



THE INFLUENCE OF TIDAL ACTIVITIES ON WATER QUALITY OF MARANG RIVER, TERENGGANU, MALAYSIA

(Pengaruh Aktiviti Pasang Surut Terhadap Kualiti Air Sungai Marang, Terengganu, Malaysia)

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Abstract

A study was conducted at seven sampling stations to determine water quality condition of Marang River, Terengganu. Each station was 2 km apart from each other, the first sampling was in 13 November 2012 and was repeated in 24 November 2013. The aim of the study is to determine water quality in spatial and temporal variation on different tides based on selected fourteen physicochemical parameters with regard to National Water Quality Standard. Six *in-situ* parameters such as pH, temperature, salinity, conductivity, DO and TDS were measured by using YSI 556 Multiparameters. Six *ex-situ* parameters such as sulphate, sodium, nitrate, phosphate, magnesium and turbidity also were measured. Sulphate, nitrate, phosphate and turbidity were analysed according to the standard method of analysis by Portable Datalogging Spectrophotometer HACH DR/2010. Sodium and magnesium were analysed using Atomic Absorption Spectrophotometer. One way ANOVA shows that there are no significant changes between first sampling and second sampling, the data were average to give impression of water quality of Marang River in spatial and temporal perspective. Overall, water quality of Marang River was classified as class I to III according to NWQS classification, therefore Marang River needs proper water treatment for tolerant fish species and other aquatic water continuance.

Keywords: Marang River, rainy season, dry season, water quality parameter

Abstrak

Satu kajian telah dijalankan di tujuh stesen persampelan untuk menentukan keadaan kualiti air Sungai Marang, Terengganu. Setiap stesen berjarak 2 km diantara satu sama lain, pensampelan pertama pada 13 November 2012 dan diulang pada 24 November 2013. Tujuan kajian ini adalah untuk menentukan kualiti air di dalam variasi ruang dan masa diantara laut pasang dan surut berdasarkan empat belas parameter fizikokimia terpilih dengan mengambil kira Piawaian Kualiti Air Kebangsaan. Enam *in-situ* parameter seperti pH, suhu, kemasinan, kekonduksian, DO dan TDS diukur dengan menggunakan Multiparameter YSI 556. Enam parameter *ex-situ* seperti sulfat, sodium, nitrat, fosfat, magnesium dan kekeruhan juga diukur. Sulfat, nitrat, fosfat dan kekeruhan dianalisis mengikut kaedah standard analisis oleh Portable Datalogging Spectrophotometer Hach DR / 2010. Natrium dan magnesium dianalisis menggunakan Spektrofotometer Penyerapan Atom. ANOVA satu hala menunjukkan bahawa tiada perubahan yang signifikan di antara persampelan pertama dan persampelan kedua, data yang rata-rata untuk memberi gambaran kualiti air Sungai Marang dalam perspektif ruang dan masa. Secara keseluruhan, kualiti air Sungai Marang diklasifikasikan sebagai kelas I hingga III mengikut pengelasan NWQS, oleh itu air Sungai Marang perlu melalui rawatan yang sesuai bagi memastikan air yang toleran bagi kelangsungan spesies ikan dan hidupan air yang lain.

Kata kunci: Sungai Marang, musim hujan, musim kering, parameter kualiti air

Introduction

Water is one of nature's most important gifts to mankind. Uses of water include agricultural, industrial, household, recreation and environmental activities. As the world population continues to rise, the needs for water demand increase. Thus, more supply is needed to supply the demand. However, not all water is suitable for domestic uses because some water were polluted. Thus, water resources quality need to be examined to identify the suitable usage. The increasing demand for water in terms of both sufficient quantity and satisfied quality has forced to be thought carefully about the comprehensive, complex and ambitious plans for good water resource management systems. Consequently, effective planning of water resources management is important for human life and socio-economic sustainability [1]. However, interactions between physical, biology and biochemical processes and human mediated processes are keys in determining changes in the global water system [2]. Effective planning of water resources management is important to facilitating sustainable socio-economic development in watershed systems. However a planning effort is often complicated with a number of social, economic, environmental, technical and political factors [3].

In addition, river is important for irrigation, recreation and fisheries development [4]. Estuaries are highly protected environments and their importance is recognized by various pieces of international legislation such as Habitats Directives. However, there is still conflict between the economic value of estuaries and their hinterlands for development and agriculture and the enforcement of protection for their internationally important species and habitats [5]. The success in the economic growth and industrialization in Malaysia has led to environmental problems with increasing of land, air and water pollution [6]. In recent decades, various tools have been developed to assist water quality management including mathematical models, optimization approaches and integrated decision support systems. Along with the increasing use of the sophisticated tools, water quality indices are also being developed and used worldwide due to their simplicity, adaptability and easy to use in nature [7]. However, particularly for small rivers, some problems hinder a straight forward model application such as specifically calibration data scarcity, lack of major investments in small systems deemed to be of minor importance and the large number of diverse inputs, especially for rivers that flow through densely populated areas [8].

Long term observation shows that freshwater ecosystems are highly in danger which affected by climate change. Society and natural systems will have to face the increasingly harmful climate change such as impacts on freshwater by other human pressures including habitat loss and pollution. This has lead to introduce policies which included adaptation and recovery to resolve this problem. However, the science community still has relatively little to say about how to adapt freshwater ecosystems to climate change [9]. The phenomenon of global warming not only affects the people, but also our sea. There are a lot of factors that contributed to global warming on the sea such as rise of sea level, changes in wave's action, water current and wind velocity [10]. In addition, the aquatic ecosystem also affected in great pressure and undergoes change. Warming environment cause rapid increase in the concentration of atmospheric carbon dioxide and ocean acidification may lead to coral bleaching [11]. Long term sea level rise is a critical issue of the global climate change because of its possible huge impacts. Since 1993, sea level is accurately monitored by satellite and these observations have shown that sea level does not rise uniformly. In some regions it rises faster than the global average while in others, the rise is slower [12]. Seawater intrusion is caused by prolonged changes (or in some cases severe episodic changes) in coastal groundwater levels due to pumping, land-use change, climate variations or sea-level fluctuations. The primary damaging effects of seawater intrusion are reduction in the available freshwater storage volume and contamination of production wells [13]. In this study, Marang River was examined to study the water quality. The two main objectives in this study are to determine water quality in spatial and temporal variation on different tides based on selected physicochemical parameters and to access water quality as regard to National Water Quality Standard (NWQS).

Materials and Methods

Study Area

The study area (Figure 1) is located along Marang River (5°14' N, 103°8' E) that situated in Marang, Terengganu, Malaysia [14]. Marang district is an area of 66,654.3 hectares and 20 km from Kuala Terengganu. This area is always flooded in November and December every year. The occurrence is due to heavy rain was brought by Northeast Monsoon winds coming from South China Sea. Views that can be seen along the Marang River are

mangrove tress, nipah and freshwater fish cages operated by residents. The resources of the river basin are increasingly being used such as for irrigated agriculture, fish cages operations.



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

Sampling Methods

Seven sampling stations were selected along Marang River from downstream to upstream. The stations were 2km apart from each other. Sampling was done twice; the first sampling was in 13 November 2012 (Northeast monsoon) and was repeated in 24 November 2013 (Southeast monsoon). At each station, water samples and in situ measurements were taken. The exact sampling location was determined using Global Positioning System (GPS). The second sampling process was done on the same locations according to recorded coordinates. The recorded coordinate for sampling stations were illustrated in Table 1.

Measurement of *In Situ* Parameters

Parameters such as pH, temperature, salinity, conductivity, dissolve oxygen (DO) and total dissolve solid (TDS) were measure using YSI 556 Multiparameters.

Laboratory Analysis

Sulphate, nitrate and phosphate concentrations as well as turbidity in water sample were analysed by using Portable Datalogging Spectrophotometer HACH DR/2010. Sodium and magnesium concentrations in water sample had been analysed by using Atomic Absorption Spectrophotometer (AAS).

Data Analysis

One way ANOVA (Analysis of Variance) and SPSS (Statistical Package for the Social Sciences) software were used to analyze the collected data.

Table 1. Coordinate position at each sampling station

Station	Latitude	Longitude
1	N 05° 12' 34.9"	E 103° 12' 49.8"
2	N 05° 11' 36.41"	E 103° 11' 43.87"
3	N 05° 10' 38.51"	E 103° 12' 03.65"
4	N 05° 09' 53.16"	E 103° 11' 32.8"
5	N 05° 08' 59.55"	E 103° 11' 11.58"
6	N 05° 08' 00.29"	E 103° 11' 34.13"

Results and Discussion

Water Quality Analysis

There were twelve physicochemical parameters analyzed to determine the water quality. Six in-situ parameters are including pH, temperature, salinity, conductivity, dissolve oxygen (DO) and total dissolve solids (TDS). Another six parameters are ex-situ parameters such as sulphate, sodium, nitrate, phosphate, magnesium and turbidity.

pH

The pH for seven sampling stations were recorded and illustrated in graphs. The pH of Marang River during the first sampling for low tide were ranging from 5.96 to 7.34, and for high tide, pH value were ranging from 6.09 to 8.5 (Fig. 2a). Station 1 shows the highest values for low (7.34) tides and high (8.50) tide. Station 7 shows the lowest values for low (5.96) tide and high (6.09) tides. Statistical analysis of one-way ANOVA revealed that there are significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 5.481$, $P = 0.006$).

The pH of Marang River at seven stations during the second sampling for high tides were ranging from 6.09 to 8.5 and for low tides were ranging from 5.96 to 7.34 (Fig. 2b). Station 1 shows the highest reading for high (8.5) and low (7.34) tides, meanwhile station 7 shows the lowest reading for high (6.09) and low (5.96) tides. Pollution can change water's pH, which in turn can harm animals and plants living in the water. Sudden changes in pH, can be very stressful to fishes even if the values remain in the recommended range [15]. Statistical analysis of one-way ANOVA revealed that there are significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 6.590$, $P = 0.006$).

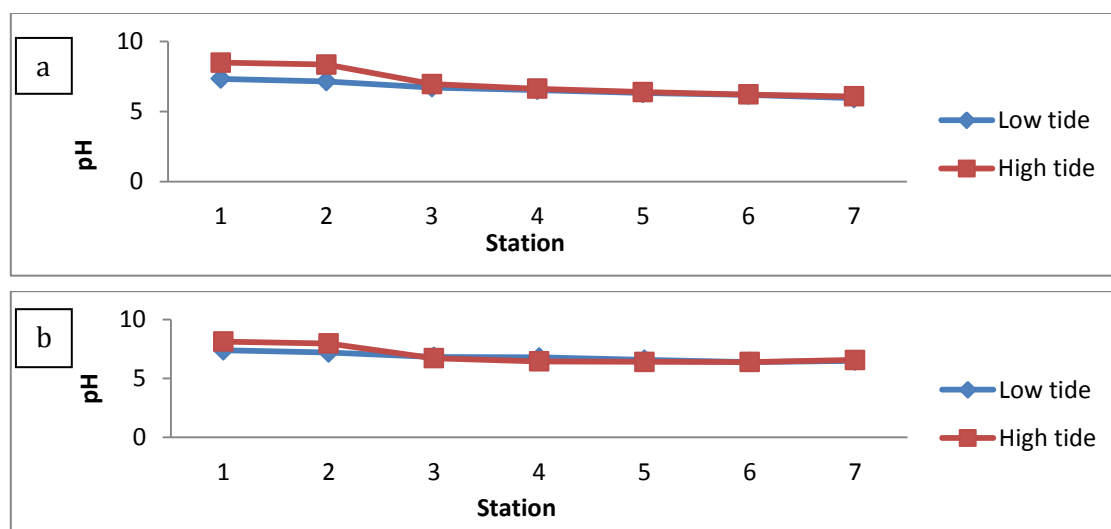


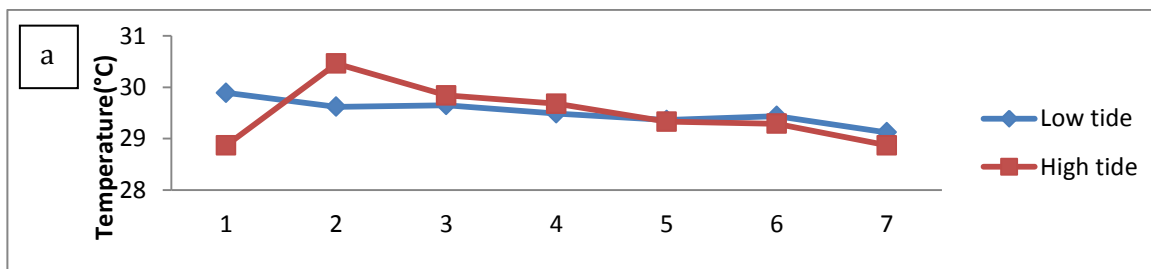
Figure 2. pH values at seven sampling stations during first (a) and second (b) samplings

Temperature

The range of temperature for the first sampling were from 29.12 °C to 29.89 °C for low tide and from 28.87 °C to 30.46 °C for high tide (Fig. 3a). Station 1 shows the highest temperature for low tide (29.89 °C) and station 2 shows the highest temperature (30.46 °C) for high tide. Station 7 shows the lowest temperature for low (29.12 °C) and high (28.87 °C) tides. Average temperature for first sampling during low tide is 29.51 °C and 29.48 °C for high tide.

Station 1 and station 2 temperatures were high because the stations were situated near to the sea and received direct sunlight as there were lacks of trees to protect the areas. Besides, the high temperature could also due to sampling timing which was during the afternoon. Conversely, station 7 had lowest temperature as the sampling was done during late afternoon and it's rainy during the sampling. Furthermore, that area was covered by trees that protect the area from receiving direct sunlight. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 1.643$, $P = 0.006$).

For the second sampling, the temperature was ranging from 26.55 °C to 27.58 °C for low tide and from 26.97 °C to 28.08 °C for high tide (Fig. 3b). Station 1 shows the highest temperature during low (27.58 °C) and high (28.08 °C) tides. Station 5 shows the lowest temperature for both low (26.55 °C) and high (26.97 °C) tides because the sampling were done during raining. The average temperature value for second sampling during low and high tides are 27.25 °C and 27.53 °C respectively. Statistical analysis of one-way ANOVA revealed that there are significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 4.105$, $P = 0.006$).



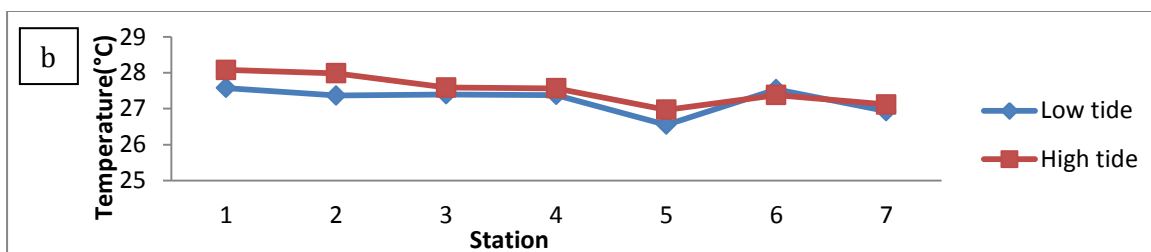


Figure 3. Temperature at seven sampling stations during first (a) and second (b) sampling

Salinity

The fluctuation of water salinity generally causes many physiological alterations which lead disturbance of hormones, energy metabolism and electrolyte in aquatic organisms [16]. Salinity reading at seven stations during the first sampling were ranging from 0.49 ppt to 9.32 ppt for low tide and from 0.68 ppt to 25.36 ppt for high tide (Fig. 4a). Salinity gradually decreasing from the first station towards the last station. Station 1 shows the highest reading for both low and high tides which were 9.32 ppt and 25.36 ppt respectively. Station 7 shows the lowest reading for both low and high tides at 0.49 ppt and 0.68 ppt respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 2.039$, $P = 0.006$). Salinity reading for the second sampling were ranging from 0.53 ppt to 7.02 ppt for low tide and from 0.81 ppt to 22.75 ppt for high tide (Fig. 4b). Station 1 shows the highest reading for low and high tides at 7.02 ppt and 22.75 ppt respectively. Station 7 shows the lowest reading for low and high tides at 0.53 ppt and 0.81 ppt respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 1.766$, $P = 0.006$).

Overall, almost all stations except station 7 had salinity exceeding 1000 mg/L for both first and second sampling as 1 ppt equal to 1000 mg/L [17]. The high salinity water other than station 7 is not suitable for aquatic organism because the aquatic biota will be adversely affected as salinity exceeds 1000 mg/L. The biota could not readily disperse, but manage to survive either with little or no reproduction or recruitment or as dormant propagules. The increase in salt may also affect the long term viability of dormant eggs of micro invertebrates and seed of aquatic plants [17]. Biota that are unable to tolerate these periods either cannot survive or disperse to recolonise when more favorable condition occur.

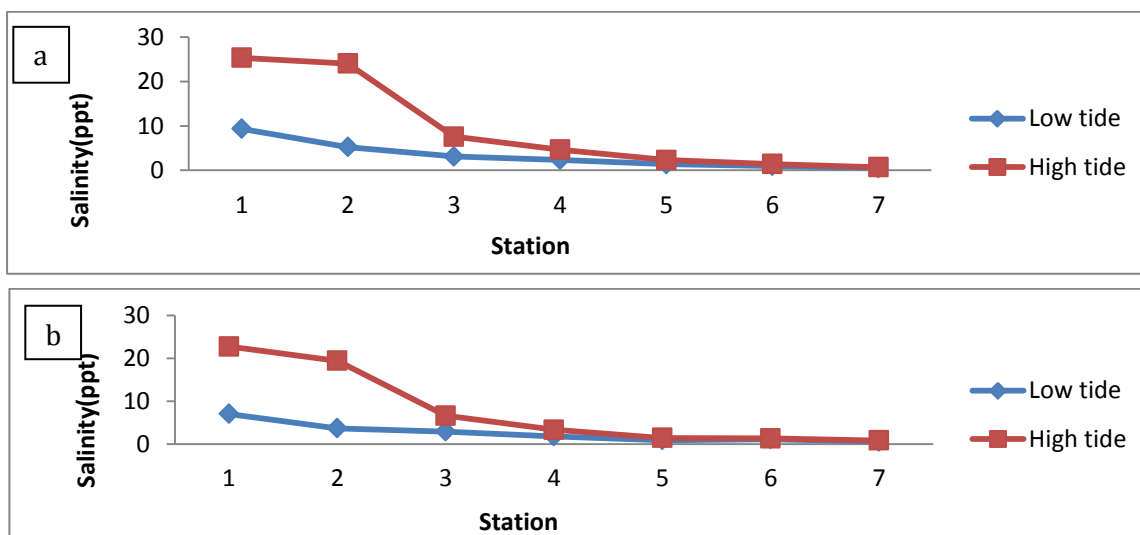


Figure 4. Salinity values at seven sampling stations during first (a) and second (b) samplings

Conductivity

The amount of conductivity in Sungai Marang for the first sampling were ranging from 1070 $\mu\text{S}/\text{cm}$ to 17541 $\mu\text{S}/\text{cm}$ for low tide and were ranging from 1478 $\mu\text{S}/\text{cm}$ to 44027 $\mu\text{S}/\text{cm}$ for high tide (Fig. 5a). Station 1 shows the highest value during low and high tides at 17541 $\mu\text{S}/\text{cm}$ and 44027 $\mu\text{S}/\text{cm}$ respectively. Station 7 shows the lowest value during low and high tides at 1070 $\mu\text{S}/\text{cm}$ and 1478 $\mu\text{S}/\text{cm}$ respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 2.200$, $P = 0.006$).

In the second sampling the conductivity were ranging from 1125 $\mu\text{S}/\text{cm}$ to 12922 $\mu\text{S}/\text{cm}$ for low tide and were ranging from 1685 $\mu\text{S}/\text{cm}$ to 38284 $\mu\text{S}/\text{cm}$ for high tide (Fig. 5b). Station 1 shows the highest value for low and high tides at 12922 $\mu\text{S}/\text{cm}$ and 38284 $\mu\text{S}/\text{cm}$ respectively. Station 7 shows the lowest value for both low and high tides at 1125 $\mu\text{S}/\text{cm}$ and 1685 $\mu\text{S}/\text{cm}$ respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 1.889$, $P = 0.006$).

In this study, the conductivity tends to be higher at stations located nearer to the sea, same finding with [14], that stated, the conductivity value exceeding 1000 $\mu\text{S}/\text{cm}$ indicates that the river is exposed to pollution. From this study, as a whole, second sampling (rainy) shows the lower value of conductivity than first sampling. [18] states that, due to the dilution by abundant precipitations, the ion concentrations and consequent conductivity values were lower in the rainy season.

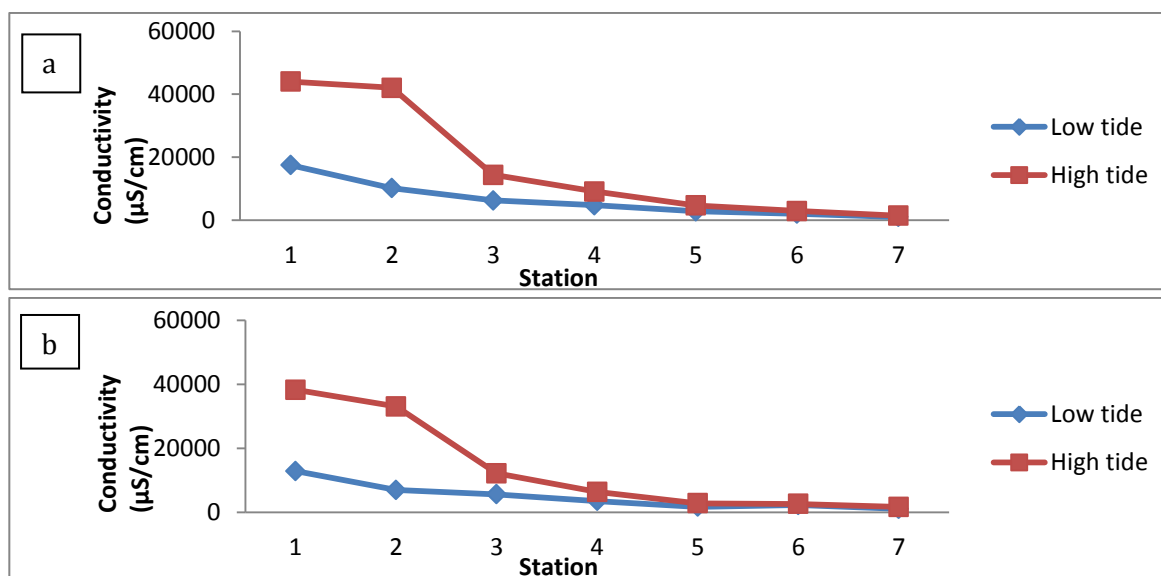


Figure 5. Conductivity values at seven sampling stations during first (a) and second (b) samplings

Dissolve Oxygen (DO)

Dissolve oxygen value for the first sampling were ranging from 4.11 mg/L to 4.41 mg/L for low tide and were ranging from 4.01 mg/L to 6.02 mg/L for high tide (Fig. 6a). Station 1 shows the highest value for low and high tides at 4.41 mg/L and 6.02 mg/L respectively. Station 5 shows the lowest value for low tide at 4.11 mg/L and station 3 for high tide at 4.01 mg/L. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 1.140$, $P = 0.006$).

Dissolve oxygen value for the second sampling were ranging from 4.75 mg/L to 5.33 mg/L for low tide and were ranging from 4.88 mg/L to 6.36 mg/L for high tide (Fig. 6b). Station 2 shows the highest value of dissolve oxygen for low tide (5.33 mg/L) and station 1 shows the highest value (6.36 mg/L) of dissolve oxygen for high tide. Station

3 shows the lowest value of dissolve oxygen during low tide (4.75 mg/L) and station 4 show the lowest value (4.88 mg/L) of dissolve oxygen during high tide. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 2.533$, $P = 0.006$).

From this study, the DO concentration in the first sampling is lower than the second sampling. Temperature decline in the rainy season. As a consequence, oxygen concentration increase and the level of saturation will be close to 100 % with increasing depth. In most situations, the settling of organic matter into the deeper areas from the productive zones could result in under saturation as a result of oxidation processes. In shallower waters, the oxygen loss was higher may be due to oxidation occurs at the sediment-water interface, where bacterial activity and organic matter are concentrated. Amount of oxygen is also lost in the water column by bacterial, plant and animal respiration. Oxygen depletion also occurs by direct chemical oxidation of dissolved organic matter (Environment Canada 1999). Many aquatic insect larvae particularly gill-breathing insects, were highly affected by the decrease in dissolve oxygen content in the water, their presence is a very good indicator of high quality river water [6].

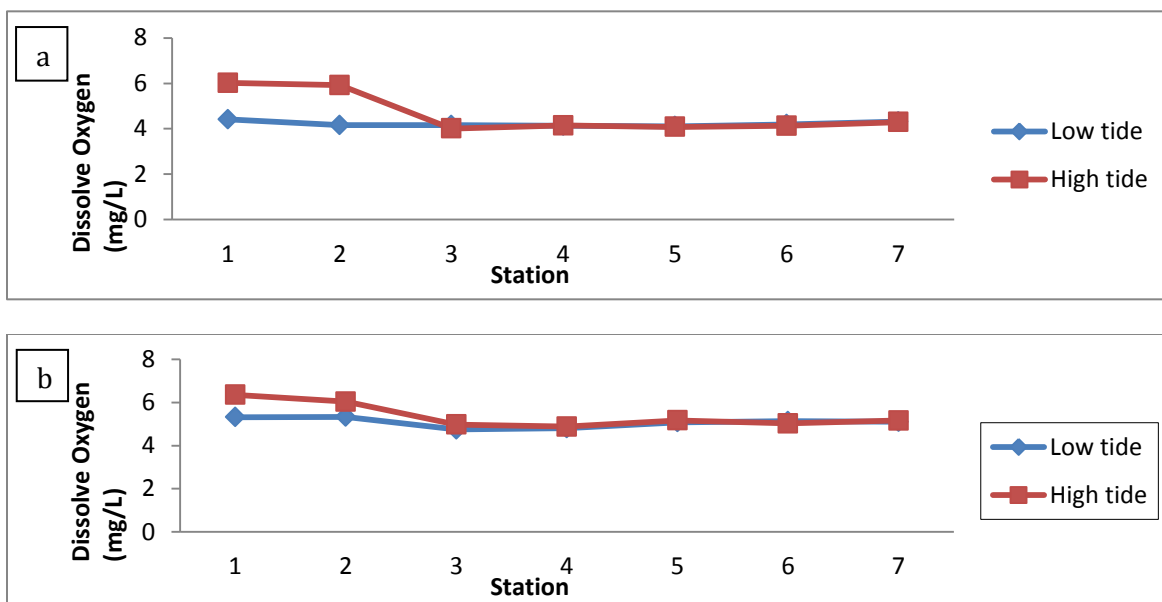


Figure 6. Amount of dissolve oxygen (DO) at seven sampling stations during first (a) and second (b) samplings

Total Dissolve Solid (TDS)

Concentrations of TDS from natural sources have been found to vary, from less than 30 mg/L to 6000 mg/L, depend on the solubility of minerals in different geological regions [19]. Total dissolve solids value in the study area during first sampling were ranging from 0.90 g/L to 10.43 g/L during low tide and from 0.90 g/L to 25.97 g/L during high tide (Fig. 7a). Station 1 shows the highest value during low and high tides at 10.43 g/L and 25.97 g/L respectively. Station 7 shows the lowest value during low and high tides at same value (0.90 g/L). Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 2.126$, $P = 0.006$).

Total dissolve solids value for the second sampling were ranging from 0.71 g/L to 8.01 g/L during low tide and from 1.05 g/L to 23.5 g/L during high tide (Fig. 7b). Station 1 shows the highest value of total dissolve solid during low and high tides at 8.01 g/L and 23.5 g/L respectively. Station 7 shows the lowest value of total dissolve solid during low and high tides at 0.71 g/L and 1.05 g/L respectively. Statistical analysis of one-way ANOVA revealed

that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 1.905$, $P = 0.006$).

Total dissolve solids value for both sampling falls between 0.71 g/L to 25.97 g/L, where they can be classified as saline (> 1000 mg/L) which is not suitable for aquatic organism [14]. The presence of dissolved solids in water may affect its taste. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/L; good, between 300 and 600 mg/L; fair, between 600 and 900 mg/L; poor, between 900 and 1200 mg/L; and unacceptable, greater than 1200 mg/L [19].

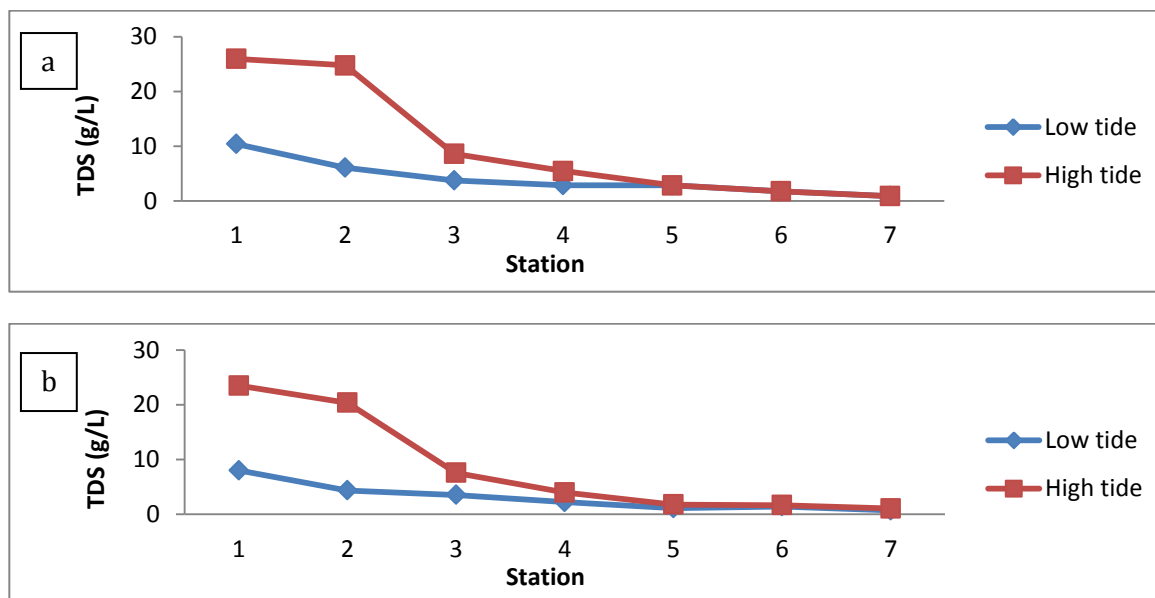


Figure 7. Total dissolved solid values at seven sampling stations during first (a) and second (b) samplings

Sulphate

The sulphate value for first sampling were ranging from 38 mg/L to 870 mg/L during low tide and from 80 mg/L to 2240 mg/L during high tide (Fig. 8a). Station 1 show the highest sulphate value during the low and high tides at 870 mg/L and 2240 mg/L respectively. Station 7 show the lowest sulphate value during low and high tides at 38 mg/L and 80 mg/L respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 2.426$, $P = 0.006$).

At the second sampling sulphate value range from 24.5 mg/L to 175 mg/L during low tide and range from 27.5 mg/L to 645 mg/L during high tide (Fig. 8b). Station 1 show the highest sulphate value during the low tide (175 mg/L) and station 2 show the highest sulphate value during the high tide (645 mg/L). In addition, station 7 shows the lowest sulphate value during low and high tides at 24.5 mg/L and 27.5 mg/L respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 1.726$, $P = 0.006$).

Overall, for both sampling, sulphate value is decreasing from station 1 towards station 7. The increasing of sulphate concentrations in river waters may were resulted from acid deposition [18]. Sulphate can be found in most freshwaters at concentrations of less than 100 mg/L. Anthropogenic influences can increase sulphate concentrations to the gram per liter range [20]. In Marang River, high value of sulphate at station 1 to station 3 during first and second samplings probably contributed from domestic wastewater from farmhouse and aquaculture activity. A few

studies have shown that the effects of excessive sulphate content in water are reducing growth, reproduction and emergence rates in aquatic arthropods [20].

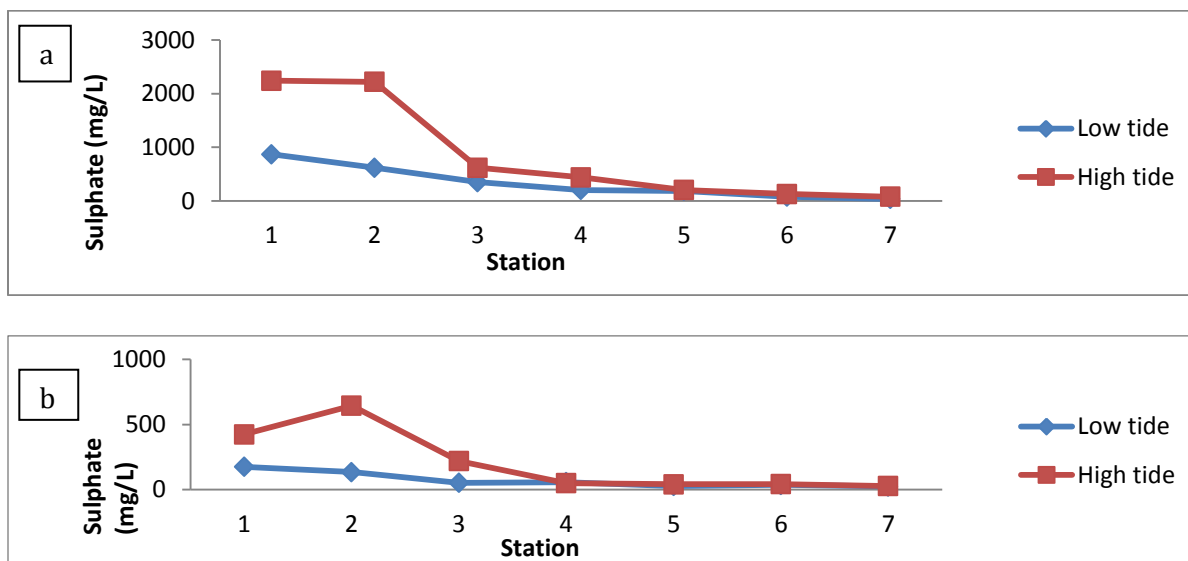
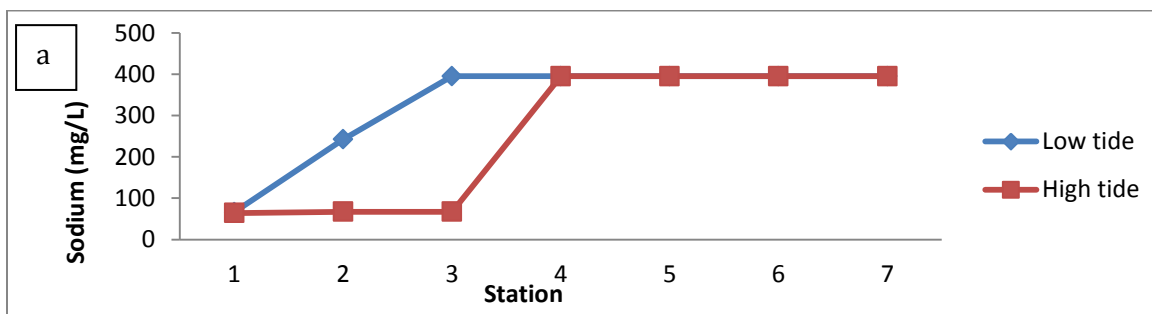


Figure 8. Sulphate values at seven sampling stations during first (a) and second (b) samplings

Sodium

The sodium value for first sampling were ranging from 66 mg/L to 395 mg/L during low tide and from 64 mg/L to 395 mg/L during high tide (Fig. 9a). From station 3 to station 7, the value of sodium was stable at highest value (395 mg/L) during low tide. During high tide, station 4 to station 7, the value of sodium was stable at highest value (395 mg/L). Station 1 show the lowest sodium value during low and high tides at 66 mg/L and 64 mg/L respectively. Statistical analysis of one-way ANOVA revealed that there are significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 3.936$, $P = 0.006$). At the second sampling sodium value range from 406 mg/L to 667 mg/L during low tide and range from 105 mg/L to 667 mg/L during high tide (Fig. 9b). From station 2 to station 7, the value of sodium was stable at highest value (667 mg/L) during low tide. During high tide, station 4 to station 7, the value of sodium was stable at highest value (667 mg/L). Station 1 show the lowest sodium value during low tide (406 mg/L) and station 2 show the lowest value (105 mg/L) of sodium during high tide. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 1.881$, $P = 0.006$).



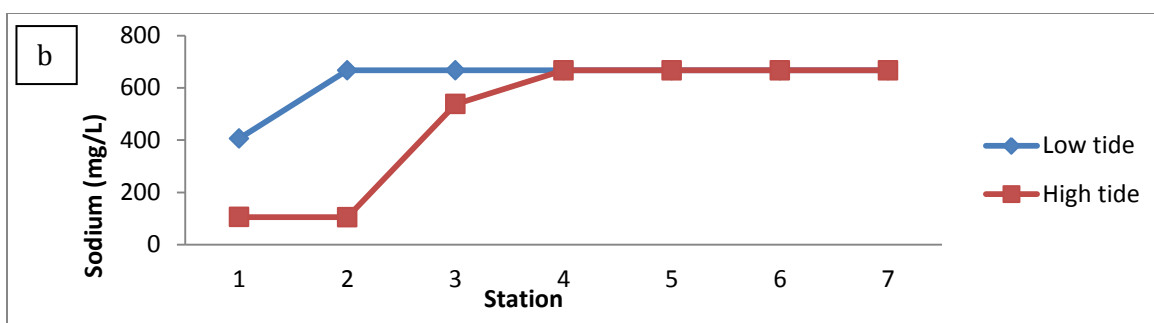


Figure 9. Sodium values at seven sampling stations during first (a) and second (b) samplings

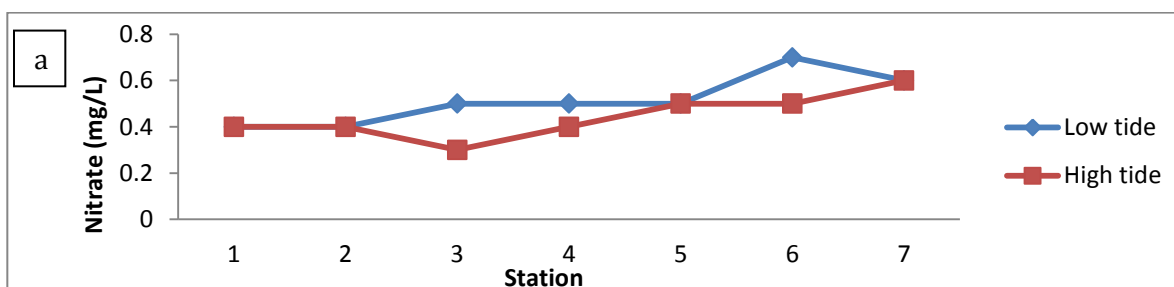
The reduction in the frequency of high flow (flushing) events caused an accumulation of salt in the river systems and gradual increase in the mean concentration over time. In this study, sodium value was high at low tide during first and second samplings. The high sodium concentration at Marang River is not suitable for aquatic organism.

Nitrate

At the first sampling nitrate value were ranging from 0.40 mg/L to 0.70 mg/L during low tide and from 0.30 mg/L to 0.60 mg/L during high tide (Fig. 10a). Station 6 shows the highest nitrate value during the low tide (0.70 mg/L) and station 7 shows the highest nitrate value during high tide (0.60 mg/L). In addition, station 1 and station 2 shows the lowest nitrate value during low tide at 0.40 mg/L and station 3 show the lowest nitrate value during high tide at 0.30 mg/L. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 2.556$, $P = 0.006$).

At the second sampling nitrate value were ranging from 0.00 mg/L to 0.20 mg/L during low tide and from 0.00 mg/L to 0.15 mg/L during high tide (Fig. 10b). Station 3 shows the highest nitrate value during low tide (0.20 mg/L) and station 1 and station 6 shows the highest nitrate value during high tide (0.15 mg/L). In addition, station 2 shows the lowest nitrate value during low tide at 0.00 mg/L and station 4 show the lowest nitrate value during high tide at 0.00 mg/L. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 0.628$, $P = 0.006$).

Nitrate is an important source of nitrogen. It is needed by plants and animals to synthesize amino acids and proteins. Nitrate enters the streams from natural sources like decomposing plants and animal waste as well as human sources like sewage or fertilizer. Nitrate can be removed from water by aquatic plants, algae and bacteria which assimilate it as a source of nitrogen. Natural levels of nitrate are usually less than 1 mg/L. Concentrations over 10 mg/L will have an effect on the freshwater aquatic environment [21]. Thus, lower value of nitrate (range from 0 mg/L to 0.7 mg/L) for both sampling in Marang River water is ideal for freshwater aquatic environment.



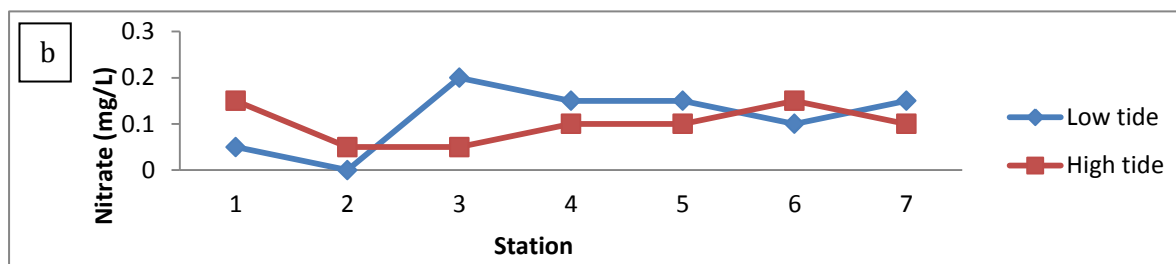


Figure 10. Nitrate values at seven sampling stations during first (a) and second (b) samplings

Phosphate

Phosphate stimulates the growth of plankton and aquatic plants which provide food for fish, but excessive use of fertilizers and detergents leads to over growth of aquatic plants, then reducing dissolved oxygen level of water which is harmful to aquatic life [22]. Therefore, monitoring of phosphate ion concentrations is very important to maintain the quality of environmental drinking water [23].

In the first sampling for the phosphate value, were ranging from 0.01 mg/L to 0.04 mg/L during the low and high tides (Fig. 11a). Station 2 shows the highest value of phosphate during the low tide (0.04 mg/L) and station 4 shows the highest value of phosphate (0.04 mg/L) during high tide. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 0.472$, $P = 0.006$).

The second sampling for phosphate value range from 0.04 mg/L to 0.14 mg/L during low tide and range from 0.02 mg/L to 0.05 mg/L during high tide (Fig. 11b). Station 3 shows the highest value of phosphate during low tide (0.14 mg/L). Station 2 and station 4 shows the highest value of phosphate during high tide (0.05 mg/L). Station 5 shows the lowest value of phosphate during low and high tides at 0.04 mg/L and 0.02 mg/L respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 0.508$, $P = 0.006$).

Phosphate concentration in coastal waters depend upon its concentration in the freshwater that mixed with the seawater within the sea-land interaction zone, phytoplankton-uptake addition through localized upwelling, and replenishment as a result of microbial decomposition of organic matters. Seawater serves as the main source of phosphate in estuarine and coastal waters except those receiving freshwater contaminated with domestic wastes containing detergents as well as wastes from agro field rich with phosphate-phosphorous fertilizers and pesticides [24].

From this study, the phosphate value in second sampling (February) was higher than first sampling (November). Distribution of rainfall in Sungai Marang at February was higher than November. The increasing concentration of phosphate after received more rain was the result of agricultural run-off together with the run-off from city drainage which in turn will serve as important phosphate contributors to the coastal environment. Re-suspension of phosphate from sediments also add significant portion of these nutrients to the estuarine water. The noticeable seasonal variation in phosphate concentration as observed in this study might be due to various processes like adsorption and desorption of phosphate and buffering action of sediments under varying environmental conditions [24].

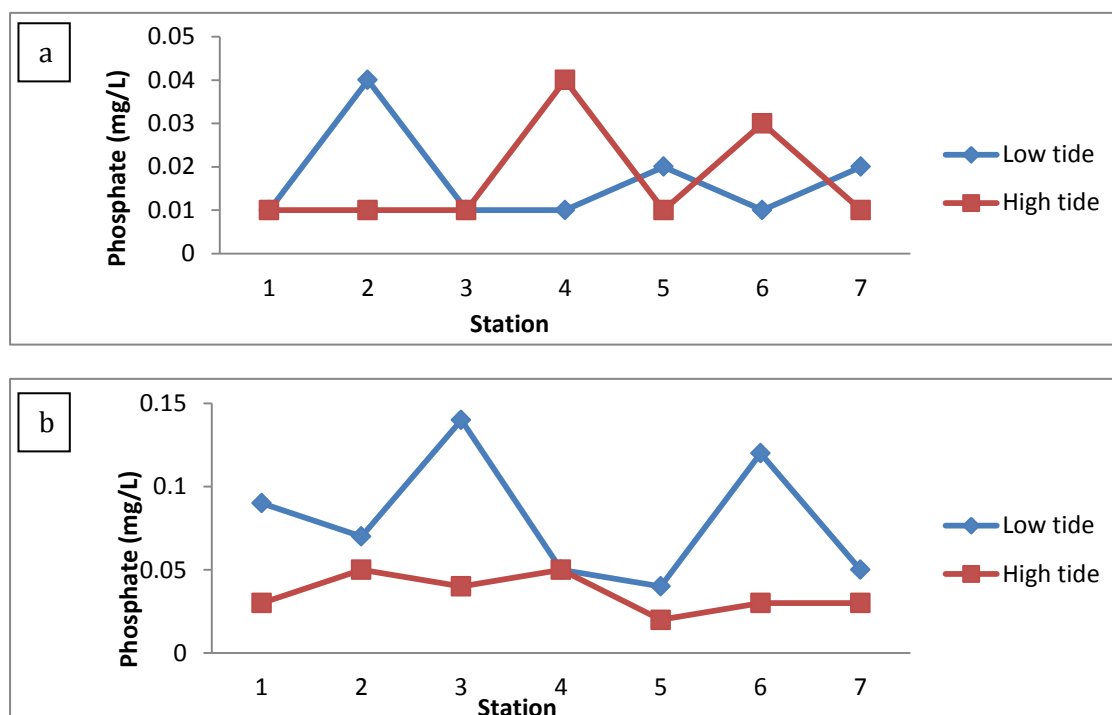


Figure 11. Sulphate values at seven sampling stations during first (a) and second (b) samplings

Magnesium

The magnesium value for the first sampling were ranging from 13 mg/L to 518 mg/L during low tide and range from 19 mg/L to 518 mg/L during high tide (Fig. 12a). Station 1 shows the highest value of magnesium during low and high tides at same value which is 518 mg/L. Station 7 shows the lowest value of magnesium during low and high tides at 13 mg/L and 19 mg/L respectively. Statistical analysis of one-way ANOVA revealed that there are significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 7.252$, $P = 0.006$).

Magnesium value for second sampling were ranging from 22 mg/L to 242 mg/L during low tide and range from 30 mg/L to 1029 mg/L during high tide (Fig. 12b). Station 1 and station 3 shows the highest value of magnesium (242 mg/L) during low tide. Station 1 and station 2 shows the highest value of magnesium (1029 mg/L) during high tide. Station 7 shows the lowest value of magnesium during low and high tides at 22 mg/L and 30 mg/L respectively. Statistical analysis of one-way ANOVA revealed that there are no significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 1.340$, $P = 0.006$).

Magnesium influence the cell division and act as a cofactor in pathways of many enzymes involved in the metabolism of carbohydrates, lipids and proteins and also in energy production. Freshwater fish ingest magnesium from both ambient water and diet sources. Dietary magnesium requirement has been reported in the 400 to 600 mg/L range for freshwater fish species [25]. The values of magnesium from this study for both sampling were ranging from 13 mg/L to 1029 mg/L. Magnesium value at downstream was lower than upstream, thus, downstream water is more suitable for freshwater fish species.

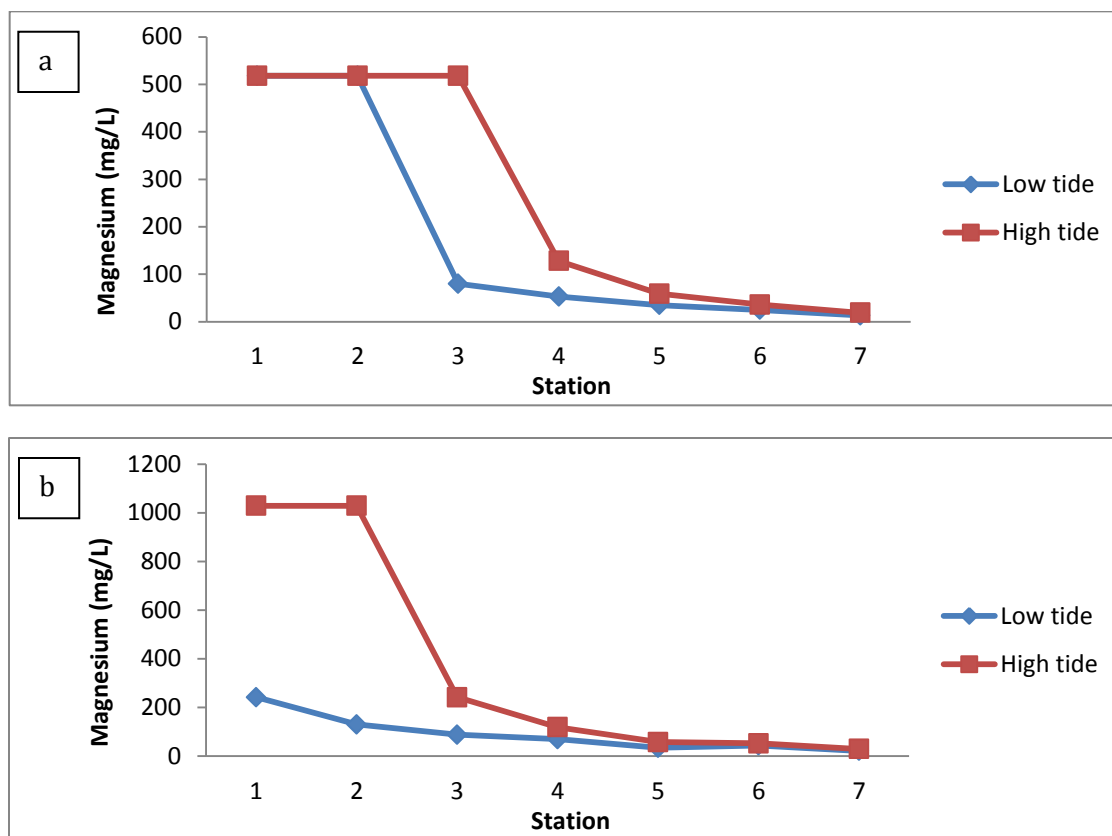


Figure 12. Magnesium values at seven sampling stations during first (a) and second (b) samplings

Turbidity

For this study, the turbidity value for the first sampling were ranging from 10 NTU to 70 NTU during low tide and range from 4 NTU to 58 NTU during high tide (Fig. 13a). Station 7 shows the highest value of turbidity during low and high tides at 70 NTU and 58 NTU respectively. Station 1 shows the lowest value of turbidity during low and high tides at 10 NTU and 4 NTU respectively. Statistical analysis of one-way ANOVA revealed that there are significant differences ($P < 0.05$) in pH between stations during the first sampling ($df = 13$, $F = 21.334$, $P = 0.006$).

For the second sampling, turbidity values were ranging from 46 NTU to 82.5 NTU during low tide and range from 37.5 NTU to 66 NTU during high tide (Fig. 13b). Station 5 shows the highest value of turbidity during low and high tides at 82.5 NTU and 66 NTU respectively. Station 6 shows the lowest value of turbidity during low tide (44 NTU) and station 3 shows the lowest value of turbidity (37.5 NTU) during high tide. Statistical analysis of one-way ANOVA revealed that there are significant differences ($P < 0.05$) in pH between stations during the second sampling ($df = 13$, $F = 4.633$, $P = 0.006$).

Increase of suspended sediment and turbidity can directly affect aquatic organisms, alter stream grade, contribute to flooding and transport a large nutrient flux. The increasing turbidity value might be from topsoil eroded into a river resulting from increasing the amount of rainfall [26]. In this study, for the first sampling, turbidity value increase from station 1 to station 7 for both low and high tides. Highest turbidity recorded at station 7 because of raining during the sampling. For the second sampling, turbidity values from station 1 to station 7 are not stable due to raining during sampling process at station 5, 6 and 7.

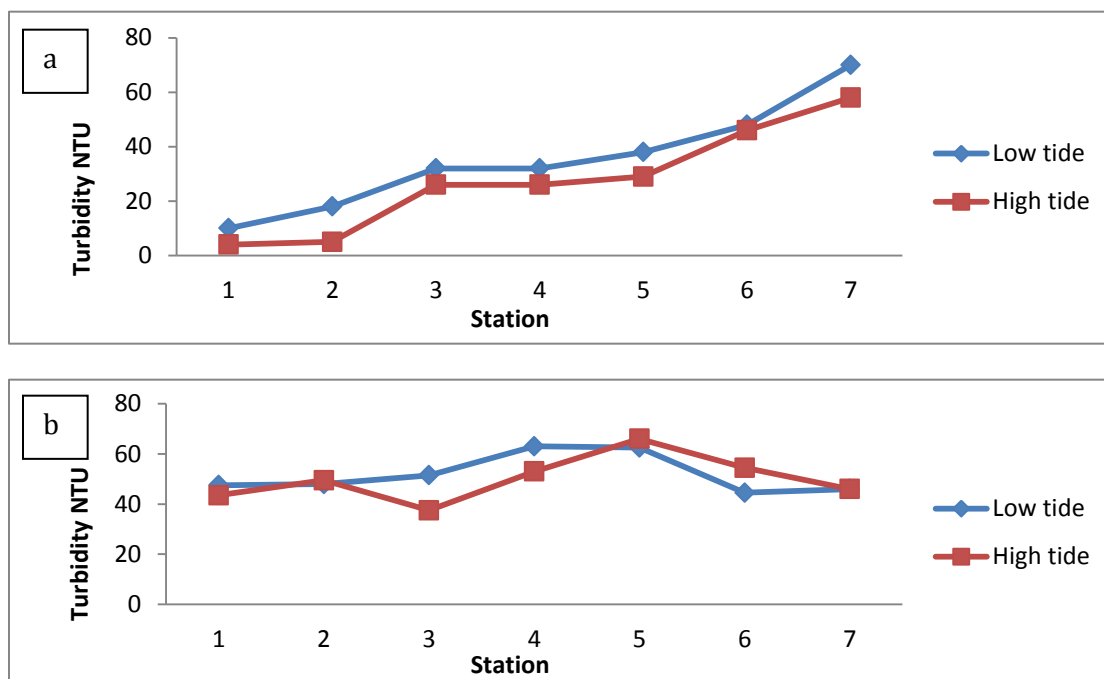


Figure 13. Turbidity at seven sampling stations during first (a) and second (b) samplings

National Water Quality Standard (NWQS)

The range of values for selected parameters acquired from this study were used to classify the water quality of Marang River (Table 2). The classifications and water uses descriptions were according to National Water Quality Standard (NWQS).

Table 2. Classification of Marang River water quality and the suitable uses

Parameter	First sampling	Second sampling	Class	Uses
pH	6.61 - 7.02	6.82 - 6.96	I	Conservation of natural environment, practically no treatment needed if it is used as water supply and suitable habitat for very sensitive aquatic species
Temperature	29.51 °C - 29.48 °C	27.25 °C - 27.53 °C	I	
DO	4.01 mg/L - 6.02 mg/L	4.75 mg/L - 6.36 mg/L	II	Recreational use with body contact, conventional treatment required if it is used as water supply, suitable habitat for sensitive aquatic species
TDS	0.9 mg/L to 25.97 mg/L	0.71 mg/L to 23.5 mg/L	II	
Turbidity	4 NTU to 70 NTU	37.5 NTU to 82.5 NTU	II	

Table 2 (cont'd). Classification of Marang River water quality and the suitable uses

Parameter	First sampling	Second sampling	Class	Uses
Nitrate	0.3 mg/L to 0.7 mg/L	0 mg/L to 0.2 mg/L	III	Extensive treatment required if it is used as water supply, suitable habitat for common, of economic value and tolerant fish species and for livestock drinking
Conductivity	1070 μ S/cm to 44027 μ S/cm	1125 μ S/cm to 38284 μ S/cm	III	

Conclusion

Based on the twelve physicochemical parameters water quality analysis, the study area is slightly alkaline, suitable temperature for aquatic life, high value of conductivity, salinity, sulphate, magnesium and turbidity and low value of nitrate and phosphate. For water quality analysis, according to one way ANOVA, for the first sampling, only four parameters show significant different and the other parameters not have significant different. For the second sampling, only three parameters have significant different and the other parameters have no significant different. From that, the data were average to show the impression or overview of water quality at Sungai Marang in spatially and temporal which is it shows there are no obvious changes between two sampling. According to National Water Quality Standard (NWQS), the water quality parameters acquired from seven sampling stations along Marang River have two parameters (pH and temperature) classified the river as class I, three parameters (dissolve oxygen, total dissolve solid and turbidity) classified the river as class II and two parameters (nitrate and conductivity) classified the river as class III. In general, Marang River water required to treatment for water supply and sensitive to aquatic organism. Thus, some action must be taken to conserve, manage and improve water quality in Sungai Marang to protect aquatic life community and for human water resources.

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