an increase in incidence of *Leptospira* contamination that we included this as an additional parameter for analysis. No growth of any colonies was observed on the EMJB agar and neither was any growth observed in the broth. Further observation microscopically showed no spiral hooked tipped organisms but normal rod bacilli (Xue *et al*., 2009).

Interim Water Quality Standards for Malaysia (INWQS): Table 1 provides the values obtained from each station, the class as in comparison to INWQS. Based on the result obtained, Relau River is classified under Class I to III of the INWQS scale. Station 3 has the highest values for temperature, pH, turbidity, Total Suspended Solid (TSS) and Biochemical Oxygen Demand (BOD) compared to other stations. pH parameter was classified under Class IIB and a BOD value of Class III. This indicates that at this point/station the water is slightly polluted. Comparison of data within parameters for all station showed that only temperature, Dissolved Oxygen (DO), turbidity, TSS and total coliform was categorised in Class I. While the parameters for pH and faecal coliform was under Class II and BOD under class III. Due to the BOD and presence of coliform in the water supply, the Relau River is no longer safe for use as drinking or water for rinsing food.

DISCUSSION

Temperature, pH and dissolved oxygen play a crucial role in enabling the normal biological and chemical processes that occur within the river (Richard and David, 2012). Station 3 showed the highest temperature basically due to the shallowness and slow flow-rate of the river approaching downstream (Idris *et al*., 2005). As for the pH values, the waste material that was being dumped from the Oil Palm Refinery into the Negeram River caused the pH at station 2 to be the lowest (Suhaimi *et al*., 2009). The waste material from the oil palm mill effluents have been reported to be approximately 5.2 (Kala *et al*., 2009) (Fig. 2a, b).

Turbidity can be influenced by the presence of various elements within the water such as soil particles (clay and mud) and microorganisms (Chen *et al*., 2012; Jenkins *et al*., 2011). This is further influenced by depth and flow rate of water at the site of study (Frederick and Wu, 2010). In this study, we found that Station 3 had the highest turbidity due to the obvious reason of shallowness and slow flow rate at this site. The water from the Negeram River is more turbid with higher particle content and thus further contributes to the high turbidity values observed in Station 3. Turbidity results in the drop in light intensity entering the water and thus affects biological processes and is not conducive for fish and may result in a higher microbial growth (Bowers *et al*., 2002; Gomez-Couso *et al*., 2009; Liltved and Landfald, 2000) (Fig. 2c).

The suspended solid particles in the water can be in the form of organic and inorganic matters (Bilotta and Brazier, 2008; Mulligan *et al*., 2009). The suspended solid particles in the water we believe are from the oil palm factory effluent that is being directed into the river in addition to the waste from campers and the possible contamination from the rest rooms found in this region. In a previous study conducted on oil palm mill effluents, it was reported that it contained colloids, oils and microorganisms (Ahmad *et al*., 2003). There were also signs of soil movement in the area surrounding the Relau

River which may have been brought about by roaming wildlife and also natural soil movement and erosion (Suhaimi *et al*., 2009) (Fig. 2d).

The dissolved oxygen values refers to the quantity of oxygen available in the water body and this usually is determined by the level of turbidity, suspended particles and population of living organisms in the locality (Karim *et al*., 2006). It is always higher upstream and gradually drops to a lower level when the water quality deteriorates due to various factors (Suhaimi *et al*., 2005). The main causes of oxygen depletion or sinks is the oxidation of organic material and other reduced matter in the water column (Cox, 2003). This is clearly demonstrated by the lower values observed in the vicinity of station 2 due to the waste material being dumped into the river from the oil pail mill and also the added burden on the water body caused by the normal human activities surrounding the campsite (Fig. 2c-e).

The biochemical oxygen demand is derived as the quantity of oxygen that is utilised by microorganisms to oxidise the organic material found within the water body in an aerobic manner (Juahir *et al*., 2011; Liu and Mattiasson, 2002). The highest values of BOD observed in Station 3 is largely due to high content in organic matter within this locality (from oil palm waste, domestic waste from chalets and cafeterias, soil movement by wildlife in the area and the merging of Relau and Negeram river at this site). The depth and flow rate of water within this region is low and this may have caused the higher level of BOD at this locality (Fig. 2f) (Shuhaimi-Othman *et al*., 2007).

The biological analysis conducted in all three stations showed that the highest level of total coliform and faecal coliform was highest in Station 1 (as this is the site for much of the tourist's activities (swimming, camping, picnicking etc.) ($p = 0.47105$ and $p = 0.07816$, respectively). In addition, this too is where most of wildlife activity has been noted and lots of faecal dropping of elephant, wild boar was observed along the river (Fig. 2g, h) (An *et al*., 2002; Field and Samadpour, 2007; Toze, 2006).

CONCLUSION

Based on the results obtained from this analysis and comparison with the INWQS values we believe that the water quality within the Relau River is only safe for recreational activities but it is not safe for consumption due to the presence of total and faecal coliform in the three tested locations (Table 1). It is therefore, recommended that the Relau River is continuously monitored for water quality and necessary measures are taken by the National Reserves authorities to ensure that the River is protected from further contamination and deterioration due to improper practices of businesses and tourists at this location. The following recommendations have been made to the Board governing the National Reserve Forest Reserve of Merapoh Pahang.

To ensure that palm oil mill effluents from the factory are no longer disposed of into the Relau River and the factory concerned to make necessary arrangements to have its treated material disposed of in accordance to the laws and ordinances of the country.

Regular water quality assessment to be conducted of the rivers within this tourist destination to ensure the safety of water for recreational use.

To ensure proper signage are posted to notify tourists that the water is only safe for recreational use and is in no way safe for consumption as drink or part of food preparation.

To post penalties for offenders of the cleanliness and safety regulations within the reserve. Where penalties are already in place to ensure proper monitoring and enforcement of the penalties ensue.

To educate the tourists of the importance in sustaining the cleanliness of the environment. To make them aware that this is their heritage and that they need to ensure the sustainability of these destinations in time to come.

We hope that as this is the first report on the water quality within this Forest Reserve that the authorities concerned will take heed to the recommendations made and take the necessary course of action to ensure that the problem at hand is mitigated and to deter further deterioration of the tourist destination. We believe that a pristine environment that ensures safety of inhabitants and tourists will only enhance the marketability of this destination and therefore should be considered a good marketing and green move.

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