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ASSESSMENT ON NUTRIENT STATUS IN WATER AND SEDIMENT QUALITY OF BERTAM RIVER, CAMERON HIGHLANDS

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ABSTRACT

A study of present nutrient status was carried out at Bertam River, Cameron Highlands within month of August - October 2012. Six sampling stations were selected representing open water body of the river catchments and sediment beds. An experimental activity involved analysis of nitrogen and phosphorus based parameter for water matrices as well as sediment quality such as particle size and organic carbon content. Results obtained indicate that the present nitrate content in river water (1.55 ± 0.09 mgL^{-1}) did not exceed the national (NDWQS) and international (WHO) maximum permissible safe limit for drinking purposed but phosphate (0.96 ± 0.20 mgL^{-1}) exceed recommended standards. While relative accumulation index indicated that nitrate and phosphate (6.27 ± 3.72; 5.03 ± 3.31 mgL^{-1}) concentrations in sediment were higher till 7.6 and 10.3 times than in water matrices. Texture analysis study classified sand type (70.72-94.12%) as predominant fractions in the sediment particle size and organic carbon has shown variation in study site. Statistical analysis (ANOVA, $p < 0.05$) showed that there were significant differences for nutrient concentrations in both matrices sample. Therefore, it was also noted that station in the vicinity of open farming practices and poor vegetated riparian at river bank (station 1A) has potential to be polluted among than others.

Key words: Nutrient, Sediment characteristics, Agriculture impact, Cameron Highlands.

INTRODUCTION

Cameron Highlands is one of hot spot popular tourist and recreational area in Malaysia. This area is located at 4°31"N and 101°29" E and has cover up approximately of 712 Km^2 or two percent of the total Pahang State land areas[1]. It consists of three sub districts

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which is namely as Telom (639.9 Km^2), Ringlet (51.56 Km^2) and Tanah Rata (20.27 Km^2). Major settlements of Cameron Highland's population were recorded at Bertam Valley, Kea Farm, Tringkap, Kuala Terla and Kampung Raja and economic growths are related to cultivation for vegetables, flowers, fruits and tea[2].

Meteorological conditions of Cameron Highlands significantly differ to present Malaysia's lowlands, with a mean daily temperature recorded in the range of 14.8-21.1°C. While the mean total rainfall was 2660 $mmyr^{-1}$ with maximum rainfall precipitation during March - April and October - December in respect to high humidity and there is none remarkably annual dry season[3,4]. Hydrological ecosystems show that Cameron Highlands are drained by major eight rivers, which called as Bertam, Telom, Lemoi, Ringlet, Habu, Burong, Tringkap and Terla River[5].

Regardless of management cultivation scheme applied in Cameron Highlands, most of the agricultural activity involved there depends on main rivers as their water resources. Recent studies stated that heavily impact of agricultural, residential and tourism activities caused deterioration of river water quality. Moreover, suspended solids from various land development activities nearby the catchment were found to be the main pollutants into river ecosystem at Cameron Highlands. Pollution problems in this area also came off from sewage treatment plants, which is major by contributed by hotels, rest houses, apartments, markets, food courts, laundries, car workshops and also leachate of garbage dumps[6].

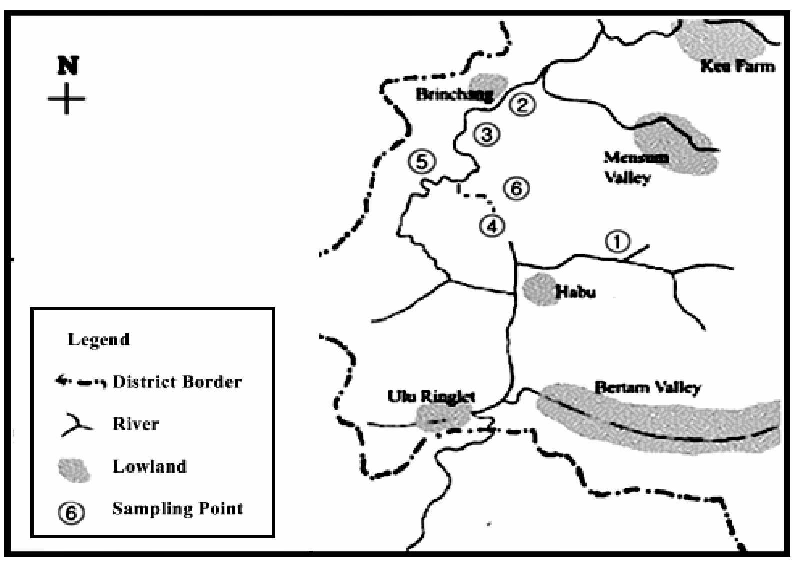

Fig. 1: Location of sampling stations in Cameron Highlands

In this study, Bertam river was selected as main location since it played a significant key role in irrigation, fresh water resources, and as main source for hydroelectric power supply of Cameron Highlands region[7]. Indeed, an aggressive land use change in recent year for agricultural activities, tourism and urban development in an area of Cameron Highlands, which have been widely reported in previous studies[6-8]. Therefore, main water resources such Bertam river will be expected to lead to more pollution loading in water and sediment matrices.

The aim of this study is therefore, to assess present status of nutrient concentration in water column and sediment of Bertam river in different localities as well as to determine the impact of varying agriculture scheme practices on aquatic ecosystems.

EXPERIMENTAL

Sampling activity

Samples were collected from six selected stations around Cameron Highland during the month of August - October 2012. All sampling locations were selected in such a way as to cover and represent variation of nutrient loss from different localities with varying anthropogenic discharge and major influences came off from agriculture site. Water sample was collected by immersed 1 Liter HDPE and glass bottles underneath 10 cm from surface of river water. Bottle sample was then labeled prior for transfer to placed into cool box filled with ice pack. Portable GPS was used to determine the coordinate each sampling station on location as presented in Table 1.

Table 1: Description of sampling location in Cameron Highland area

Station	Latitude	Longitude	Depth (m)
1A Bertam river (Tea plantations)	04°21.334 N	101°22.676 E	0.7
2A Bertam river (Golf course)	04°26.561 N	101°23.279 E	0.5
3A Bertam river (Slim camp)	04°28.928 N	101°22.821 E	0.3
4A Bertam river (MARDI office)	04°28.914 N	101°22.825 E	0.3
5A Bertam river (Strawberry park)	04°26.531 N	101°23.820 E	0.4
6A Parit waterfall	04°28.914 N	101°22.828 E	0.3

Physical water quality was measured *in situ* using YSI model 550 multi sensor probe for pH, temperature, conductivity, total dissolved solids and dissolved oxygen (DO). Calibration of every YSI model, 550 probes was conducted in the laboratory prior before field sampling and once again after sampling progress work was done. Depth level of each sampling station was measured using an echo sounder® model speedtech.

Meanwhile set sample of sediments were collected using Eckman grab sampler, and three replicates were taken from each station. Sediment samples was hence carefully collected using anti rust scoop, wrapped in aluminum foil and stored in a labeled polythene zipper bags prior to stored into cool box. Finally samples were transferred to ALIR laboratory for further analysis.

Laboratory analysis

The collected water samples were analyzed for several parameters namely as nitrate, nitrite, ammoniacal nitrogen, reactive phosphate, and total phosphorus. Concentrations of nitrate and nitrite in water sample matrices were analyzed according to cadmium reduction method. Another nitrogen-based by product (ammoniacal nitrogen) was analyzed following guidelines of salicylate method. For phosphorus group analysis, reactive phosphate and total phosphorus were determined following ascorbic acid and acid persulfate digestion method, respectively. Final determination was done by using HACH DR 2400 spectrophotometer. All sample analysis techniques are in accordance to guidance though Water Analysis Handbook (HACH, 1989).

The collected sediment samples were analyzed for the parameters namely as nitrate, total nitrogen, reactive phosphate, total phosphorus and organic carbon. Firstly, the percentage of moisture content in sediment sample was calculated by loss of weight at 105°C and sediment fraction grain size was separated using dry sieving analysis technique. Hence, sediment particle size was categorized based on International Soil Science Society (ISSS) Scheme; sand (< 200 µm), silt (< 20 µm) and clay (< 2 µm).

Nitrate content in sediment samples were extracted using 2 M potassium chloride solution, followed by filtration, prior to analyze following cadmium reduction method. Total nitrogen in the sediment sample was determined by Kjeldahl method using 0.2 g of wet sample. Sample was digested with mixture of concentrated sulphuric acid and potassium persulfate using mercury sulphate as catalyst. Final determination was done by titration with boric acid[9].

Meanwhile, phosphate content in sediment samples were extracted using 0.5 M sodium bicarbonate method and total phosphorus concentration was obtained by digested samples using 60% perchloric acid prior to final determination using DR 2000 spectrophotometer. Organic carbon content in sediment samples were determined by Walkey and Black method using 0.16 M potassium dichromate solution ($K_2Cr_2O_7$) and 96% sulfuric acid (H_2SO_4) as extracting agents[10]. The excess of $K_2Cr_2O_7$ solution was back titrated with 0.5 M ferrous ammonium sulphate solution using a few drops of ferroin solution as indicator. Total organic carbon was calculated using the following equation:

$$\text{Organic carbon (\%)} = \frac{[B - A] \times 0.195\,(\text{Factor})\text{ of blank of sample}}{\text{Weight of soil sample (g)}} \quad \ldots(1)$$

Where B is the total volume (mL) of Fe^{2+} solution used to titrate the blank while A is the total volume (mL) of Fe^{2+} solution used to titrate the sample.

Statistical analysis

Statistical analysis of the present data were interpreted using single factor analysis of variance (one way – ANOVA, $p < 0.05$) to measure significant differences between sampling stations. Pearson correlation was analyzed to identify the association between pairs of variables for sampling stations.

RESULTS AND DISCUSSION

In situ measurement

The pH value has shown no variation in Bertam river except only slightly change in the range of 6.98 to 6.72 (mean 6.52 ± 0.12) during time of sampling. Water temperatures were relatively constant at all stations in range of 18.01 to 19.41 (mean 18.83 ± 0.46) °C. Electrical conductivity values obtained varied between 38 to 62 (mean 51.83 ± 8.03) μScm^{-1}.

Concentrations of dissolved solids in water sample were recorded in the ranged of 23 to 46 (mean 40 ± 5.9) mgL^{-1}. Higher value of dissolved solids especially at station 2A was a result of leaching out dissolved ions from soil loss nearby the golf course area. Meanwhile, presence of dissolved oxygen concentration in Bertam river were obtained in the range of 3.61 to 5.45 (mean 4.99 ± 0.03) mgL^{-1}. Mean concentrations of *in situ* parameters are summarized as in Table 2.

Results show a significant increase for physical parameters such as conductivity and dissolved solids as compared to Eisakhani and Malakahmad[7]. Statistical analysis showed that conductivity and dissolved solids concentrations in water sample have significant differences (ANOVA, $p < 0.05$) between sampling stations.

Table 2: Mean concentrations of *in situ* parameters for Bertam river study

Station	pH	Temp. (°C)	EC (μScm^{-1})	TDS (mgL^{-1})	DO (mgL^{-1})
1A Bertam river (Tea plantations)	6.98	19.41	49	36.21	5.45
2A Bertam river (Golf course)	6.21	18.71	62	46.16	3.61
3A Bertam river (Slim camp)	6.29	18.88	56	41.42	5.17
4A Bertam river (MARDI office)	6.48	18.97	53	39.04	5.23
5A Bertam river (Strawberry park)	6.72	18.01	38	28.17	4.69
6A Parit waterfall	6.41	19.04	53	39.13	4.82
Eisakhani and Malakahmad (2009)	6.84	-	46.25	23.60	-

Nutrient in water

The concentrations of nitrate in Bertam river were recorded in the range of 0.72-3.41 (mean 1.55 ± 0.09) mgL^{-1}. Highest level of nitrate was obtained at station 1A in the vicinity of farming area, nearby tea plantations. In this area, sources of nitrate pollution came from nutrient loss of agriculture site. It could be truly significant for the present river aquatic environment especially early stage of cultivation was done during time of sampling. Therefore, it was reflected that most of the river bank riparian in this area are considered still poorly vegetated. Mostly fertilizers type applied in the cultivation of Cameron Highland crops are nitrogen, phosphorus, potassium inorganic fertilizers (NPK), chicken dung and other organic fertilizers[11]. The mean concentrations of nutrient based parameter are summarized as in Table 3.

Table 3: Mean concentrations of nutrient based parameter for Bertam river catchment

Station	Concentration (mgL^{-1})				
	NO_3^-	NO_2^-	NH_4-N	PO_4^{3-}	TP
1A Bertam river (Tea plantations)	3.41	0.045	0.07	1.35	2.85
2A Bertam river (Golf course)	1.62	0.015	0.19	0.91	1.66
3A Bertam river (Slim camp)	1.21	0.010	0.18	0.89	1.21
4A Bertam river (MARDI office)	1.31	0.015	0.14	0.95	1.62
5A Bertam river (Strawberry park)	1.13	0.021	0.13	0.80	1.32
6A Parit Waterfall	0.72	0.011	0.14	0.63	0.93

Although previous study stated that both runoff and leachate water can potentially pollute the surface and ground water resources, Aminuddin et al.[12], reported that NO_3 contaminant was found more persistent in Cameron Highland's groundwater rather than in runoff. Nevertheless, soil aggregations are expected to change after heavily land use change for agriculture in recent years. Being loosely bound to soils, nitrate was expected to be more in runoff and hence, its concentration in river catchments increases especially during rainy days.

In this study, station 6A (Parit Waterfall) be marked as control station as it was highly expected to be very clean (very low in nitrate content) since factors such as far away from human disturbance, no such agriculture activity and surrounded by forest make it cleaner than other areas. Another nitrogen-based by product (nitrite and ammonia), both show similar trend of small variation in measurement except for station 1A, which shows highest concentrations of nitrite and lowest ammoniacal nitrogen.

The concentration of ammoniacal nitrogen were recorded to be in the range of 0.07-0.19 (mean 0.14 ± 0.04) mgL^{-1} during time of sampling. Highest concentration for ammoniacal nitrogen was obtained at station Bertam river golf course (2A) with values of 0.19 mgL^{-1}. Higher ammonia levels found in this area could be related with low DO content during time of sampling. This phenomenon has been mainly attributed to rapid conversion of the oxides form of nitrogen compounds such as nitrate to ammonia in water with role of DO at low concentrations[13]. Nevertheless, present level of ammoniacal nitrogen concentrations recorded in this study can be still considered low. It was also figured out that another source of ammonia pollution from sanitary systems especially at Brincang residence area for instance do not yet have significant impact for aquatic ecosystems.

The concentration of phosphate in Bertam river were recorded in the range of 0.80 - 1.35 (mean 0.96 ± 0.20) mgL^{-1}. Higher level of phosphate obtained at station 1A was highly expected since this compound was present with nitrate in fertilizer usage. An application of phosphate as fertilizer in early stage cultivation of cabbage crops near station 1A during time of sampling possibly contributed much more phosphate content in river catchments. Furthermore, reactive phosphorus seems to be dominant in the percentage of 54.8-73.5 % as compared to total phosphorus concentrations in water samples.

According to Aminuddin et al.[2], agricultural schemes practices in the Cameron Highlands will lead to different environmental impact pollution. Open farming cultivation techniques seem to give rise in soil erosion rate and environmental pollution rather than rain shelter type. In this study, it was clearly observed that an applied of rain shelter cultivation activities in the vicinity of Bertam river catchments such as Strawberry park station (5A) give much more lower concentration of nitrate (1.13 mgL^{-1}) and phosphate (0.80 mgL^{-1}) in water sample during time of sampling.

Statistical analysis showed that there were significant differences (ANOVA, $p < 0.05$) both the nutrient concentrations in water sample between sampling stations. High correlation were also obtained between nitrate and phosphate ($r = 0.92$) in water samples during monitoring period. Thus, it showed that an excessive of fertilizer in agriculture crops soil will enhance an accumulation of contaminants and lead to more serious pollution problem, if sustainability management was not taken.

Nitrate concentrations in this study still did not exceed by Malaysian National Drinking Water Quality Standard[14] (NDWQS; 10 mgL^{-1}) and international recommended maximum permissible safe limit (WHO)[15] for drinking purpose. Otherwise mean concentrations of phosphate contents exceed both the recommended guidelines by NDWQS (0.2 mgL^{-1}) and WHO (0.1 mgL^{-1}).

Sediment characterization

Moisture content of Bertam river sediment was obtained between 20.21-30.45 %. Generally, sandy type of particle size sediments showed lower water content as compared with those of clay type of sediment. There are clearly indicated that decreasing trend percentage of moisture content were proportional to an increasing percentage of dominant sand type in sediment fractions.

The texture analysis study indicated that particle size for sandy type was in the range of 70.72-94.12%, silt type (3.40-17.93) % and clay type (1.64 to 7.22) %. The present texture study also revealed that sandy type was predominant fractions for sediment particle size at all the sampling stations. Spatial variations of physical sediment characteristic in present study are summarized as in Table 4.

Table 4: Spatial variation of physical sediment characteristic in Bertam river

Station	Moisture (%)	Sand (%)	Silt (%)	Clay (%)
1A Bertam river (Tea plantations)	30.10	70.72	4.31	10.22
2A Bertam river (Golf course)	24.28	84.41	8.75	4.28
3A Bertam river (Slim camp)	24.74	75.54	14.43	7.22
4A Bertam river (MARDI office)	30.45	86.08	7.15	4.19
5A Bertam river (Strawberry park)	30.45	76.70	17.93	5.35
6A Parit waterfall	20.21	94.12	3.40	1.64

Nutrient in sediments

The concentration of nitrate loading in Bertam river's sediment was recorded in the range of 2.50-12.2 (mean 6.27 ± 3.72) $mgkg^{-1}$. In the vicinity of farming area, results on several stations gave strength to previous hypothesis[2] that the concentration of nitrate as surface runoff impact from cultivation area could exceed the acceptable limit of 10 mgL^{-1}. Moreover, during high precipitation season, the concentration of NO_3 was expected to become higher than this study.

Previous study had claimed that nitrate concentrations could be increased at downstream of operational golf courses, could be as impact of constructional activity[16]. Although there are no reconstruction work on the golf course during sampling period, it was believed that leaching out dissolved ions into river streams during past operational may also increase nutrient and conductivity values during the present study.

These finding also observed that in the rain shelter agriculture practice type such as Strawberry park station (5A) was not highly affected by variations in nitrate content and therefore, probably had no significant effect by soil erosion. Relative accumulation index showed that the nitrate contaminant in sediment matrices were 1.5 to 7.6 times higher than in water. The mean concentrations of nutrient based parameter in sediment sample are summarized as in Table 5.

Table 5: Mean concentrations of nutrient content in Bertam river's sediment

Station	Concentration (mgL^{-1})				TOC (%)
	Nitrate	TN	Phosphate	TP	
1A Bertam river (Tea plantations)	8.44	8.82	7.70	9.62	7.4
2A Bertam river (Golf course)	12.24	14.31	9.91	10.03	3.6
3A Bertam river (Slim camp)	2.50	2.74	2.49	4.21	4.3
4A Bertam river (MARDI office)	7.33	8.01	5.90	6.25	3.6
5A Bertam river (Strawberry park)	3.15	3.92	3.65	4.15	1.9
6A Parit waterfall	1.10	1.80	1.83	2.01	0.6

The concentration of phosphate pollutant in Bertam river's sediment was recorded in the range of 1.83-9.91 (mean 5.03 ± 3.31) $mgKg^{-1}$. The pollutant fate pathway for phosphorus in form of particulates is greater from cultivated ground than grassland area.

Indeed, the phosphorus content would be lost from agricultural areas is mostly as particulate-P. There are not much differences of reactive phosphate and total phosphorus, since it would be dominant form in sediment sample. An amount or quality of phosphorus losses in the present study could depend on two main factors, which is the magnitude of source P discharges and dominance of P pathways[17].

In present study, due to poor vegetated at riparian zones, it could not react as a P trap along agricultural areas. This phenomenonal trend was similarly indicated at station those related to agriculture area such as station 1A, near MARDI office (4A) or even at golf course station (2A). Even though no such observed agriculture activity at station 3A, retention of phosphorus occurred, caused by high clay content in sediment abundance at particular area. Relative accumulation index showed that the contaminant of phosphate in sediment matrices were 2.7 to 10.3 times higher than in water sample.

The percentage of organic carbon content in Bertam river's sediment was recorded in the range of 0.6-7.4 (3.56 ± 1.72) %. There are not many differences among stations except for station 1A. Highest TOC levels in river bed sediments at station 1A give the significant impact that soil erosion would lead to pollution at the study site. Furthermore, the distribution of total organic carbon closely related to high percentage clay content abundance in sediment sample for station 1A. According to Kumary et al.[18], an increasing clay percentage would increase proportionally the accumulation of organic carbon content. This relationship had been shown by moderate correlation between organic carbon and clay type of sediment ($r = 0.65$).

Statistical analysis showed that there were significant differences (ANOVA, $p < 0.05$) both for nutrient concentrations in sediment samples between sampling stations. Then, strong correlation had also been obtained between TOC and TP ($r = 0.87$) in sediment sample, which reflected the role of organic substances in the leaching out of phosphorus into the river catchment. Additionally, it indicated that prevailing phosphorus species in this study area are dominant by reactive phosphorus form.

CONCLUSION

As nutrient loading to freshwater ecosystems increases, caused by anthropogenic activities, an ability to predict the resulting nutrient impact is becoming more important since Bertam river plays significant role as water resources for drinking, irrigation and hydroelectric power especially for people living in Cameron highlands area. Although, present nitrate concentrations in this study are lower than permissible safe limit suggested by the National Drinking Water Quality Standard (NDWQS) and international guidelines

(WHO), there were still extensively monitoring especially for phosphate contaminants those abundance with nitrate in fertilizer usage. Since almost agro systems are fertilizer dependent on crop growth, which is possibly leaching out into catchments and is continuously significant. Thus, it would reflect also an accumulation of nutrient contaminant in sediment bed, which become higher especially at different localities of agriculture schemes practice.

Results of sediment characteristic study clearly showed that local communities' activity such as land use for cultivation is known to have negative impact on river sediment quality in term of accumulation of organic carbon content especially in the vicinity of poor vegetated river bank area. Furthermore, it was also identified that station in the vicinity of open farming practices like station 1A tend to be polluted area among others. It is imperative to initiate some sort of Integrated River Water Management (IRWM) in Bertam river especially to reduce potential nutrient loading as a part of sustainability management for aquatic ecosystems in Cameron Highlands.

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REFERENCES

1. N. W. Abdullah and E. Toriman, J. E-Bangi, **5(2)**, 161 (2011).
2. B. Y. Aminuddin, M. H. Ghulam, W. Y. Wan Abdullah, M. Zulkefli and R. B. Salama, Water Air Soil Poll., **5**, 89 (2005).
3. N. W. Chan, Consumer Association of Penang, Malaysia, 66 (2000).
4. Z. Zainuddin, Z. Abdul Rashid and J. Jaafar, Malay. J. Anal. Sci., **13(2)**, 170 (2009).
5. M. Eisakhani, M. P. Abdullah, O. A. Karim and A. Malakahmad, Am. J. Appl. Sci., **9(3)**, 382 (2012).
6. M. B. Gasim, I. Sahid, E. Toriman, J. J. Pereira, M. Mokhtar and M. P. Abdullah, Am. Eurasian J. Agric. Environ. Sci., **5(6)**, 725 (2009).
7. M. Eisakhani and A. Malakahmad, World Appl. Sci. J., **7**, 769 (2009).
8. A. Hashim and G. M. Rahaman, Malaysian Agricultural Research and Development Institute, **1**, 10 (2006).
9. E. E. Schulte and B. Hoskins, Cooper. Bull., **493**, 63 (2009).

10. Z. Rivas, H. L. De Medina, J. Gutierrez and E. Gutierrez, Water Air Soil Poll., **117**, 27 (2000).

11. W. Y. Wan Abdullah, B. Y. Aminuddin and M. Zulkifli, Water Air Soil Poll. Focus, **5**, 115 (2001).

12. B. Y. Aminuddin, W. Y. Wan Abdullah, M. Zulkefli, A. Rahim and G. Osman, ACIAR Proceedings, **104**, 32 (2000).

13. N. M. Tahir, S. Suratman, N. A. M. Shazili, M. M. Ariffin, M. S. M. Amin and W. N. H. W. Sulaiman, J. Sustain. Sci. Manage., **3(1)**, 1 (2008).

14. National Drinking Water Quality Standards for Malaysia, Retrieved from http://kmam.moh.gov.my/[30-10-2012].

15. World Health Organization (WHO), International Standards for Drinking Water recommended by World Health Organization, Geneva, Switzerland Ed., **2** (1999) pp. 97-100.

16. J. G. Winter and P. J. Dillon, Environ. Pollut., **133**, 243 (2005).

17. D. R. Dos Santos, M. A. Santanna, R. Schenato, J. Kaminski, J. Dos Anjos and T. Tiecher, 9th World Congress of Soil Sci., Soil Solutions Changing World, 101 (2010).

18. K. S. A. Kumary, P. K. A. Azis and P. Natarajan, Ind. J. Marine Sci., **30**, 75 (2001).

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