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Trend Analysis of Water Quality at Sungai Sarawak

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ABSTRACT

Sungai Sarawak is the most important river in Sarawak. This study was aimed at assessing water quality in the selected stations from Satok bridge to the downstream, Muara Tebas, located along Sungai Sarawak. Water quality trend analysis was conducted to determine the correlation between the water quality parameters. Trend analysis was carried out using Mann-Kendall Test because data collected was non-parametric. Next, Spearman rank was used in order to determine the correlation between parameters. The results obtained and the observation made in this study reveals that the trend exists only for Chemical Oxygen Value (COD). But there are trends for Biochemical Oxygen Demand, (BOD), Dissolved Oxygen (DO), Total Suspended Solid (TSS), Ammoniacal Nitrogen (NH4N) and Turbidity to decrease or increase with no trends between 2007 and 2011. The correlation between parameters is not very strong because there are many determinants of water quality parameters. The result from this study would provide useful information for water quality management in order to maintain and improve the water quality of Sungai Sarawak.

Keywords: Correlation, management trends analysis, water quality

INTRODUCTION

Rivers have been utilised by mankind over the centuries to the extent that, very few, if any, are now in their natural condition (Wetzel, 2001). Kovacs (1986) describes river pollution as an integrated, environmental problem resulting from unregulated industrial pollutants and accidental spills as well as from airborne and other non-point sources, urbanisation, deforestation, erosion and intensive agriculture. Chau et al. (2002) stated that is important to predict accurately quality of water bodies in water resource planning and management. Chang et al. (2001) stated that it is essential to assess water quality of the river

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even though data availability is limited. Additionally, there are various classification methods that have been used for estimating the changing status usability of surface water in river basins. This study provides water quality trend analysis and correlation among the parameters.

MATERIALS AND METHODS

Data Collection

Data was collected from Natural Resources and Environment Board Sarawak (NREB). There are about 24 water quality parameters monitored by NREB. However, only the following are assessed for this study: DO, BOD, COD, NH_4N, TSS and Turbidity while research focus was south of Sungai Sarawak.

Research Design and Procedure

Trend Analysis. Hydrology data are rarely normally distributed or independent (Cluis et al., 1989). Data was analysed using Mann-Kendall Test. The purpose of the Mann-Kendall (MK) test (Gilbert 1987) is to statistically assess if there is an upward or downward trend of the variable of interest over time.

According to this test, the null hypothesis H0 assumes that there is no trend (the trend is independent and randomly ordered) and this is tested against the alternative hypothesis H1, which assumes that there is a trend. The computational procedure for Mann-Kendall test considers time series of n data points. The data values are evaluated as an ordered time series. Each data value is compared with all subsequent data values. If a data value from a later time period is higher than a data value from an earlier time period, the statistics S is incremented by 1. On the other hand, if data value from a later time period is lower than a data value sampled earlier, S is decremented by 1. The net result of all such increments and decrements yields the final value of S. Once S statistic has been calculated (in this study, S-statistic was calculated using Excel), it is compared with the table of null probability values of S for the number of data points (n) in the series. If the probability value for the calculated S-statistic is less than the specified significance level for the test (α=0.05), the result is significant at the 1-α confidence level and a trend is present (David, 2005). Value of S-statistic will be in negative or positive - the former means that a decreasing trend in concentration over time is present at the 95% confidence level, while the latter of S-statistics means that an increasing trend in concentration over time is present at the 95% confidence level.

The Correlation between Water Quality Parameters. In order to achieve the third objective of this research which is the correlation between water quality parameters, Spearman's rank correlation coefficient or Spearman's rho have been used. Based on the result of normality test, data is nonparametric and the most suitable statistical test is Spearman's rank correlation. This test will assess how well the relationship between two variables can be described using monotonic functions. Correlation is a strength measurement for linear relation between two variables under review. Bidin Yatim in Rali (2003) described the correlation coefficient value which is near to-1 or 1 which indicates strong linear relation between two variables. Guilford's

Rule of thumbs (Guilford, in Kaprawi, 2000) was used to interpret the magnitude of the correlation between parameters to see if the correlation was strong or weak.

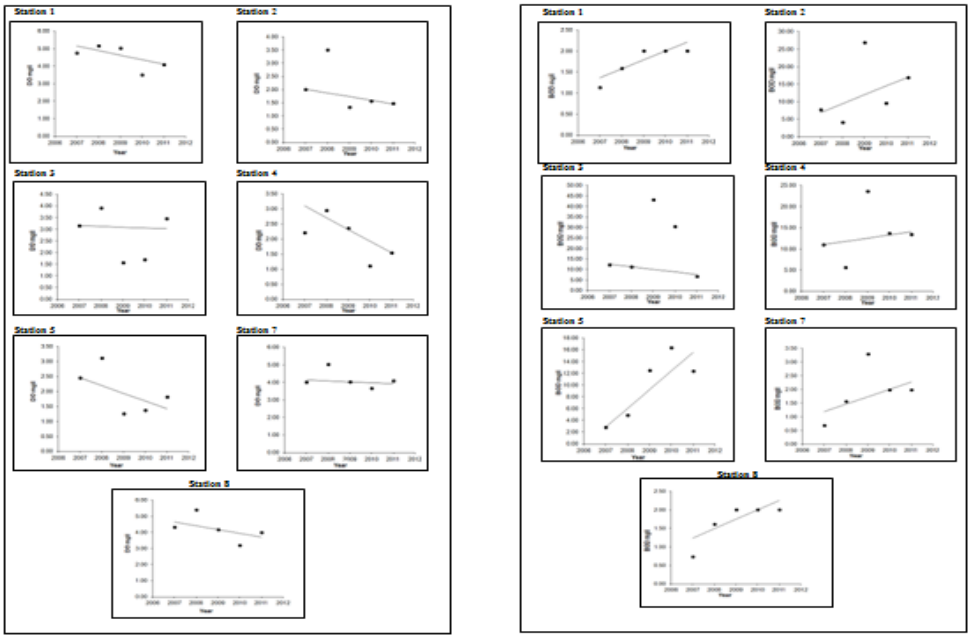
RESULTS AND DISCUSSION

Trend Analysis of Water Quality Parameter

Trend analysis was carried out using Mann-Kendall test according to the water quality parameters that have been selected. The seven selected locations were Satok Bridge (Station 1), Confluence of Sungai Bintangor (Station 2), Holiday Inn (Station 3), Confluence of Sungai Padungan (Station 4), Confluence of Sungai Sekama (Station 5), Upstream Barrage (Station 7) and Downstream Barrage (Station 8). The null hypothesis (H0) and alternative hypothesis (Ha) are as below:

H_0: There are no trend exist ; H_a: There are trend exist

Dissolved Oxygen. The analysis reveals an absence of trend for dissolved oxygen (DO) along Southern Sarawak River between 2007 and 2011. The probability value for each station is more than α value (0.05). Thus, H_0: There is no trend, and is accepted. It also can be seen in Figure 1(a) where all the data are scattered with no trend throughout the year. Although there is no trend for dissolved oxygen along the river, the linear for all station shows that the dissolved oxygen has a tendency towards deterioration.



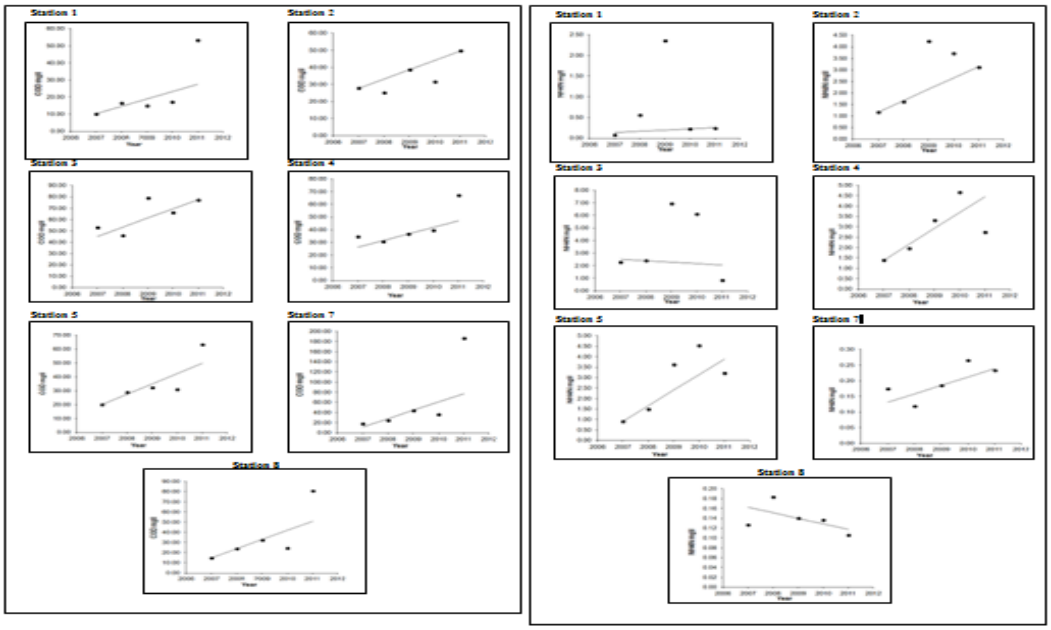
(a) (b)

Figure 1. Linear lines for: (a) DO; and (b) BOD

Biochemical Oxygen Demand

Results showed the lowest probability value for Biochemical Oxygen Demand (BOD) is 0.117 and the highest probability value is 0.408 which are more than the significant value, α=0.05. Thus H0: There is no trend, is accepted. Figure 1(b) shows all the data are scattered with no trend for all the year. From this figure, all the linear lines indicate the tendency of deterioration of BOD except at station 3.

Chemical Oxygen Demand. There is trend at stations 1, 4, 5, 7 and 8 for Chemical Oxygen Demand between 2007 and 2011 along Southern Sarawak River. By using Mann-Kendall method, probability for these station is 0.042<0.05 which means H_0 is rejected and Ha is accepted. The trend indicates that COD is increasing which means there is deterioration in water quality in the study duration. However, there are 2 stations with no trend, station 2 and station 3 with the P value which is more than 0.05. Although there is no trend at station 2 and 3, but the linear lines in all graph plotted in Figure 1(c) show that the content of COD is increasing randomly with no trend at all stations along the river.



(c) (d)

Figure 1. Linear lines for: (c) COD; and (d) NH_4N

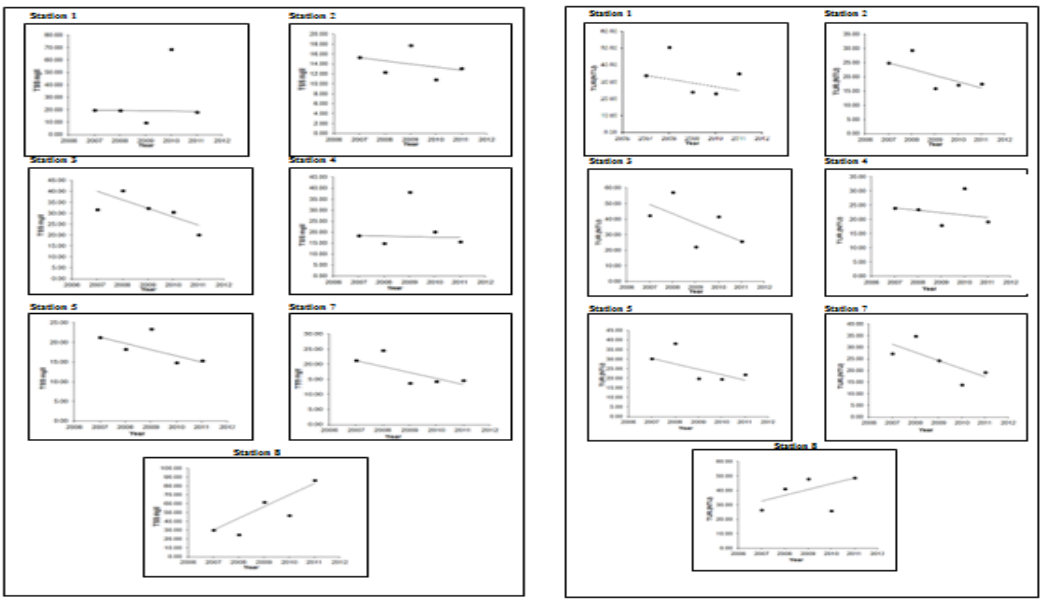
Ammoniacal Nitrogen

From the analysis, no trend exists at all station for Ammoniacal Nitrogen between 2007 and 2011 along Sothern Sarawak River. By using Mann-Kendall method, probability for these stations is more than 0.05 which means H_0 is accepted. Figure 1(d) shows all the data are

randomly plotted with no trend. However, NH4N content at stations 1, 2, 4, 5 and 7 show no trend while at stations 3 and 8, NH_4N content is decreased with no trend.

Total Suspended Solid

Analysis shows that no trend exists at all stations for Total Suspended Solid. Probability for these stations is also more than 0.05 which means H_0 is accepted and no trends exist. Figure 1€ shows all the data are scattered randomly. However, Figure 1(e) shows TSS at stations 1, 2, 3, 4, 5 and 7 show no trend, while it decreased with no trend at station 8.



(e) (f)

Figure 1. Linear lines for: (e) TSS; and (f) Turbidity

Turbidity

In terms of turbidity, the analysis shows no trends exist at all station for the study period. By using Mann-Kendall method, probability for these stations is also more than 0.05 which means H_0 is accepted and there are no trends. Figure 1(f) shows all the data are distributed randomly. However, the quality of turbidity at stations 1, 2, 3, 4, 5 and 8 increased without any trend; while at station 7, TSS content decreased without any trend.

Correlation among Parameters

Table 1 shows a weak correlation between BOD and DO. The rho's value = -0.298 indicates that when BOD is level is high, there is a decline in DO levels. The findings support the theory that when BOD levels are high, DO levels decrease. This is because the demand for oxygen by bacteria is high and they are taking that oxygen dissolved in water. If there is no organic waste

present in the water, there won't be as many bacteria present to decompose it and thus, BOD will tend to be lower and the DO level will tend to be higher. When BOD levels are high, DO levels decrease because the oxygen that is available in the water is consumed by the bacteria.

The second correlation is between Ammoniacal Nitrogen (NH_4N) and Dissolved Oxygen (DO). Rho's value is -0.49. Negative sign means that when NH_4N is high, so DO will decrease. Ammoniacal Nitrogen (NH_4N) is indicates the presence of animal and human waste, domestic waste, urban and industrial as well as agricultural fertiliser. High concentration of NH_4N will enhance pulse, respiration rate and balance aquatic activities and affect metabolism. For example, Sungai Langat also suffers from NH_4N pollution caused by domestic, industrial and land use activities (Haslinur et al., 2012). Thus, when NH_4N is high, it means there is a lot organic waste, and the bacteria will begin the process of breaking down this waste. The third correlation exists between BOD and COD. The Rho's value is 0.591 indicating a moderate correlation between BOD and COD. Positive value of Rho's value indicates that there is positive significance between BOD and COD. According to Byod (1990), it is possible if BOD and COD have same value, but the former should not be greater than COD.

The fourth correlation is between NH_4N and BOD. It is moderate correlation. The Rho's value is 0.572 and positive value of Rho's means there is positive significance between BOD and NH_4N. Ammoniacal Nitrogen (NH_4N), as stated previously, is a major indicator of the presence of animal and human waste, domestic waste, urban and industrial as well as agricultural fertilizer. High concentration of NH_4N leads to increased pulse rate, respiration rate and affect aquatic life activities aquatic as well as affects metabolism. Microorganisms such as bacteria are responsible for decomposing organic waste. If there is a large quantity of it in the water. There is a lot of bacteria present working to decompose this waste and in this case, the demand for oxygen will be high and so the BOD level will be high.

The fifth correlation is between BOD and TSS. The Rho's value is 0.304 indicating a weak correlation between BOD and TSS. The positive value of Rho's value means that as TSS increased, so did the BOD level. This is confirmed by Tagarotop (2009) who concluded that BOD and TSS have high correlation. Total suspended solids (TSS) include all particles suspended in water which will not pass through a filter. The TSS consists of sanitary wastewater, soil erosion from agricultural and construction sites. As level of TSS increase, the water body begins to lose its ability to support a diversity of aquatic life. Microorganisms will begin to decompose organic waste which will directly increase the biochemical oxygen demand.

Besides, a correlation also exists between COD and NH_4N. The Rho's value is positive, =0.401, that indicates the positive relationship between COD and NH_4H. The COD is a measure of the amount of oxidisable matter present in the water. Sometimes, COD and NHN may come from similar sources such as industrial waste and agricultural fertiliser. Therefore, these two parameters have a positive relationship. Lastly, the correlation also exists between TSS and turbidity. The Rho's value is equal to 0.584. The correlation is positive and this result is parallel with Hannouche et al. (2011) who showed that the turbidity-TSS calibration relationship show good linearity regardless of weather conditions.

Table 1
Correlation among parameter of water quality

Correlation	Rho value	P value	Hnull	Magnitude of Correlation
DO-BOD	-0.298	0.047	Rejected	weak
DO-NH_4N	-0.49	0.01	Rejected	moderate
BOD-COD	0.591	0	Rejected	moderate
BOD-NH_4N	0.572	0	Rejected	moderate
BOD-TSS	0.304	0.042	Rejected	weak
COD-NH_4N	0.401	0.006	Rejected	moderate
TSS-TUR.	0.584	0	Rejected	moderate

CONCLUSION

The results of this study showed that although almost all linear lines of parameters tend to represent the increase or decrease in water quality, only COD displayed a trend. This is because data plotted is distributed randomly with no trend. Although there are correlations among the parameters, it is weak. The correlation between the parameters is not strong because there are many other factors that affect water quality parameters.

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