



## Trend of Six Physiochemical Water Quality Parameters between 2012 and 2015 of the Marang River, Terengganu, Malaysia

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### ABSTRACT

An environmental study was carried out at Marang River, Terengganu on determination of river water quality trend variations temporally and spatially at seven sampling stations between 2012 and 2015. Sampling stations were selected along the river started from downstream to upstream; where each station was 2km apart from each other. Sampling was done twice at each sampling stations which were during low and high tides in November 2012 and also was repeated in November 2015. Both samplings were conducted during Northeast monsoon period. Selected water quality parameters such as salinity, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), pH and turbidity were measured using certified scientific instruments. One way ANOVA and Tukey Kramer multiple comparison were used for statistical analysis. This study revealed that there is significant temporal variation in DO and turbidity which was increased from downstream to upstream between 2012 and 2015 due to the increase of land use activities; while other parameters such as EC, salinity, TDS and pH were decreased. These results were concluded that global change coupled with the enactment of heavy storm and flood phenomenon during 2014 was lead to the rising of sea level and salinity dilution of the South China Sea.

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### INTRODUCTION

Malaysia received abundance amount of rainfall every year. Peninsular Malaysia received average rainfall approximately 2400mm per year [1]. Some of the water will seep into the ground to become groundwater resources, some will turn into evapotranspiration and the rest will form surface runoff [2, 3]. The surface runoff eventually will gather into the river stream as river water. River is important in ensuring the continuity of lives apart from other water resources. Some of activities related to river is fisheries, aquiculture, water sport activities, farming activities and many more. Years ago, rivers were very clean and less polluted compared to present. This situation is resulted from the increasing populations living along the riverbank and numerous activities carried out close to river areas [4, 5].

Other than anthropogenic activities, the natural phenomena are also affecting the river water quality such as sea level rise and tidal activities [6]. Melting glaciers

and thermal expansion of seawater are among the major factors that caused sea level rise [7]. In conjunction to these phenomena, the influx of saltwater into river through estuary was amplified. As a consequence, there is variation in water quality of surface water. Besides, diurnal variation of sea level which is also known as tidal activities were also affected by this phenomena. It was shown by the alteration of low and high tides level.

Physiochemical parameters such as total dissolved solids (TDS), dissolved oxygen (DO), salinity, electrical conductivity (EC), turbidity and pH are effectively in assessing water quality [8, 9]. From these parameters, the potential activities that controls water quality can be indicated and the degree of variations could be determined. Therefore, a water quality assessment with respect to sea level rise impact at Marang River is carried out in this study to determine water quality trend variations spatially and temporally as well as the potential factors that contributing to the variations.

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## MATERIAL AND METHODS

### Sampling stations and methods

Marang River is located in Marang district of Terengganu, Malaysia. Water quality sampling was carried out along this river on 13 November 2012 and was repeated on 25 November 2015. Both samplings were during Northeast monsoon period. During this period, the eastern part of Peninsular Malaysia received heavy rainfall and its sea surface temperature declined [10, 6]. Seven sampling stations were selected from downstream to upstream of this river for water quality assessment. The first station is located at the estuary where the meeting point between the ocean and Marang River is situated. The last station is located at upstream where this area is less disturbed by tidal activities. Each station is 2km apart, explaining the total sampling distance along this river as approximately 18km (Figure 1). In this study, tidal activities are considered as one of the factors that influenced river water quality and hydrology of the river. Thus, sampling is done twice where the first sampling is done during low tide and, the other sampling during high tide. Both samplings were done at the same location according to the coordinate pinpointed by Global Positioning System (GPS). The recorded coordinate for each sampling stations is tabulated in Table 1.

### Measurement of *in situ* parameters

Parameters such as dissolve oxygen (DO), electrical conductivity (EC), total suspended solids (TDS), salinity and pH were measure using YSI 556 Handheld Multiparameter meter. Turbidity was measured using 2100Q Portable Turbidimeter. Instruments were calibrated before the measurements.

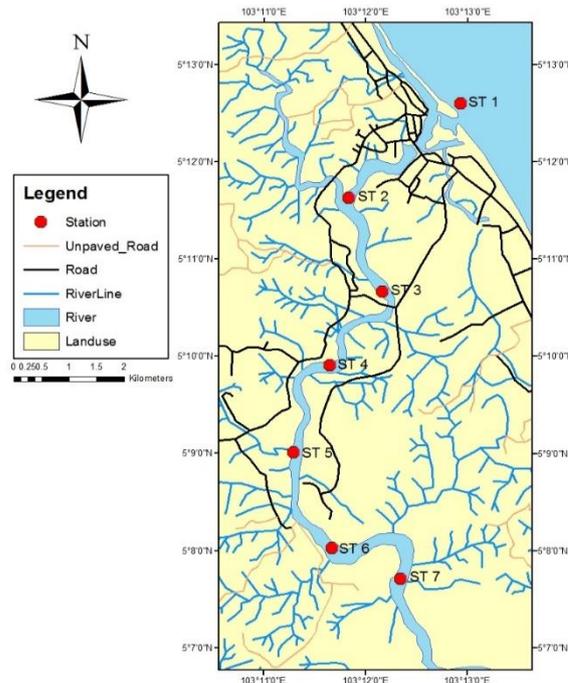
**TABLE 1.** Coordinate location of each sampling station

Station	Latitude	Longitude
ST1	N 05° 12' 34.9"	E 103° 12' 49.8"
ST2	N 05° 11' 36.41"	E 103° 11' 43.87"
ST3	N 05° 10' 38.51"	E 103° 12' 03.65"
ST4	N 05° 09' 53.16"	E 103° 11' 32.8"
ST5	N 05° 08' 59.55"	E 103° 11' 11.58"
ST6	N 05° 08' 00.29"	E 103° 11' 34.13"
ST7	N 05° 07' 41.04"	E 103° 12' 14.06"

### Statistical analysis

One way ANOVA (Analysis of Variance) is used to determine the significant difference between low tide 2012, high tide 2012, low tide 2015 and high tide 2015 data populations of each parameter based on p-value (P). No significant difference between data populations meaning that there are insufficient evidence to prove the data population means are not similar. Significantly

difference explains that there are sufficient evidence to state that at least one data population mean is not the same. Parameters that show significant difference was further analysed by using Tukey Kramer multiple comparison. This method is effective in identifying which data sets have different mean populations. One way ANOVA and Tukey Kramer multiple comparison analysis were performed by using Microsoft Office Excel 2010.



**Figure 1.** A map showing the seven sampling stations along Marang River

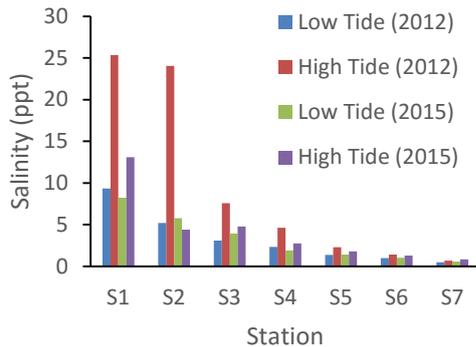
## RESULTS AND DISCUSSION

### Water quality analysis

There were six physicochemical water quality parameters analysed to determine the water quality based on temporal and spatial variations. Six in-situ parameters such as DO, EC, TDS, salinity, pH and turbidity are included.

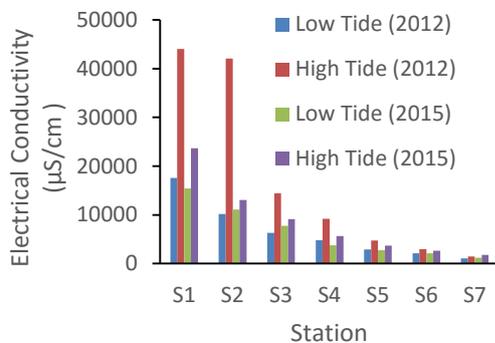
#### 1. Salinity, Electrical Conductivity (EC) and Total Dissolved Solids (TDS)

The salinity readings for seven sampling stations along Marang River for low and high tides during 2012 and 2015 are illustrated in Figure 2. During 2012, for low tide, salinity readings were ranging from 0.49 – 9.32 ppt with average of 3.26 ppt meanwhile during high tide, salinity readings were ranging from 0.68 – 25.36 ppt with average of 9.37 ppt. During 2015, salinity was ranging from 0.57 – 8.22 ppt with average of 3.26 ppt for low tide meanwhile, salinity were ranging from 0.84 – 13.1 ppt with average of 4.13 ppt during high tide.



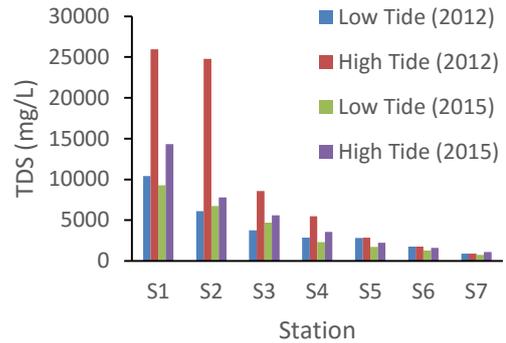
**Figure 2.** Salinity at seven sampling stations for low tide and high tide of 2012 and 2015

Figure 3 shows the EC readings of Marang River for low and high tides during 2012 and 2015 at seven particular sampling stations. During 2012, EC readings of these sampling stations were ranging from 1070 – 17541  $\mu\text{S}/\text{cm}$  with average of 6407  $\mu\text{S}/\text{cm}$  for low tide, meanwhile, EC readings were ranging from 1478 – 44027  $\mu\text{S}/\text{cm}$  with average of 16975  $\mu\text{S}/\text{cm}$  during high tide. During 2015, EC readings were ranging from 1203 – 15432  $\mu\text{S}/\text{cm}$  with average of 6309  $\mu\text{S}/\text{cm}$  for low tide, meanwhile, EC readings were ranging from 1755 – 23685  $\mu\text{S}/\text{cm}$  with average readings of 8499  $\mu\text{S}/\text{cm}$  during high tide.



**Figure 3.** EC at seven sampling stations for low tide and high tide of 2012 and 2015

The TDS reading for low and high tides during 2012 and 2015 at seven sampling stations along Marang River is as shown in Figure 4. During 2012, TDS were ranging from 900 – 10,430 mg/L with average reading of 4,091 mg/L for low tide; meanwhile, TDS were ranging from 900 – 25,970 mg/L with average reading of 10,046 mg/L during high tide. During 2015, TDS were ranging from 745 – 9,276 mg/L with average reading of 3,832 mg/L for low tide; meanwhile, TDS were ranging from 1,094 – 14,336.8 mg/L with average reading of 5,172 mg/L during high tide.



**Figure 4.** TDS at seven sampling stations for low tide and high tide of 2012 and 2015

Salinity, EC and TDS parameters of Figures 2, 3 and 4 respectively were showing similar distribution trend which are declining from station 1 (S1) to S7. The similar trends suggesting an association between these parameters. One way ANOVA ( $P < 0.05$ ) revealed no significant difference between data populations of salinity ( $P = 0.206$ ), no significant difference between data populations of EC ( $P = 0.206$ ) and no significant difference between data populations of TDS ( $P = 0.245$ ). However, the salinity, EC and TDS reading amplitudes for 2012 are greater than 2015 and significantly shown at S1 and S2. These results emphasized a slight declination in salinity, EC and TDS from 2012 to 2015 but it is not significant enough as revealed by one way ANOVA.

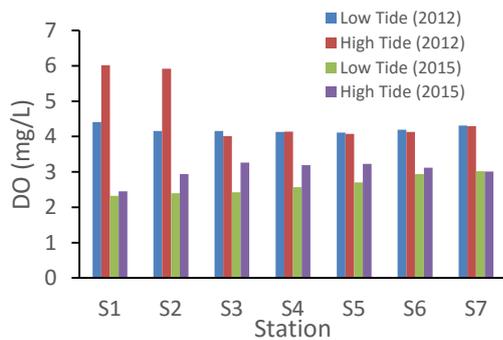
These declinations are proposed to be caused by an influx of freshwater into the ocean contributed by rainfall, melted glaciers and ice [11]. Addition of freshwater into ocean lead to salinity dilution [12, 10]. Water is polar molecule that have equal number of positively charge hydrogen and negatively charge oxygen components. These water molecules react with the main constituents of ocean salinity and reduced their concentrations. As salinity decreases, electrical conductivity and TDS are also decreases. This is because of linear relationship between salinity, electrical conductivity and TDS [14, 15].

The readings of salinity, EC and TDS were higher during high tide compared to low tide for bothin 2012 and 2015. This variation was due to the tidal activities. During high tide, sea water level rises and causing saltwater to intrude into river, meanwhile, less of saltwater content in the river during low tide. This situation also explained the reason for salinity, EC and TDS were varied between stations. Stations that located at estuary, near to the sea received more saltwater compared to the middle and upstream of the river.

#### Dissolved oxygen (DO)

Figure 5 shows the DO readings at seven sampling stations along Marang River for low and high tides during

2012 and 2015. During 2012, DO reading were ranging from 4.11 – 4.41 mg/L with average of 4.21 mg/L for low tide, meanwhile, DO were ranging from 4.01 – 6.02 mg/L with average reading of 4.66 mg/L during high tide. During 2015, DO reading were ranging from 2.32 – 2.94 mg/L with average of 2.62 mg/L during low tide, meanwhile, DO were ranging from 2.45 – 3.26 mg/L with average reading of 3.03 mg/L during high tide.



**Figure 5.** DO at seven sampling stations for low tide and high tide of 2012 and 2015

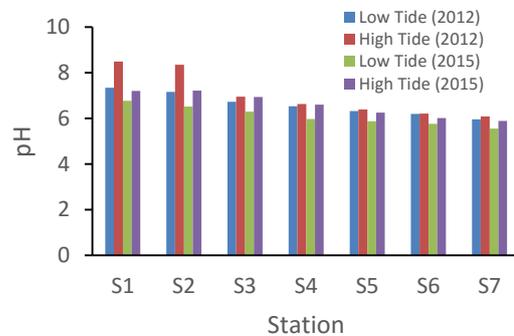
Figure 5 also visualized the distribution trend of DO from S1 to S7 for 2012 and 2015. DO in 2012 were rapidly declined from S1 to S3 and then slowly increased until S7. During 2015, DO was slowly increases from S1 to S7. One way ANOVA ( $P < 0.05$ ) revealed that there are significant differences between data populations ( $P = 0.0001$ ). Tukey Kramer multiple comparison determined that significant differences are existed between data populations of low tide (2012) to low tide (2015), low tide (2012) to high tide (2015), high tide (2012) to low tide (2015) and high tide (2012) to high tide (2015). These significant differences were due to great variation between data populations of respective low and high tides of 2012 and 2015 caused by the increasing rate of land use activities close to riverbank [16].

In general, distribution trend of DO is increasing from S1 to S7. It has an inversed trend to salinity (Figure 2). This trend emphasized that dissolved oxygen is increase when salinity decreases [17]. Oxygen is less soluble compared to salinity constituents [18]. Thus, water can easily combined to salinity constituents and reduced water potential to dissolve in water. Salinity of water is decreasing from downstream to upstream, explaining the increasing potential of oxygen to be dissolved from downstream to upstream (S1 to S7). Increasing trend of DO is also caused by increasing of land use activities from upstream to downstream.

### pH

A pH reading for seven sampling stations along Marang River for low and high tides during 2012 and 2015 are shown in Figure 6. During 2012, low tide, pH readings were ranging from 5.96 – 7.34 with average of 6.61,

meanwhile for high tide, pH readings were ranging from 6.09 – 8.5 with average of 7.02. During 2015, pH were ranging from 5.55 – 8.22 with average of 6.11 for low tide, meanwhile, pH readings were ranging from 5.89 – 7.22 with average of 6.59 during high tide.

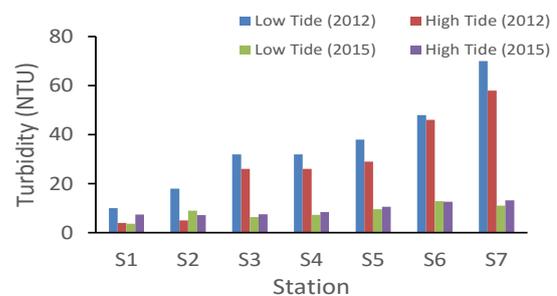


**Figure 6.** pH at seven sampling stations for low tide and high tide of 2012 and 2015

The distribution of pH trend was gradually decreasing from S1 to S7 during low and high tides in 2012 and 2015 (Figure 6). One way ANOVA ( $P < 0.05$ ) performed on pH data was revealed that there is no significant difference between data populations ( $P = 0.112$ ). Decreasing of pH trend emphasized that the river water became more acidic towardupstream [18]. It has a linear relationship with salinity [19]. As salinity decreases towards upstreamand river water became more acidic.

### Turbidity

The turbidity readings for seven sampling stations along Marang River for low and high tides during 2012 and 2015 are shown in Figure 7. During low tide 2012, turbidity were ranging from 10 – 70 NTU (Nephelometric turbidity units) with average reading of 35 NTU, meanwhile during high tide, turbidity were ranging from 4 – 58 NTU with average reading of 28 NTU. During low tide 2015, turbidity were ranging from 3.7 – 12.87 NTU with average reading of 8.54 NTU for meanwhile, turbidity were ranging from 7.18 – 13.2 NTU with average reading of 9.56 NTU during high tide.



**Figure 7.** Turbidity at seven sampling stations for low tide and high tide of 2012 and 2015

Distribution trend of turbidity for low and high tides show a gradual increased from S1 to S7 for 2012 and 2015 (Figure 7). Interestingly, the amplitude of increasing turbidity during 2012 is significantly greater than 2015. Data populations of turbidity have significant differences between them ( $P = 0.003$ ), determined by one way ANOVA ( $P < 0.05$ ). Tukey Kramer multiple comparison analysis revealed that the significance difference is existed between data populations of low tide (2012) to low tide (2015) and low tide (2012) to high tide (2015). Increase in anthropogenic activities close to riverbank such as farming, crops, domestic and industrial activities were the contributors to significant differences between turbidity during 2012 and 2015.

On the other hand, increasing turbidity trend from S1 to S7 has inversed relationship with increasing salinity. This result emphasized that decreasing salinity from downstream to upstream caused increase in turbidity [19]. Turbidity is the cloudiness of water contributed by planktonic and suspended matter. Plankton cannot lived in high salinity water [10]. Thus, it will die and water become clearer meanwhile, less saline water which is towards upstream, is the ideal condition for plankton to live. This condition is causing a spike in populations of plankton and a rise in turbidity.

## CONCLUSION

Environmental studies based on six water quality parameters analysis during low and high tides between 2012 and 2015 were concluded. Overall trend of the six water quality parameters of Marang River showed a significant downward trend between 2012 and 2015. But there are some parameters, such as turbidity showed an increase of S1 (downstream) to the S7 (upstream), respectively for 2012 and 2015, while for DO value, despite a downward trend between 2012 to 2015, but it increase slightly to the upstream for 2015. There are no significant difference for salinity, electrical conductivity (EC), total dissolved solids (TDS) and pH during 2012 and 2015 for both low and high tides of Marang River, except for turbidity and dissolved oxygen (DO). An increase in turbidity and decline of DO trend between 2012 and 2015 is due to an increase in anthropogenic activities close to riverbank such as farming, crops, domestic and industrial activities. While there was a reduction of pH, TDS, EC and salinity between 2012 and 2015 most probably was due to the occurrence of sea level rise. The evidence of global change coupled with the enactment of heavy storm and flood phenomenon during 2014 Northeast monsoon season was lead to the rising of sea level and salinity dilution of the South China

Sea. As a consequence, salinity was diluted and resulted in the alteration of Marang River water quality.

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**Persian Abstract**

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**چکیده**

یک مطالعه زیست محیطی رودخانه Marang شهر Terengganu درباره تعیین روند تغییرات زمانی و فاصله‌ای کیفیت آب رودخانه در هفت ایستگاه نمونه برداری بین سال‌های ۲۰۱۲ تا ۲۰۱۵ صورت گرفته است. ایستگاه‌های نمونه برداری در امتداد رودخانه از پایین دست تا بالادست انتخاب شدند؛ که فاصله هر ایستگاه تا ایستگاه دیگر ۲ کیلومتر بود. نمونه برداری در هر ایستگاه ۲ بار در طی جزر و مدهای پایین و بالا در نوامبر ۲۰۱۲ انجام شد و همچنین در نوامبر ۲۰۱۵ تکرار شد. هر دو نمونه گیری در زمان باران موسمی شمال شرقی انجام شد. پارامترهای کیفی انتخاب شده‌ی آب مانند شوری، رسانایی الکتریکی (EC)، کل مواد جامد محلول (TDS)، اکسیژن محلول (DO)، pH و کدورت با استفاده از ابزار علمی تایید شده اندازه‌گیری شد. یک روش مقایسه چندگانه ANOVA و Tukey Kramer برای تحلیل آماری استفاده شد. این مطالعه نشان داد که تغییرات زمانی قابل توجهی در میزان اکسیژن محلول و کدورت وجود داشت که از پایین دست به بالادست بین سال‌های ۲۰۱۲ تا ۲۰۱۵ به دلیل افزایش فعالیت‌های استفاده از زمین، افزایش یافته بود؛ در حالی که پارامترهای دیگر نظیر EC، شوری، TDS و pH کاهش یافت. این نتایج نشان داد که تغییرات جهانی همراه با ایجاد طوفان سنگین و پدیده سیل در سال ۲۰۱۴ منجر به بالا آمدن سطح دریا و رقت شوری دریای چین جنوبی شد.

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