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Research paper

In-Situ Current Speed Measurement and Sediment Characteristics at UPNM Lake

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Abstract

This paper focuses on a hydrographic survey conducted at Universiti Pertahanan Nasional Malaysia (UPNM) Lake. The aim is to measure the current speed and sediment characteristics due to the limitation of information and references regarding on UPNM Lake. The hydrographic survey conducted is essential as it is the first survey carried out and indirectly outlines and provides details of the lake for future applications. All the information from the survey is prominent seeing that UPNM Lake is constantly used for either research activities, fishing activities, recreational activities by students and as a training ground for military cadets. The outcome gathered from this research is an analysis of data for in-situ current speed and direction at 26 designated locations (23 locations for bottom current) in the lake area and also sediment characteristics. Current speed distribution at UPNM Lake shows 80% current speed recorded in between 0.02 m/s to 0.5 m/s with the highest current speed was recorded at the magnitude of 0.68 m/s and the lowest current speed is at magnitude 0.02 m/s. For sediment characteristics, all sampling stations show mud sediment with few stations show different types of mud. The study of this water body either in physical or chemical aspect is performed to derive a better understanding of the composition of the lake for safety functionality.

Keywords: *water current speed; sediment bed; hydrographic survey; water current direction*

1. Introduction

Water bodies which embrace from oceans, seas, rivers, lakes, and streams are the indispensable basis for the subsistence of living life on the Earth. Though recent studies show that lakes only cover of less than 1% of the total Earth's surface area [2], nevertheless, the prevailing of lakes is indisputable due to its importance as a habitat for marine species, act as food resources and also for recreational activities [3]. Over 304 million lakes are estimated which can be found in certain areas or regions [3]. The existing lakes in these particular areas are strongly dependant on the geographical and geological traits of one area [2]. The basic formation of lake is basin and depressions which act as holding ground for water [4]. Occasions such as glacial activity, tectonic movement, volcanic activity, river erosion and also man-made are contributing factors for the formation of lakes [5].

UPNM Lake is one of the man-made lake located on the UPNM campus. Being one of the facilities provided, UPNM Lake functions as an area for fishing activities, recreational activities and also as a training area for military cadets. The utilization of UPNM Lake can be considered at frequent level by students or staffs at most of the time. However, none hydrographic surveys had been conducted to study the physical features and chemical compositions of the lake. This study is vital because it is a pioneer in other research that will be carried out in the future with regard to UPNM Lake. In addition, the understanding and comprehension of the lake structure, current speed, sediment, water depth is crucial for safety purposes for any activities held at UPNM Lake.

Therefore, a 2-days survey was carried out to perform the measurement, processing, and analysis of data for in-situ current speed and direction at 26 designated locations in the lake area. The result collected also includes sediment characteristics of the lake.

2. Geographical Location

26 stations were selected at the UPNM Lake and in-situ data for current speed and direction data along with sedimentation observation and water quality measurement were performed. At same time, bathymetry survey was also carried out within the lake area. Sampling trips were successfully carried out from 23rd of February until 24th of February 2017. Figure 1 indicated the actual deployment locations for all sampling stations. The in-situ current measurement and water quality locations were marked and labelled as P1-P23 and PS1-PS3. At each station, data was collected and analyse together with the sediment sample. For the surface current speed and direction data acquisition, the stations were marked as PS1, PS2, and PS3. The final geographical locations for all the installation is illustrated in Table 1 and Table 2 below.



Fig. 1: Sampling stations in-situ current and water quality measurement.

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Table 1: Geographical locations of the sampling stations

Station	Latitude	Longitude	Depth (m)
P1	3° 2'53.15"N	101°43'14.50"E	0.60
P2	3° 2'53.40"N	101°43'13.47"E	0.90
P3	3° 2'52.13"N	101°43'12.59"E	2.10
P4	3° 2'51.07"N	101°43'13.92"E	2.20
P5	3° 2'49.47"N	101°43'13.50"E	2.30
P6	3° 2'49.64"N	101°43'11.87"E	3.30
P7	3° 2'50.21"N	101°43'10.27"E	3.10
P8	3° 2'49.67"N	101°43'8.43"E	2.90
P9	3° 2'48.48"N	101°43'9.21"E	2.70
P10	3° 2'47.27"N	101°43'11.09"E	2.50
P11	3° 2'45.77"N	101°43'10.74"E	3.20
P12	3° 2'43.08"N	101°43'11.00"E	1.70
P13	3° 2'40.95"N	101°43'10.18"E	2.20
P14	3° 2'38.25"N	101°43'8.85"E	1.60
P15	3° 2'38.40"N	101°43'6.68"E	1.40
P16	3° 2'38.72"N	101°43'4.37"E	2.00
P17	3° 2'40.48"N	101°43'5.48"E	2.30
P18	3° 2'42.75"N	101°43'7.33"E	2.80
P19	3° 2'45.86"N	101°43'9.28"E	4.10
P20	3° 2'50.57"N	101°43'4.88"E	3.20
P21	3° 2'47.63"N	101°43'3.90"E	2.70
P22	3° 2'42.38"N	101°43'2.60"E	1.00
P23	3° 2'42.85"N	101°43'3.60"E	1.40

Table 2: Geographical locations of surface current measurement

Station	Latitude	Longitude	Depth (m)
PS1	3° 2'50.91"N	101°43'13.17"E	2.60
PS2	3° 2'47.22"N	101°43'8.03"E	4.00
PS3	3° 2'41.87"N	101°43'4.90"E	2.10

3. Current measurement

For the current measurement, the Aquadopp current meter (Figure 2) manufactured by Nortek AS, Norway was used. The equipment is designed for any body of water, whether ocean, estuary, lake or river. It measures the water current velocity in a single volume using Doppler technology. Although the Aquadopp current meter is small in size but it is an extremely powerful sampling system that allows it to be used in a variety of applications.

From the 26 stations selected, 23 stations labeled as P1-P23 were for bottom current measurement while the remaining 3 stations labeled as PS1-PS3 were for surface current measurement. The in-situ current data measured provided information on the current flow pattern within the study area where current speed magnitude, (m/s) and direction, (degrees) were recorded.

Before deployment of the Aquadopp current meter, it was properly secured to the pole and lowered into the lake. The pole was further tied and secured to the side of the boat to ensure the pole is straight and static during data collection to minimize data lost due to over tilt and roll.

For this study, data collection interval was set at every 10 seconds for every station. In addition to the current measurement, the Aquadopp current meter also produced data for tilt and roll along with bearing from the internal compass and tilt sensors.



Fig. 2: The Aquadopp current meter used for current measurement.

4. Results and Discussion

4.1. Current speed measurement

Current meter data was recorded every 10-second interval on each sampling stations during the first and second day of the survey. Another important data recorded simultaneously during the current meter data measurement was sediment observation at each of the sampling stations from P1-P23 and PS1-PS3. Summary of all the current speed and direction data is provided in Table 3 and Table 4 for stations PS1-PS3 and P1-P23 respectively.

Table 3: Result for current meter data acquisition for surface measurement at PS1-PS3

Total Station	3		
Site Detail	Surface Current Measurement		
Interval	10 second		
Equipment	Aquadopp Current Meter, Nortek		
Station	Date/Time	Speed (m/s)	Direction (degrees)
PS1	24/2/2017 11:56:00	0.03	205.87
PS2	24/2/2017 12:05:00	0.03	104.80
PS3	24/2/2017 12:15:00	0.03	174.69

Table 4: Result for current meter data acquisition for bottom measurement at P1-P23

Total Station	23		
Site Detail	Bottom Measurement		
Interval	10 seconds		
Equipment	Aquadopp Current Meter, Nortek		
Station	Date/Time	Speed (m/s)	Direction (degrees)
P1	23/02/17 16:01:00	0.02	210.53
P2	23/02/17 16:04:00	0.02	198.59
P3	23/02/17 16:08:00	0.02	180.27
P4	23/02/17 16:12:00	0.03	149.89
P5	23/02/17 16:16:00	0.27	53.32
P6	23/02/17 16:20:00	0.44	145.18
P7	23/02/17 16:23:00	0.37	102.81
P8	23/02/17 16:26:00	0.46	208.28
P9	23/02/17 16:29:00	0.68	159.10
P10	24/02/17 10:37:00	0.11	168.26
P11	24/02/17 10:40:00	0.16	194.95
P12	24/02/17 10:47:00	0.22	179.83
P13	24/02/17 10:51:00	0.02	169.25
P14	24/02/17 10:56:00	0.08	145.10
P15	24/02/17 11:01:00	0.12	149.93
P16	24/02/17 11:06:00	0.05	212.99
P17	24/02/17 11:10:00	0.16	116.27
P18	24/02/17 11:14:00	0.04	213.77

P19	24/02/17 11:18:00	0.09	233.10
P20	24/02/17 11:23:00	0.10	157.50
P21	24/02/17 11:28:00	0.03	141.91
P22	24/02/17 11:36:00	0.07	196.25
P23	24/02/17 11:40:00	0.27	191.10

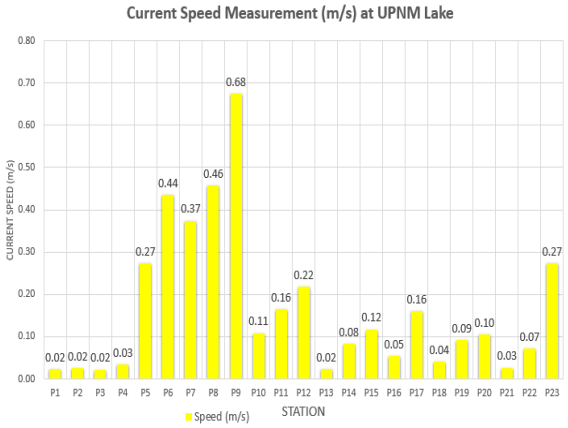


Fig. 3: Clustered column chart for current speed measurement at P1-P23 sampling stations.

Figure 3 indicates the information on the current speed distribution at UPNM Lake with 80% current speed recorded in between 0.02 m/s to 0.5 m/s. The highest current speed was recorded at P9 with the magnitude of 0.68 m/s. Meanwhile, the lowest current speed can be seen at magnitude 0.02 m/s at four sampling stations (P1, P2, P3, and P13).

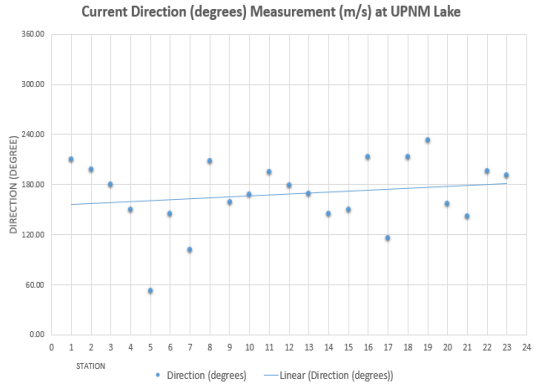


Fig. 4: Scattered graph for current direction measurement at P1-P23 sampling stations.

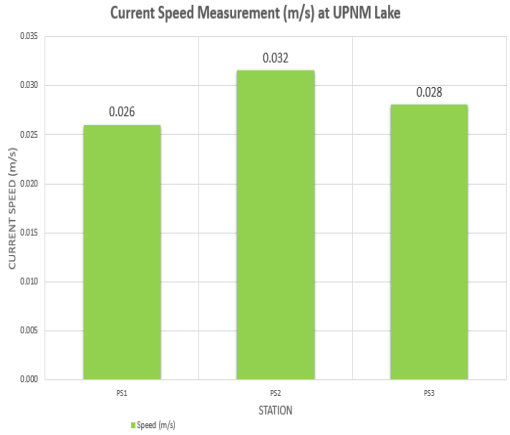


Fig. 5: Clustered column chart for current speed measurement at PS1-PS3 sampling stations.

Figure 5 indicates the information for surface current speed distribution at UPNM Lake.The highest current speed was recorded at PS2 with the magnitude of 0.032 m/s. PS1 and PS3 both show 0.026 m/s and 0.028 m/s respectively.

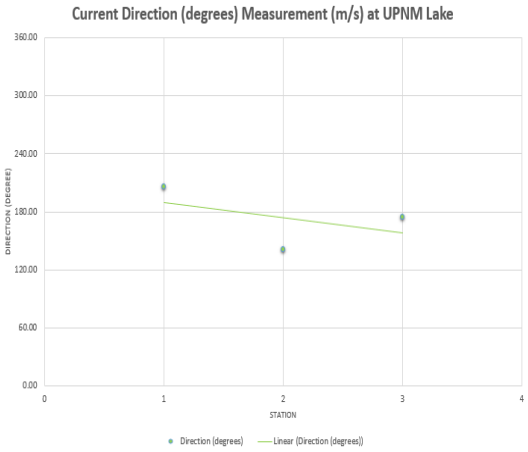


Fig. 6: Scatter chart for current direction measurement at PS1-PS3 sampling stations

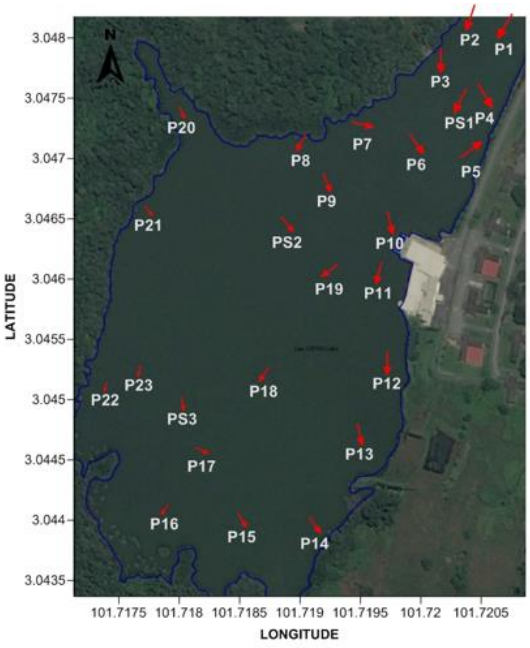


Fig. 7: Current direction measurement at P1-P23, PS1-PS3 sampling stations, UPNM Lake.

The variation of current speed is strongly due to several factors, for instance shape of the channel [1], or lake basin. Higher resistance experience by water flowing around the edge of the lake (P1, P2, P3, and P13) due to deceleration encounters when water moving and indirectly slow down the water speed. In contrast, no resistance encounters by water moving at the center of the lake. Therefore, the highest speed is recorded at P19 sampling station.

Another factor contributes to the distribution of current speed is the characteristics of the lake itself [1]. Rough character of lake can be categorized as having huge amount of rocks, pebbles or any substances that can slow down the movement of water through it. Since P1, P2, P3, and P13 are located at the edge of the lake, therefore it can be expected that large amount of rocks, stones or pebbles accumulate around these areas. In addition, UPNM Lake is not a stagnant lake in which there are ingoing and outgoing water sources at few locations around the lake. Ingoing water areas are located at both P1 and P20 stations wherein the water flows directly from sewer of Akademi Latihan Ketenteraan (ALK) building. The sewage comes from this inward water source

contains bulky amounts of residue from the construction site in the UPNM itself. Therefore, it can be concluded at P1, P2, and P3 stations experience high concentration of substances accumulate around these three stations and consequently, reduce the current speed.

4.2 Sediment characteristics

From the observation done by fabricated corer instrument, all the sampling stations were covered with mud substrate on the lake bed. Details of the sediment characteristic for P1-P23 sampling points are shown in Table 5.

Table 5: Sediment characteristic at sampling stations, UPNM Lake

Point	Characteristics
P1	Mud
P2	Black Mud
P3	Mud
P4	Mud
P5	Mud
P6	Mud
P7	Mud
P8	Mud
P9	Mud
P10	Mud
P11	Mud
P12	Brown Mud
P13	Sandy Mud
P14	Mud
P15	Mud
P16	Mud
P17	Brown Mud
P18	Sandy Mud
P19	Mud
P20	Mud
P21	Mud
P22	Mud
P23	Mud

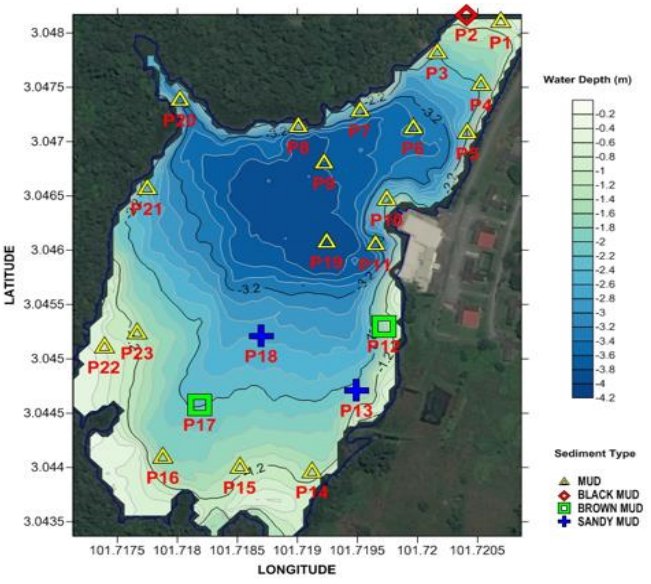


Fig. 8: 2D classed post map for sediment characteristic distribution at UPNM Lake

Figure 8 illustrates the sediment characteristics at 23 stations. 18 stations show mud sediment, while 2 stations depict brown and sandy mud respectively. Only 1 station (P2) shows black mud sediment which is on top of the lake.

The distributions of lake sedimentation are due to the sediment transport form the ingoing water areas. As stated, UPNM lake encounters the incoming water from the sewer and this indirectly carries diversity of chemical compounds into the lake. This results to the lake sediment formation. Other factors for the sediment formation are for instance, sediment maturity and existing microorganisms in the lake.

5. Conclusions

This paper discussed the in-situ current speed data and sediment characteristics gathered from a hydrographic survey conducted at UPNM Lake. The results demonstrate the current speed at UPNM Lake is safe for any water activities due to the low magnitude speed is shown at all 26 locations. Other than that, types of sediment also are observed at these locations. All of the data collected are important to be studied for better comprehension of UPNM Lake and this paper marks as the initial reference. Future improvements needed to implement is to analyze the depth of lake water by producing a bathymetric map. In addition, quality of water should be contemplating which comprises of the living organism and chemical elements that might be harmful to human. As for long-term enhancement, a study and analysis on the volume of UPNM Lake's water need to consider as well. This might be useful when water shortage situation encounters by UPNM and UPNM Lake might be an advantageous resource.

Acknowledgements

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