Profiles of temperature, salinity, dissolved oxygen, and pH in Tidal Lakes

Profiles of temperature, salinity, dissolved oxygen, and pH in Tidal Lakes

R Leidonald, A Muhtadi, I Lesmana, Z A Harahap and A Rahmadya

Department of Aquatic Resources Management, Universitas Sumatera Utara, Medan Indonesia

Email: rusdi.leidonald@usu.ac.id

Abstract. Siombak Lake is a brackish or coastal lake in Medan, Indonesia. Water fluctuation in the lake was affected by sea tide, so it was more appropriately called tidal lake. Thus the influence of tides could affect the quality of water in the lake, especially temperature, salinity, dissolved oxygen, and pH. The purposed of this study was to describe the profile of temperature, salinity, dissolved oxygen, and pH in the waters of Siombak. Lake. This study was conducted in June to July 2018. The data measured and were analyzed in the waters spatially (horizontally) and vertically. The results showed no significant difference of temperature distribution in surface between high tide and low tide. However, it was more influenced by daily time differences. While salinity was quite different between high tide and low tide. In the dry season (April to June) salinity values were higher during high tide compared to low tide. Conversely, during the rainy season (June to August) the salinity values in low tide were higher than when they were in high tide. The vertically distribution of temperature, oxygen, and pH decreases with respect to increasing depth. But the salinity value increases with depth increased.

1. Introduction

Temperature, dissolved oxygen and pH were very important water quality parameters related to the life of aquatic organisms [1,2]. They were key parameters of water quality that controlled the distribution and spread of aquatic organisms [3,4], including salinity in estuary [5,6] and in tidal lake [7]. Vertical distribution and stratification of temperature, salinity, oxygen, and pH in lake could show the aquatic dynamics, productivity potential and chemical evolution in them [1,2,4,8,9].

Temperature stratification in the water played an important role in the ecological process of water bodies [10]. Vertical temperature profiles on the lake were needed to determine the heat content in the waters, the thermocline layer and the mixing of water masses [10,11]. The temperature of a water body was influenced by the season, latitude, height of sea level (altitude), time of day, air circulation, cloud cover, water flow and the depth of water bodies [1].

The salinity distribution in the water affected the distribution of aquatic organisms, due to differences in the environmental osmoregulation system with the fish bodies [2,5]. Salinity spread was influenced by various factors such as the water circulation pattern, evaporation, precipitation and river flow (run-off) around it [5,6]. The distribution of temperature and salinity vertically in the water would form a layer so that it would be difficult to mix between the upper and lower layers [10].

Mean while, dissolved oxygen was very important for respiration, growth, breeding, metabolic processes by all aquatic living organisms[1,2,5]. In addition, dissolved oxygen also played a role in the

decomposition of organic matter in waters [1]. The dynamics and distribution of oxygen in heat-stratified lakes were controlled by a combination of solubility conditions, hydrodynamics, input from photosynthesis, and loss for metabolic and chemical oxidation [8,10]. Vertical temperature and oxygen profiles would provide important information regarding turbulence, stirring and oxygen reduction in the hypolimnion layer [4,10]. Dissolved oxygen and pH directly or indirectly affected other limnology parameters such as viscosity, total dissolved solids and conductivity which were very important in water management [1,3].

Siombak Lake was a tidal lake because water fluctuations in this lake were very influenced by the sea tides of Belawan waters [12]. Thus study of profiles of temperature, salinity, dissolved oxygen and pH was needed as an initial description of the lake's characteristics. This was expected to be important information for the management of tidal lakes in Medan City.

2. Method

2.1. Study site

This research was carried out in Siombak Lake, Medan City, North Sumatra Province, Indonesia. It was conducted in June to July 2018. The tools used in this study were Garmin Oregon GPS 65 with accuracy up to 3 m, hand refractometer, DO meter and pH meter.

2.2. Data retrieval procedure

The sampling point was taken as many as 9 observation locations. Measurements were done in situ at the time of high tide and low tide. For vertical profiles the data was taken at the depth of the surface (0.1 m), and within the 1 m interval to a depth of 6 m (high tide) and 3 m (low tide).

2.3. Procedure for processing and analyzing data

The results of the study were processed with MS Excel for vertical profiles and Arc Gis for spatial (horizontal). Data analysis was carried out descriptively.

3. Results and Discussions

3.1. Temperature

Temperature observed at SiombakLake ranged from 28.5 to 30.1 ºC in the rainy season and 29.5 - 32 ºC in the dry season (Figure 1). The high temperature in the dry season was related to heat or sunlight that plenty in the dry season. Meanwhile, there was no significant difference in temperature on the surface of the waters between high tides and low tides. The temperature difference in the surface of the water was more due to weather factor and the measurement time. The water body temperature was affected by season, latitude, altitude from sea level, time of day, cloud cover and depth of water [1].

The temperature of the research at Siombak Lake has decreased with increasing depth (Figure 5). Even though the changes were not so drastic. The results of previous studies recorded the same thing that the temperature will decrease with increasing depth [1,3,4,8,9,10,11]. In volcanically formed lakes, the temperature at the bottom was not always lower than the surface. However, it could be higher as reported in Kivu Lake in Congo [11]. Even at the Toba Lake in the 400 m depth, the temperature raised to near surface temperature [8]. This was because Toba Lake was a lake that was formed volcanically and was a caldera from Toba Mount [13].

Based on the temperature stratification at SiombakLake there was no thermocline layer. Thus there was no striking temperature difference between the surface and bottom of the waters. This was because the lake was shallow (average depth 4 - 6) and was easy to experience stirring [12]. It was very different from Toba Lake which reached a maximum depth of 508 m with a thermocline layer estimated at a depth of 0-30 m [8]. But despited Rudrasagar Lake in India relatively shallow (6m), but the change in temperature between surface with the bottom large enough reached 3 ˚C [4], while on

the Siombaklake only about 1 ˚C **(**Figure 5**)**.This showed that there was an influenced of climate and geographical conditions of the lake which could affected temperature fluctuations in lake [4].

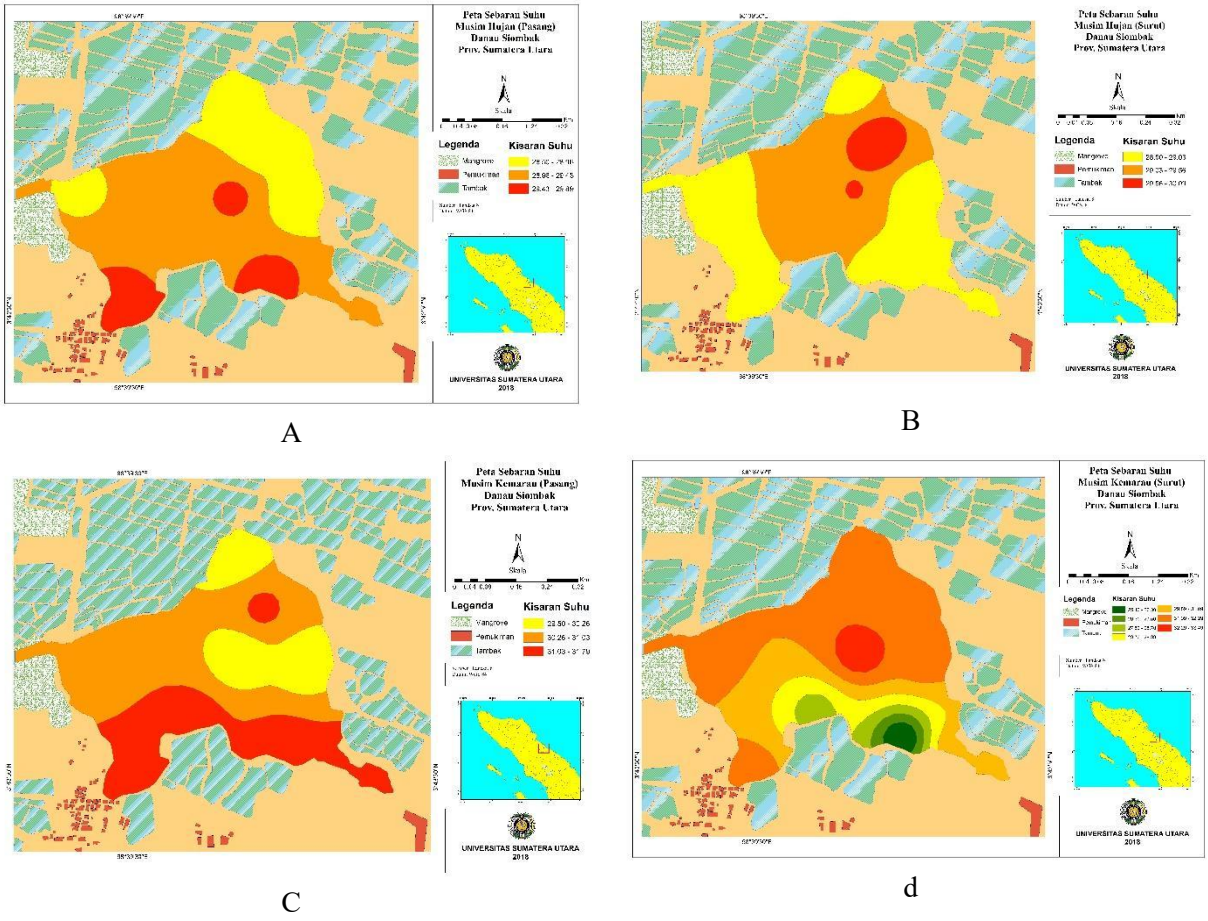

Figure. 1 Distribution of temperature horizontally in Siombak Lake a) high tide at rainy, b) low tide at rainy, c) high tide at dry, and d) low tide at dry

3.2. Salinity

Salinity measurement results ranged between 15-17$^{0}/_{00}$ at high tide, and lower tide at 14-15$^{0}/_{00}$ at lower tide in dry season (Figure 2). In the rainy season the salinity spread normally (4 $^{0}/_{00}$) on the surface at high tide and low tide ranged between 3-5 $^{0}/_{00}$. Based on the salinity distribution during the dry season at high tide as shown in Figure 2 showed that the salinity value was not been spread evenly where in the western part that was close to the inlet has a higher salinity compared to the eastern part. In the eastern part the salinity ranged of 15-17 $^{0}/_{00}$, it was lower due to the influenced of the tide push became smaller to theeastern part. The difference between the value of salinity in the lake's part was relatively small 1-2 $^{0}/_{00}$.This indicated that the influenced of tides was quite large affected the salinity distribution in Siombak Lake. At low tide it was seen that salinity was lower in the western and northern part, while in the eastern part it was slightly higher. It was also evident from the study results that the fish diversity that found in each part in SiombakLake did not show a significant difference. Diversity index obtained in the study ranged from 0.20 to 0.59 [14].

During the rainy season at high tide, salinity measured was the same (4 $^{0}/_{00}$). This indicated that the influence of rainwater (river discharged) that enters the lake's waters was very large. This also indicated that the salinity that came in from the sea was low due to the amount of water discharged from the river. At low tide water salinity values varied (3-5 $^{0}/_{00}$) and became higher. This was presumed because the water volume reduced so that the water that was left is experiencing evaporation

and the water below was "raised" upwards, so the value became higher. This could be seen from the vertical distribution of salinity which indicated that the salinity at the bottom was higher than the surface. In other words, there was an increase in salinity value along with the increased in depth (Figure 5) both during high tide and low tide. During high tide, the salinity vertical profile was also higher than at low tide.

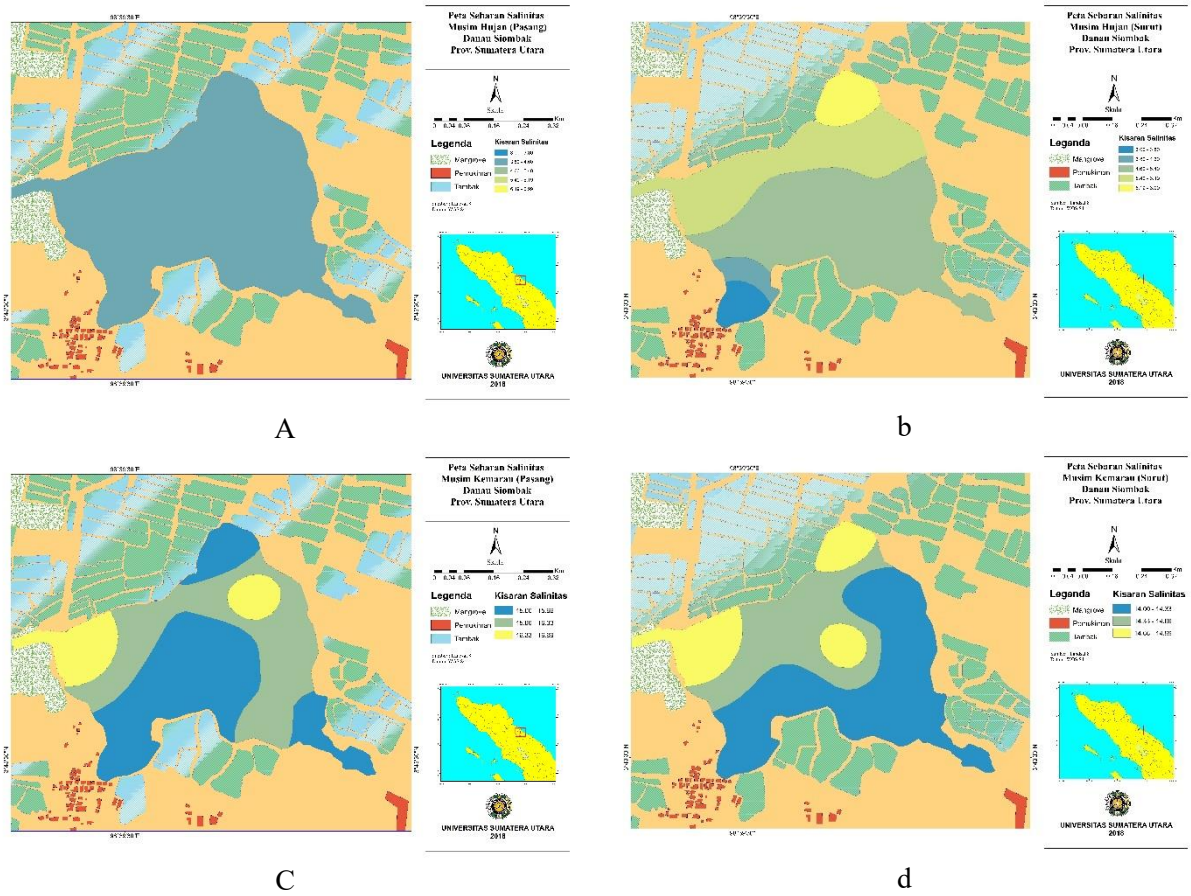

Figure. 2 Horizontal distribution of salinity a) high tide at rainy, b) low tide at rainy, c) high tide at dried, and d) low tide at dried

3.3. Dissolved Oxygen

During the rainy season the measured oxygen ranges from 5.5-7.6 mg / L at high tide and 5.5-6.1 mg / L at low tide. While in dried season oxygen was measured 7.1-7.4 mg / L at high tide and lower tide at 7-7.1 mg / L low tide (Figure 3). The oxygen was higher during high tide due to "fresh" water entering the lake from the sea or river. The entry of the water caused the stirring of the water mass to allow diffusion to occur.

Dissolved oxygen concentration in SiombakLake has decreased with increasing depth (Figure 5). The results of previous studies recorded the same thing that oxygen would decrease with increasing depth [1,3,4,8,9,10,11,15,16]. In stagnant waters such as lakes or reservoirs, the condition of dissolved oxygen was generally stratified. This was thought to occur because oxygen supply from photosynthesis and diffusion processes decreased [9]. In addition, in the bottom layer of water occured organic matter decomposition [8].

The highest dissolved oxygen concentration in each station was at the surface layer of the water. This was because the presence of sunlight in the surface layer of the water was observed so that it helped the photosynthesis process in supplying oxygen to the waters [9]. This was related to the highest phytoplankton on the surface and would decrease with increasing depth [9,15,16]. Others,

caused by the waters oxygen diffusion became slower, excepted in conditions of strong turbulence, some of the important sources of oxygen were through photosynthesis process by organisms and aquatic plants [3].

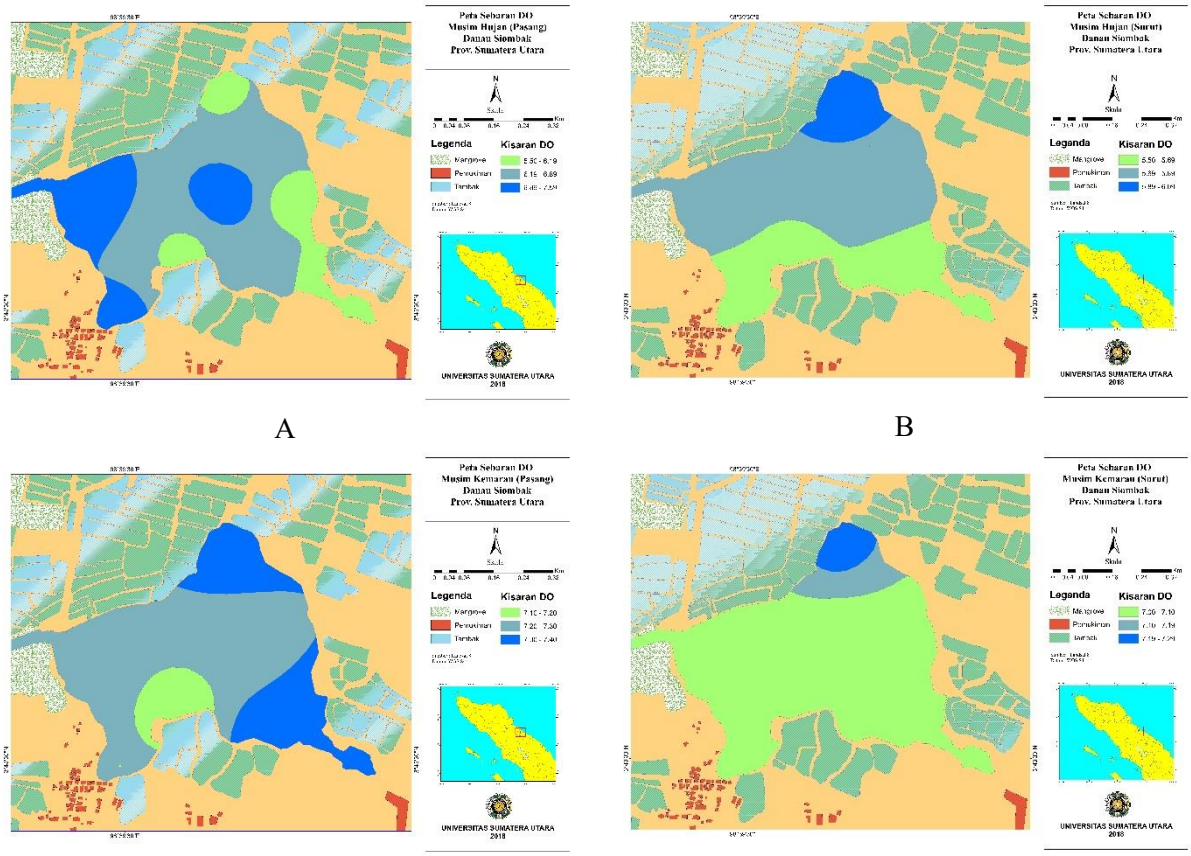

Figure. 3 Horizontal oxygen distributionin Siombak Lake a) high tide at rainy, b) low tide at rainy, c) hightide at dry, and d) low tide at dry

3.4. pH

At the rainy season the measured pH ranges between 6.9-7.5 at high tide and 6.7-6.9 at low tide. In the dry season the pH ranges from 6.2 to 6.4 at high tide and 6.3-6.4 at low tide (Figure 4). The lower pH in the dry season was thought to be high decay of organic matter in the dry season, because the high intensity of sunlight entering the waters.

In general, the observed pH values also appeared to decrease with water depth increased (Figure 5). The results of previous studies recorded the same thing that pH would decrease with increasing the water depth [3,9]. The decreased of pH at the bottom was increased in microbial activity to decompose organic matter so that O_2 decreased and CO_2 increased. Increased CO_2 would make the waters became more acidic (pH decreases) [3,9].

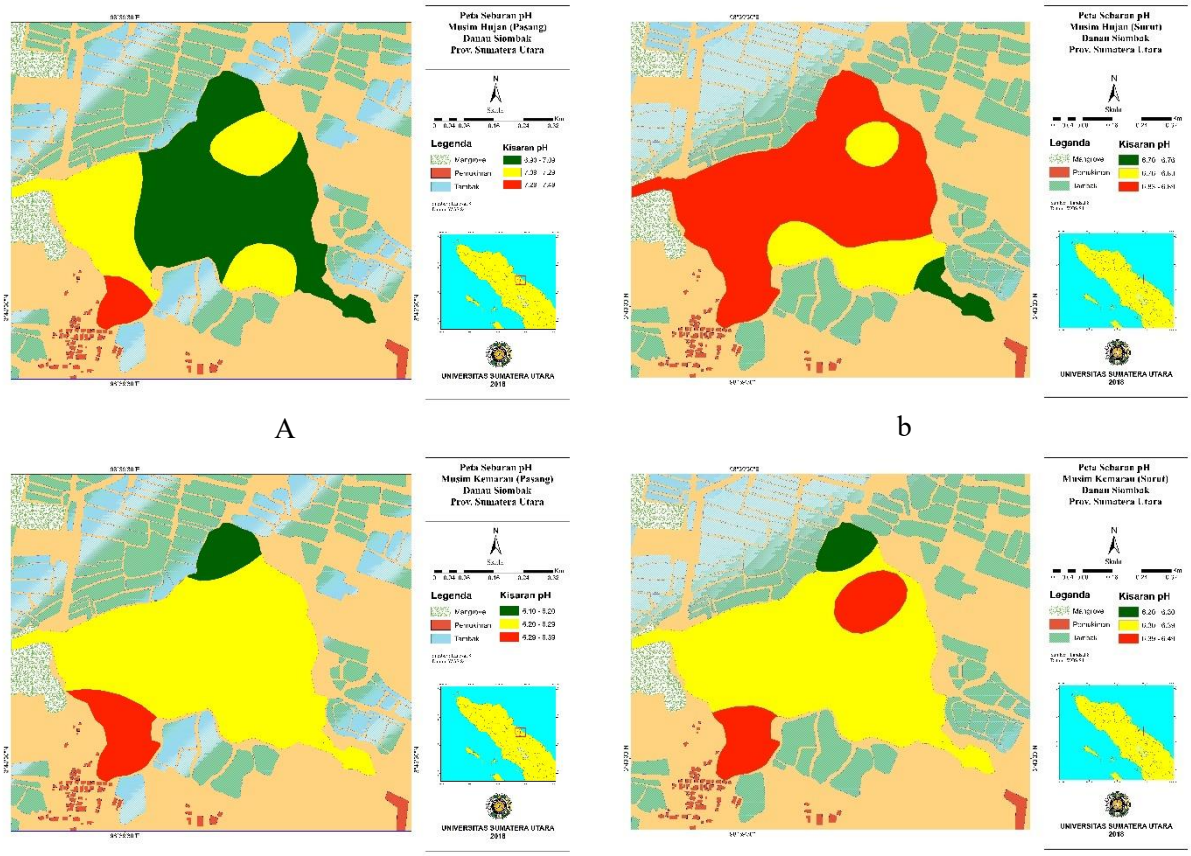

Figure. 4 Horizontal pH distribution in Siombak Lake a) high tideat rainy, b) low tide at rainy, c) high tide at dried, and d) low tide at dried

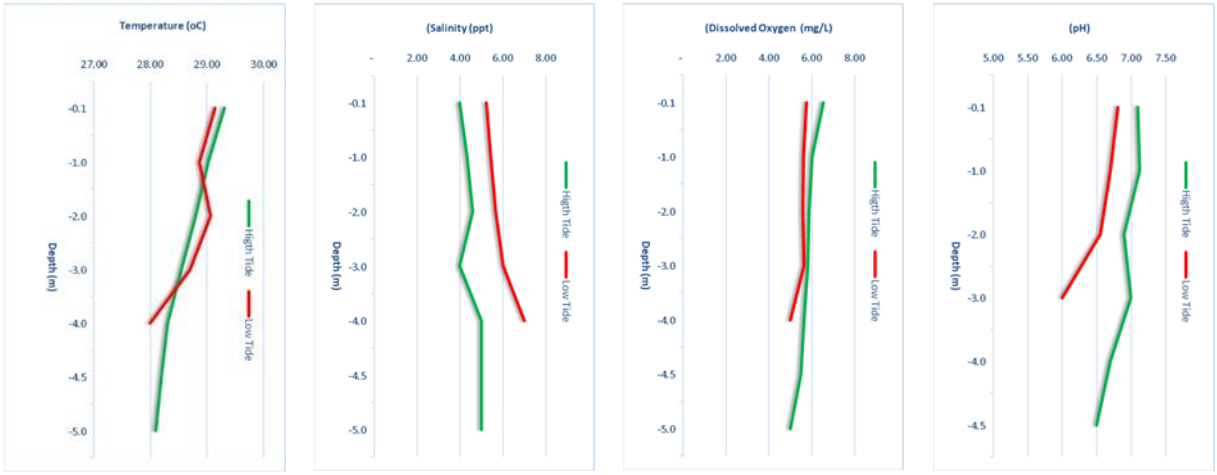

Figure. 5 Distribution of temperature, salinity, O_2, and pH vertically in SiombakLake

4. Conclusions

There was no significant difference in the temperature distribution on the surface between high tide and low tides. While salinity was quite different between high tide and low tide. In the dry season (April to June) salinity values were higher during high tide than low tide. Conversely, during the rainy season (June to August) the salinity values at low tide were higher compared to when low tide.

Vertically the distribution of temperature, oxygen, and pH decreased with respect to depth increased. But the salinity value increased with depth increased.

References

[1] Effendi H 2003 *Water Quality Study* (Jakarta, Indonesia: Kanisius publisher)

[2] Odum E P 1996 *Fundamentals of Ecology (3rd Edn)* Translator T Samingan (Yogyakarta, Indonesia: Universitas Gajah Mada)

[3] Araoye P A 2009 The seasonal variation of ph and dissolved oxygen (DO_2) concentration in Asa lake Ilorin Nigeria *Int. J. Phys. Sci.* **4** EF7163018888

[4] Pal M, Samal N R, Roy P K and Roy M B 2014 Temperature and dissolved oxygen stratification in the Lake Rudrasagar Preliminary investigations *Sustainability, Agri, Food and Environmental Research*, **2** 1 p 1-12

[5] Nybakken J W 1992 *Marine Biology An Ecological Approach* (Jakarta, Indonesia: Gramedia)

[6] Rangkuti A M, Cordova M R, Rahmawati A, Yulma and Adimu E H 2017 *Ekosistem Pesisir dan Laut Indonesia [Indonesian Coastal and Marine Ecosystems]* (Jakarta, Indonesia: PT. Bumi Aksara)

[7] Opadokun I O, Falaye A E and Ajani E K 2015 Seasonal Variation in Physicochemical Parameters of Lekki Lagoon and the Conservation of Its Ecosystem *Journal of Geoscience and Environment Protection* **3** p 11-17

[8] Lukman I and Ridwansyah 2010 Kajian kondisi morfometri dan beberapa parameter stratifikasi perairan Danau Toba [Study of morphometric conditions and some parameters of stratification of the waters of Lake Toba] *Journal Limnotek* **17** 2 p 158 – 70

[9] Sinaga E L R, Muhtadi A and Bakti D 2016 Profil Suhu, Oksigen Terlarut, dan pH Secara Vertikal Selama 24 Jam di Danau Kelapa Gading Kabupaten Asahan Sumatera Utara [Profile of Temperature, Dissolved Oxygen, and pH Vertically for 24 Hours in Lake Kelapa Gading Asahan Regency, North Sumatra] *Omni-Akuatika* **12** 2 p 114 - 124

[10] Wetzel R G 2001 *Limnology Lake and River Ecosystems* (California: Academic Press)

[11] Katsev S, Aaberg A A, Crowe S A and Hecky R E 2014 Recent arming of Lake Kivu. *PLoS ONE* , **9** e109084

[12] Muhtadi A, Harahap Z A, Leidonald R 2017 Morphometry dynamical of siombak lake, medan indonesia *Omni-Akuatika* **13** 2 p 48-56

[13] Herdendorf C E 1982 Large lakes of the world *J. Great Lakes Res.* **8** 3 p 379 – 412

[14] Muhtadi A, Yunasfi, Leidonald R, Sandy S D, Junaidy A and Daulay A T 2016 Limnological status of Lake Siombak, Medan, North Sumatra *Oceanologi dan Limnologi di Indonesia* **1** 1 p 39-55

[15] Siagian M and Simarmata A H 2014 Vertical profile of dissolved oxygen in Lake Pinang Luar (Oxbow lake) Siak Hulu District, Kampar District, Riau Province *Jurnal Akuatika* **5** 1 p 16 – 20

[16] Siagian M and Simarmata A H 2015 Vertical profile of dissolved oxygen in the Pinang Dalam Oxbow Lake Buluh Cina Village, Siak Hulu Sub District, Kampar District, Riau Province *Jurnal Akuatika*, **6** 1 p 87 – 94

Acknowledgments

The authors acknowledge gratefully to the Ministry of Research, Technology and Higher Education Republic of Indonesia. The support is under grant **TALENTA University of Sumatera Utara of Year 2018, With TALENTA University of Sumatera Utara Research Contract Number 2590/UN5.1.R/PPM/2018, date 16 March 2018**. The author also expressed the gratitude to Rosmawati Waruwu and Henny S Siregar for their assistance in the field.