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# Correlation between physico-chemical water quality and river ecosystems in Malaysia rivers with different land uses

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**Abstract.** River water quality is one of the major issues in water supply in Malaysia. Most people understand that, water pollution caused by the discharge from the factories and municipal waste but is that the real case? So, in order to answer the above question, this study was done to determine the interaction or correlation between physico-chemical water quality and river ecosystems. Component of river ecosystems measured are river riparian composition, large woody debris (LWD), canopy cover and substrate composition (D50). This study was conducted in Sungai Mengkibol, Sungai Madek and Sungai Dengar in Johor. There were a total of five sampling sites, three for impact stations and two as reference stations, including one highland station. For water quality, six in-situ parameters were measured namely temperature, conductivity, dissolved oxygen (DO), pH, turbidity and salinity using a multi parameter probe as well as a single parameter probe. Meanwhile, field survey form was used to assess river habitat namely river riparian compositions, canopy cover and LWD. In addition, Pebble Count Method was used to measure substrate compositions (D50). Results shows that, physico-chemical water quality was correlated ( $p < 0.05$ ) with riparian cover, LWD and canopy cover but it was not correlated ( $p > 0.05$ ) with substrate composition (D50) of the river. Based on the results obtained from the study, it can be suggested that physico-chemical river water quality was not caused by pollution alone but river ecosystems were also played significance role in determining the quality of water. Hopefully, this finding can be used by the responsible authorities for effective river management in order to sustain our drinking water supply.

## 1. Introduction

Basically, river has its own ecosystem which consists of several components or attributes. The changes of any one or more attributes will change the whole river ecosystem including water quality. Pollutants that enter and are in the body of water usually depend on the type of land use in the river area. Different land uses produce different pollutants. Normally, physicochemical parameters were used as an indicator to show whether the river water quality is good or bad [1]. Salam et al., [2] determined the heavy metals component in Perak River Malaysia as one of the parameter to gauge water quality status of Perak River and they expect the source come from wastewater and industrial discharges. This is in line with the findings of Camara et al., [3], where they found agricultural and forest-related activities as a cause of river pollution. However, lately more and more studies are being conducted by researchers to look at not only the physico-chemical quality but also the health of the river by correlating between aquatic life, especially benthic macro invertebrates with physico-chemical water quality [4].



Townsend and Riley [5], use the term 'integrity' to represent the natural state of an ecosystem (having little or no human disturbance), while on the other hand, Karr [6] defined river health as river which can still be used by the society at large. In the same breath, Townsend and Riley [5] pointed out certain considerations to be taken into account before quantifying the state of health of a river. Firstly, the need to determine whether some of the river ecosystem attributes are more fundamental to the maintenance of their functions than others. This is very important if physico-chemical or biotic measures are going to be used to assess river ecosystems whether it is being protected or not. Furthermore, the need to determine whether any single measure taken is sufficient to assess a river's health and, if not, the minimal parameters or attributes of measures have to be identified and incorporated into the monitoring programmes. Trush and Mc Bain [7] has proposed 10 general attributes of river ecosystems which are required to be considered while performing river health assessment or monitoring. One of them is channel morphology followed by flows and water quality, riverbed surface, riverbed scour and fill, fine and coarse sediment, channel migration, functional floodplain, channel resetting floods, riparian, and groundwater table. Moreover, based on a report published, it suggested that to maintain a riverine environment, biota, habitat and water quality are used as indicators for ecosystem health [8]. These indicators, however, consist of three river ecosystem attributes, namely biological, physical and chemical, so that these then can form an integrated approach to assess river health. According to the report [8], aquatic biota is used as a key indicator of river health because damage to the biota is often the end-point of environmental degradation. The availability and quality of habitat can affect the biotic community's characteristics in a river system, so that, evaluating habitat is an important component of ecosystem health assessment [9]. Water quality is also one of the river ecosystem attributes and thus can affect the biotic community present. The observation of flow also can be used as a supplementary element of the assessment. The observations will broadly indicate whether flow persisted along the length of the river system during the study period, and provide useful contextual information for interpreting the biotic data.

However, the effort or management of water resources requires the cooperation of all parties, whether the public, project developers, the private sector or the government, but, according to Nilsson and Malm Renofalt [10] the biggest role should be played by politicians or those who govern the country. This is because they are the ones who can make decisions and they are also the ones who can make policies and regulations. They are also the ones who can find allocations to implement related projects.

This study was conducted to determine the correlation between physicochemical water quality and river ecosystems for river receiving water run-off from different land uses.

## 2. Materials and Methods

This study was conducted within Sungai Endau watershed in the districts of Segamat, Kluang and Mersing in the state of Johor. The main tributary of these catchments is Sungai Sembrong which in-turn is fed by several tributaries such as Sungai Madek, Sungai Mengkibol and Sungai Dengar. River tributary that was selected for the study sites was in Order 2 to 3. This Order was chosen in the study in order to reduce the size of catchment area, so that, all the attributes can be assessed. There were a total of five sampling sites, three for impact stations and two as reference stations. Two sampling stations per site and three sampling points per station were identified, except the most up-stream station at Gunung Berlumut only had one station. Two sampling stations were identified for Sungai Mengkibol which was located in the middle of the town of Kluang. This station was categorized as the impact station (urban river) and incidentally was a receiver basin for all kinds of domestic wastes including wastewater from the industries and agriculture waste which were located upstream of the sampling stations. Two sampling stations were identified for Sungai Madek which was located in Lenggong Forest Reserve, Kahang, in Kluang. These stations were categorized as impact stations (logging area). The study site for agricultural land use is at Sungai Dengar Oil Palm Plantation. Two sampling stations were identified for Sungai Dengar which was located in the Gunung Berlumut of Kluang. These stations were categorized as impact stations (agricultural activities). Two sampling stations were identified for Sungai Hulu Dengar which was located at the foot of Gunung Berlumut, Kluang. These stations were

categorized as reference points. One sampling station was identified for Sungai Hulu Dengar which was located at the top of Gunung Berlumut itself about 300 m above mean sea level. This station was also categorized as reference point.

There were two types of data obtained from river water quality sampling exercise, i.e. in-situ and laboratory analyses data, where all the sampling and data analysis was carried out based on the standard procedure provided by the USEPA [11] and the Standard Methods for the Examination of Water and Wastewater [12]. Water Quality Index (WQI) and National Water Quality Standards for Malaysia (NWQS) published by the Department of Environment Malaysia used to interpret the data obtained.

All the river ecosystems components were recorded in the prepared field survey form prior to statistical analysis. The sampling method was mainly observation with the aid of some instruments such as measuring tape to measure the size of Large Woody Debris (LWD) and metric caliper as well as the meter ruler to measure the size of substrate during the pebble counts. LWD survey was basically undertaken to estimate total LWD volume or density, and data from all categories was collected for the entire basin. Measurements were designed such that for each piece of LWD encountered, volume can be approximated using the formulae for various geometric shapes. For small streams at least 100 m of channel was surveyed to stabilize the volume estimate as suggested by Janisch et al., [13]. On the other hand, canopy cover and riparian vegetation assessment was followed the Field Methodology for the Christchurch River Environment Assessment Survey (CREAS) [14] and also from the study conducted by Timbol et al., [15]. In addition, statistical analyses were also performed by using one-way ANOVA test to compare whether there were significant differences between treatment means, or in other words, to determine whether there were significant differences in terms of water quality parameters between sampling events and sampling stations. Chi-square test was also performed to determine the association level between one variable with another. Pearson Chi-Square value or *P*-value was used to determine the level of association. Numerical data or quantitative data was transformed into categorical data where the data was categorized into different categories and the value of each data was then categorized into simple coding.

### 3. Results and Discussion

Physicochemical water qualities were crosstab with river discharge, substrate composition, LWD, canopy cover and riparian composition (Table 1). There was no association and correlation between water quality and river discharge ( $p > 0.05$ ). Similarly with the cross tabulations made between water quality and substrate composition, there was no association and correlation amongst them ( $p > 0.05$ ). However, there was a significant association between physicochemical water quality with large woody debris ( $p < 0.05$ ), canopy cover ( $p < 0.05$ ) and riparian composition ( $p < 0.05$ ). At the same time, the correlations between water quality with LWD and canopy cover were very strong with Pearson's *R* value of 0.825 and 0.664 respectively. On the other hand, there was a weak correlation between physicochemical water quality with riparian cover with a Pearson's *R* value of 0.389.

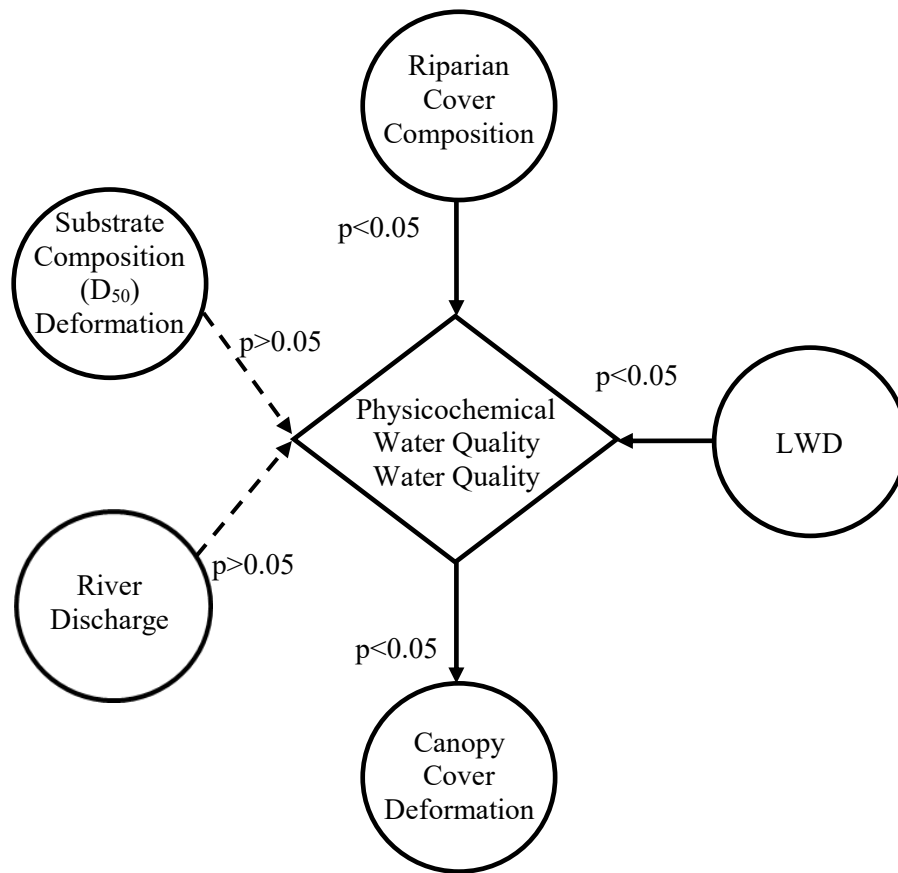
**Table 1.** Correlation between physicochemical water quality and physical characteristics.

<b>Index</b>	<b><i>P</i> - value</b>	<b>Pearson's <i>R</i> Value</b>
River Discharge	0.572	0.199
Substrate Composition ( $D_{50}$ )	0.545	0.354
Large Woody Debris (LWD)	0.000	0.825
Canopy Cover	0.000	0.664
Riparian Composition	0.000	0.389

The results recorded is supported the concept of river health where it is usually associated with good physical and chemical water quality as well as maintenance of natural habitat, natural river morphology and sustainable aquatic life. As each attribute has its specific and intended use, each of which may not give a true picture of the health of river when such assessment is conducted, an alternative approach for

a complete river health assessment would obviously entail integrating these attributes in a unified manner. Integration here means connecting or creating links between one with other attributes in the system. In this respect, the integration of the river ecosystem attributes is basically connecting or linking the factors usually used such as riparian cover, canopy cover, LWD, substrate compositions, river discharge, river bank type, shape of river channel, river meander, physicochemical water quality and aquatic life. Riparian cover and compositions as well as canopy were the main factors which contributed to changes of all other factors of the ecosystem, such as LWD, substrate compositions, river discharges, riverbank types, shapes of river channel, river meanders, physicochemical water quality and aquatic life forms. The added advantage of determining each of them will give an indication as to how a river system has been abused by human intervention. For example, river riparian cover acted as filter for suspended solids before water flow into a river and also helped to impede and slow down the flow indirectly helping to minimize river bank erosion. The river canopy, on the other hand, plays the role in reducing water temperature. This is amply exhibited from the results obtained where rivers which had reach canopy cover recorded a good water quality as compared to the least or those of poor canopy cover. Usually the undisturbed river which are located upper most of the stream channel have good canopy cover compared to those locations at the downstream channel which is almost always with poor canopy as a result of human encroachment. The results from this study revealed that good water quality were recorded in rivers which had good canopy cover (Sungai Hulu Dengar, Dengar and Madek) compared to the river with the least or poor canopy cover (Sungai Mengkibol), especially in terms of lower temperature regime and higher content in dissolved oxygen. This was confirmed with study from Fatimah and Zakaria Ismail [16], where they found very good water quality of the Hulu Selai River, Endau-Rompin National Park.

All the results obtained was summarized in a form of diagram showing the interaction of different components as illustrated in Figures 1. LWD, canopy cover and riparian cover would be the most crucial component needed to be determined in order to ascertain the physicochemical water quality. The direction of these arrows in the diagram towards the attribute of physicochemical water quality represented the association in addition to indicating which attributes are dependent variables and which are independent. From Figure 1, parameters given in the circle which are placed surrounding the diamond box represent independent variables, i.e. attributes such as riparian cover, canopy cover, LWD, substrate compositions and river discharge which will have an influence on physicochemical water quality. However, this study revealed that,  $D_{50}$  and river discharge were not the influencer of water quality. Meaning that, these two parameters were not the crucial parameter to determine physicochemical water quality. The information obtained could be used as a basis for river rehabilitation programme. Additionally, the determination of river riparian and canopy cover are also important to ascertain the degree of channel deformation and density of LWD. These two attributes together with physicochemical water quality would have to be put in place first and must form a compulsory feature when beginning the process of river rehabilitation. The first tier tool or indicator for river rehabilitation process comprises of primary (mandatory) parameter which is the physicochemical water quality and of secondary parameters which are canopy cover, riparian cover, LWD, substrate compositions ( $D_{50}$ ) and river discharge.



**Figure 1.** Interaction between physicochemical water quality with riparian cover, canopy cover, LWD, river discharge and substrate composition.

#### 4. Conclusion

There are correlations between water quality with LWD, canopy cover and riparian cover but there was no association and correlation for river discharge and substrate compositions (D50). The correlation between water quality with LWD and canopy cover were very strong, however, there was a weak correlation between physicochemical water quality with riparian composition. It can be concluded that river water quality changes with the density of LWD, canopy cover and riparian cover. The higher the density means the better the quality of river water.

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