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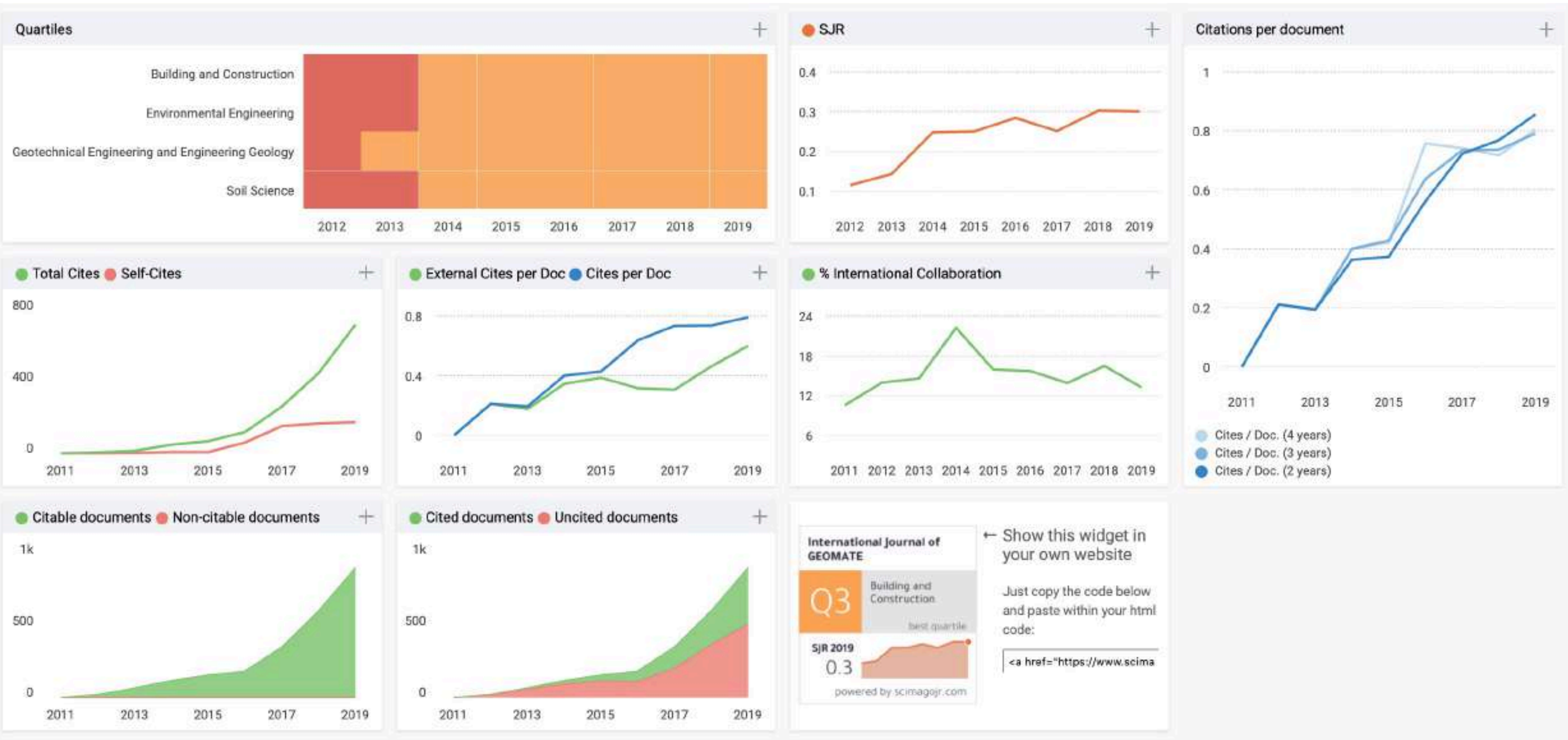

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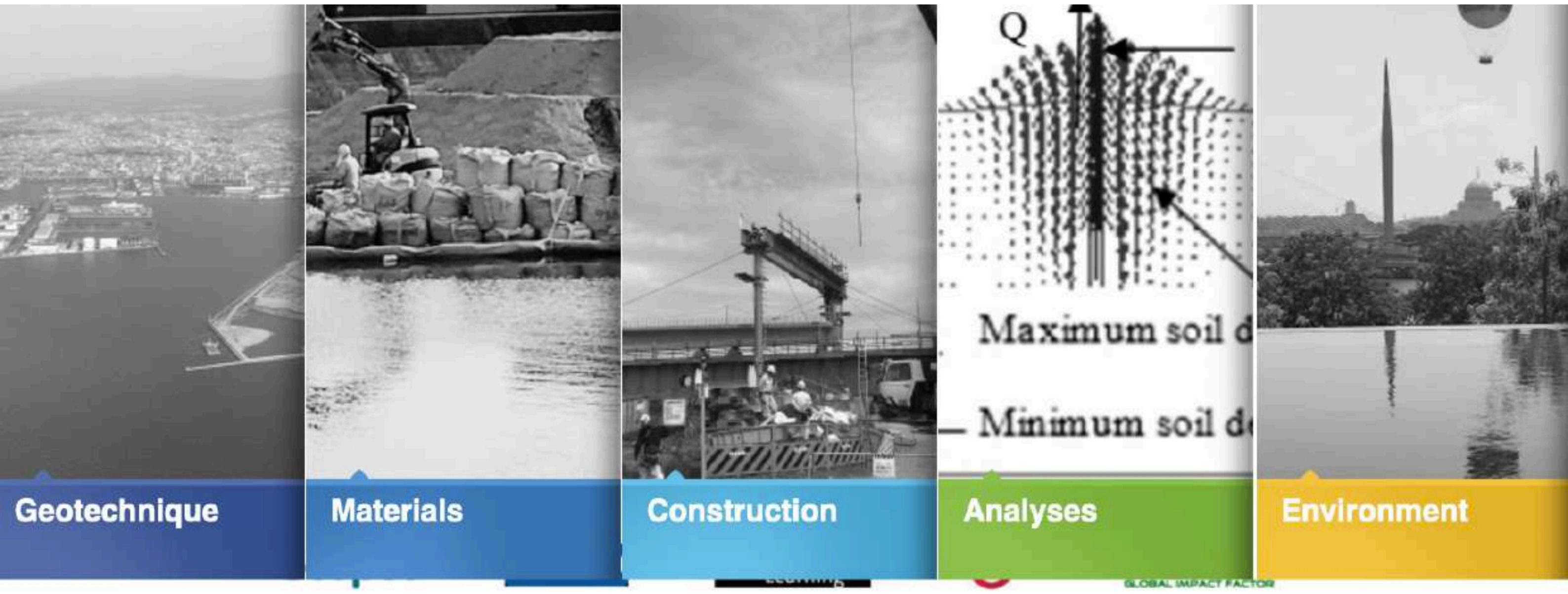

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THE CARBON SEQUESTRATION BY PHYTOPLANKTON IN TROPICAL LAKE AND RESERVOIR

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*Corresponding Author, Received: 28 Oct. 2018, Revised: 21 Nov. 2018, Accepted: 26 Dec. 2018

ABSTRACT: The increasing of atmospheric carbon dioxide has become a public and scientific concern, especially in potential aquatic ecosystem such as lake and reservoir as carbon sequestration is inevitable to decelerate the global warming process. The aim of the study is to estimate carbon sequestration by phytoplankton in tropical lake and reservoir, case study in Maninjau Lake (0°19′S; 100°12′E), West Sumatera Province and Pluit Reservoir (6°6'58.13"S; 106°47'54.69" E), Jakarta Province, Indonesia. The study was conducted in eleven sampling points to represent the lake during in May–July 2016 in Pluit Resevoir and in May-July 2017 in Maninjau Lake. Plankton nets were used for sampling phytoplankton. The determination of sampling points are based on the Indonesian National Standard 6989.57: 2008 regarding the method of sampling of surface water. Phytoplankton sampling was carried out by filtering water samples as much as 100 liters from 50 cm surface water by using a plankton net (25 µm mesh size). To find out the ammount of carbon sequestration an analysis was carried out to measure the abundance of phytoplankton communities and the concentration of chlorophyll-a. The results of this study revealed the abundance of phytoplankton in Maninjau Lake range 78-273-cell/l belonging to 4 classes and carbon sequestration average was 0.0504 mgC/m^3. However, in Pluit Reservoir abundance range was 72-800 cell/l belonging to 2 classes with carbon sequestration average 0.1181 mgC/m^3. The study concluded that phytoplankton could give the information about the carbon sequestration rate and as instrumental in formulating efficient strategies related to carbon sequestration.

Keywords: Carbon Sequestration, Chlorophyll-a, Phytoplankton, Lake and Reservoir

1. INTRODUCTION

During the 21st century a steady increase in the atmospheric carbon dioxide concentration has been observed. The concentration of anthropogenic CO_2 in the atmosphere that is predicted to increase year on year are primarily due to fossil fuel use, with land-use change providing another significant but smaller contribution, which enhances the natural greenhouse effect and warms the planet, where the global surface temperatures will increase from approximately 2°C and 4°C compared to 1990 [1,2,3]. Furthermore, Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions have grown between 1970 and 2004 by about 80%, from 21 to 38 Gigatonnes (Gt), and represented 77% of total anthropogenic GHG emissions in 2004 [4].

Impact of increased CO_2 will change water supply and local weather pattern, changes the planting season of food crops and rising sea level pose an increasing threat to coastal communities. Global warming has the potential to result in more wildfires, droughts and tropical storms, changing weather affects the agricultural industry and the human food supply. Carbon emissions contribute to increasing temperatures and decreasing precipitation. It takes only a small change in temperature to have enormous environmental effects; temperatures at the end of the last ice age were only cooler than today's temperatures by 2.5 to 5 degrees Celsius [5, 6, 7].

Some of strategies to lower carbon dioxide (CO_2) emissions to mitigate climate change come in three flavors: reducing the amount of energy in using primarily fossil fuels for development [8]. through more efficient technology or through changes in lifestyles and behaviors; expanding the use carbon negative oil, that the CO_2 is sourced from the fermentation emissions from an ethanol plant [9] and biological sequestration is basically performed by living organisms including plants and many microorganisms which lead to carbon capture and storage via various biological processes. Enhancement in phytoplankton CO_2 fixation is an added advantage along with Carbon Sequestration [10].

Lake has an ecological function to maintain the ecological balance of fresh water and as a carbon sink. Lakes also can be considered as a key ecosystem for managing carbon stocks and in the process of photosynthesis phytoplankton release oxygen into the water.

Phytoplankton absorb and scatter light, warming the topmost layers of the waters, and they produce volatile organic compounds, but their most significant role is moving carbon around the waters, on a scale large enough to affect levels of carbon dioxide in the

atmosphere. This is how plankton plays a part in the natural greenhouse effect. Therefore, it was necessary to conduct the research on the estimation of carbon sequestration in lake by phytoplankton. This study aims to estimate the potential of carbon dioxide sequestration in lake. The results of this study are expected to obtain the amount of potential data on the amount of carbon stock in the lake.

2. MATERIALS AND METHODS

2.1 Location and Time

This study was conducted in 2 (two) aquatic ecosystem those were Maninjau Lake and Pluit Reservoir, both of them located in Indonesia. Maninjau Lake (0°19' S; 100°12'E) is a natural lake located in West Sumatra Province (Sumatra Island). The functions of Maninjau Lake are as a catchment area, water recreation area, and fish breeding area. Inlet channel comes from Batang Antokan River while its outlet channel flows into 3 small rivers namely Batang Tumayo, Batang Amparan, and Batang Kurambik. Around Maninjau Lake there are recreation areas, housing, laundry, hotels, and restaurants.

Meanwhile, Pluit Reservoir (6°6'58.13"S; 106°47'54.69" E) is a man-made ecosystem located in Jakarta Province (Java Island). The functions of this reservoir are as recreation facilities, water catchment area. This reservoir holds water from the Ciliwung River, Krukut River, Angke River, rainwater, and waste from surrounding reservoir. Around Pluit Reservoir there are recreation areas of settlements, commerce, industry and services, as well as offices.

Determination of sampling point based from the Indonesian National Standard (SNI) No. 6989.57:2008 about surface water sampling method, which consist natural water resources, at locations that have not or less pollution occurred, polluted water source, at the locations that has received the waste, utilized water source, the location where tapping the water source, and location of water entry to reservoir or lake.

The samples were collected monthly May – July 2017 in Maninjau Lake and May- July 2016 in Pluit Reservoir at 11 sampling point scattered along the waters were representing main inlet, main outlet and the activities both of waters surounding as show in Table 1 below:

Table 1 Sampling Point Coordinate

Sampling Point	Maninjau Lake	Pluit Reservoir
1	$0^0$19'28.1" S; $100^0$13'06.2" E	$6^0$7'29.123" S; $106^0$48' 5.610" E;
2	$0^0$17'23.7" S; $100^0$13'36.8" E	$6^0$7'25.668" S; $106^0$48' 2.792" E
3	$0^0$17'29.4" S; $100^0$09'09.4" E	$6^0$7'19.607" S; $106^0$47' 55.376" E
4	$0^0$18'23.6" S; $100^0$09'53.2" E	$6^0$7'23.170" S; $106^0$48' 6.838" E
5	$0^0$20'57.3" S; $100^0$09'58.7" E	$6^0$7'3.370" S; 106^0 48' 4.658" E
6	$0^0$22'21.2" S; $100^0$09'53.8" E	$6^0$7'1.998" S; 106^0 47' 42.409" E
7	$0^0$23'35.9" S; $100^0$12'06.1" E	$6^0$6' 53.333" S; 106^0 48'7.590" E
8	$0^0$18'56.0" S; $100^0$06'36.8" E	$6^0$6'57.000" S; $106^0$47' 42.353" E
9	$0^0$16'41.5"S; $100^0$11'22.5" E	$6^0$6'51.856" S; $106^0$47'54.065" E
10	$0^0$18'50.2" S; $100^0$11'33.8" E	$6^0$6'44.951" S; $106^0$47'58.369" E
11	$0^0$22'53.9" S; $100^0$11'40.2" E	$6^0$6'41.234" S; $106^0$47' 50.664" E

2.2. The Abundance of Phytoplankton

The phytoplankton samplings were done 3 months in each waters. Phytoplankton sampling was carried out by filtering water samples as much as 100 liters from 50 cm surface water by plankton net (25 µm mesh size). Filtered water samples were stored in the sample bottle, and then preserved with Lugol's solution immediately after sampling and kept in cooler box. The samples of phytoplankton were brought to be identified and classified by a binocular microscope at a magnification of ×400 and identification book [11]. Phytoplankton abundance is the number of individuals or cells per unit volume. was calculated using the following equation [12]:

$$\mathbf{N = n \ x \ \frac{Vr}{Vo} \ x \ \frac{1}{Vs}} \quad (1)$$

N= phytoplankton abundance (cell/l); n= number of observed phytoplankton; Vr= volume of filtered water (30 ml); Vo= concentrate volume of Sedgwick Rafter Counting Cell (ml); Vs= volume of filtered water sample (100 l).

2.3. Chlorophyll-a Concentration

Chlorophyll-a was counting using the following equation [13]:

$$\textbf{Chlorophyl} - \textbf{a}\left(\frac{\textbf{mg}}{\textbf{m}^3}\right) = \frac{\{(\textbf{11,85}(\textbf{E664}) - \textbf{1.54}(\textbf{E647}) - \textbf{0.08}(\textbf{E630})\}\textbf{x Ve}}{\textbf{Vs}} \quad (2)$$

2.4. Carbon Sequestration

Carbon absorption for the phytoplankton was calculated using carbon conversion factor for chlorophyll-a of phytoplankton. Total carbon calculated by the following equation:

$$\text{Value of Chlorophyll} - \text{a}\left(\frac{\text{mg}}{\text{m}^3}\right) \text{x mol } CO_2 = \text{mg}\frac{CO_2}{\text{m}^3}$$

$$\text{mg}\frac{CO_2}{\text{m}^3} \text{x } \frac{12}{44}\left(\frac{\text{ArC}}{CO_2}\right) \rightarrow \frac{\text{mgC}}{\text{m}^{3*}} \quad (3)$$

*Converting mg/m^3 to determine the potential of carbon sequestration in the waters and the amount carbon sequestration in a certain time period.

3. RESULTS AND DISCUSSION

The results of identification and classification found several classes of phytoplankton as follows: in Pluit Reservoir consist 4 classes and from Maninjau Lake consist 3 classes as in Table 2.

Table 2 The results of phytoplankton identification in waters

Phytoplankton	Total Genera	
	Maninjau Lake	Pluit Reservoir
Chlorophyceae	5	8
Cyanophyceae	4	7
Bacillariophyceae	-	13
Euglenophyceae	-	5
Chrysophyceae	7	-

The abundance of phytoplankton varied with different sampling point. In Maninjau Lake the average abundance during the study ranged from 78-273 cells/l, whereas in Pluit Reservoir the average abundance ranged from 72 to 800 cell/l. The dynamics of abundance show in Fig. 1 and Fig. 2.

The species abundance of phytoplankton were species has a high tolerance, in addition supported by water conditions and affected by changes in the aquatic environment as well. One factor that can affect plankton abundance is the availability of nutrients, especially nitrate greatly determines the abundance of phytoplankton species in a waters and as the limiting factor for phytoplankton growth in freshwater ecosystems. On the other side, phosphate was the primary nutrient for phytoplankton growth. Water conditions contain enough nutrients needed for the development of phytoplankton nitrate and phosphate generally derived from household and industrial waste disposal.

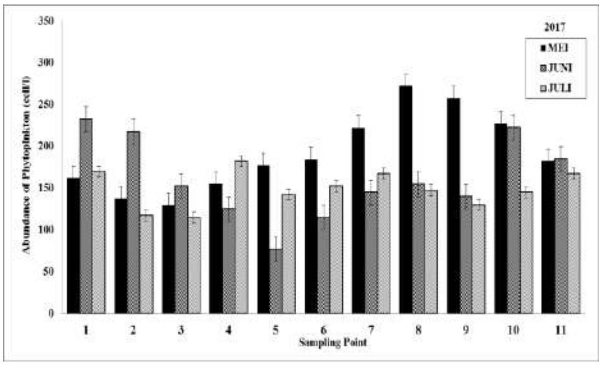

Fig. 1 The Abundance of phytoplankton in Maninjau Lake (2017)

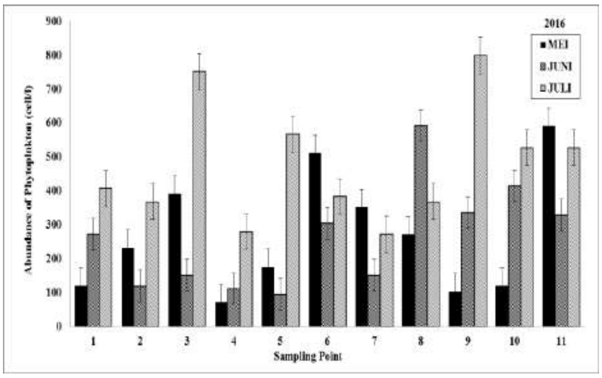

Fig. 2 The Abundance of phytoplankton in Pluit Reservoir (2016)

The correlation of chlorophyll-a to nitrate and phosphate concentration is significant [15]. The results of water quality analysis to nitrate and phosphate concentrations show that waters conditions contain sufficient nutrients needed for growth of phytoplankton, as shown in Table 3, but not for optimal growth. The optimal growth of phytoplankton requires a nitrate concentration ranging from 0.9 to 3.5 mg/l [16,17] and phosphate concentration ranging from 0.9 to 3.5 mg/l. Therefore, both of waters condition is inadequate for phytoplankton growth. Although the air temperature is sufficient for photosynthesis.

Table 3. Value of water quality parameter

Parameter	Maninjau Lake	Pluit Reservoir
Nitrate (mg/l)	0.02-0.40	0.31- 1.53
Phosphate (mg/l)	0.12-0.54	0.21 – 1.72
Temperature (^{O}C)	27.0-32.0	27.3-28.3

The pigment that plays a high role in the process in of photosynthesis is chlorophyll-a [18]. Fig. 3 and Fig. 4 show that the chlorophyll-a concentration is influenced by the type of phytoplankton. Types of phytoplankton containing lots of chlorophyll-a are class Chlorophyceae and Cyanophyceae, whereas another type of phytoplankton contains another type of other pigment. There is a linear correlation between the abundance of phytoplankton with chlorophyll-a concentration [19,20].

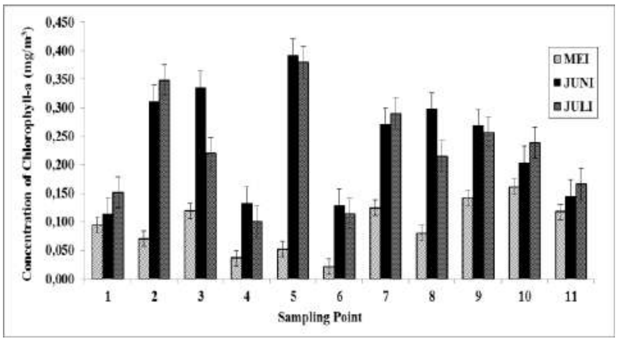

Fig. 3 Chlorophyll-a concentrations (mg/m^3) in Maninjau Lake (2017)

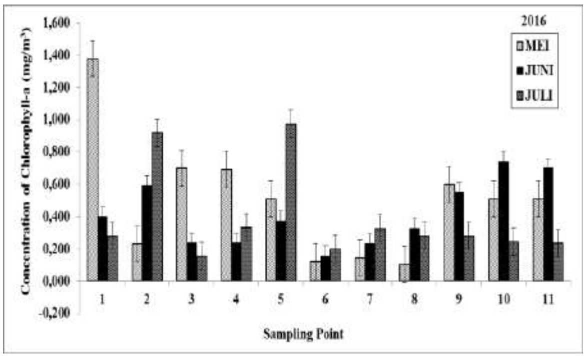

Fig. 4 Chlorophyll-a concentrations (mg/m^3) in Pluit Reservoir (2016)

With the type of phytoplankton mentioned above, it show that the chlorophyll-a concentration was obtained from Chlorophyceae and Cyanophyceae, which in each aquatic contain 0.088-0.275mg/m^3 in Maninjau Lake and 0.159-0.687 mg/m^3 in Pluit Reservoir. The results obtained in the tropical country are smaller, although physical factors allow for the process of photosynthesis when compared with the results of studies that have been carried out in sub-temperate condition by other researchers such as Superior Lake (mean = 0.99 mg/m^3), Michigan Lake (mean = 0.88 mg/m^3), and Huron Lake (mean = 0.77 mg/m^3) [22], and also in Taihu Lake, China, Chl-a estimation on July–August of 2005 and March of 2011 chlorophyll-a ranges of 5.0–156.0 mg/m^3, 4.0–98.0 mg/m^3 and 11.4–35.8 mg/m^3, respectively [21].

This is due to several factors namely the area of water, there is water pollution, rain day. The carbon sequestration in lake and reservoir show in Table 4.

The small absorption of carbon that occurs in Lake Maninjau with an average value of 0.0504 mgC/m^3 and in Pluit Reservoir 0.1181 mgC/m^3 caused by the small value of chlorophyll-a concentration.

Table 4 Carbon Sequestration (mgC/m^3) estimates for the lake and resevoir

Sampling Point	Carbon Sequestration (mgC/m^3)	
	Maninjau Lake	Pluit Reservoir
1	0.0327	1.8733
2	0.0664	0.9298
3	0.0613	0.9963
4	0.0245	1.1514
5	0.0749	1.1499
6	0.0241	1.4286
7	0.0624	1.8255
8	0.0539	1.5520
9	0.0606	1.2996
10	0.0549	1.3602
11	0.0390	1.3172
Average	0.0504	0.1181

4. CONCLUSION

Based on the results obtained in this study, in relation to the issue of climate change and global warming, it is necessary to maintain the ecological function and water quality of lake and reservoir in order to absorb more CO_2. The abundance of phytoplankton in Maninjau Lake range 78-273-cell/l consist 4 classes, the carbon sequestration average 0.0504 mgC/m^3. However, in Pluit Reservoir abundance range 72-800 cell/l consist 2 classes the carbon sequestration average 0.1181 mgC/m^3. The concluded that phytoplankton could be gives information about the carbon sequestration rate and as instrumental in formulating efficient strategies related to carbon sequestration and reduction of greenhouse gas emissions in tropical country.

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THE CARBON SEQUESTRATION BY PHYTOPLANKTON IN TROPICAL LAKE AND RESERVOIR

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ABSTRACT: The increasing of atmospheric carbon dioxide has become a public and scientific concern, especially in potential aquatic ecosystem such as lake and reservoir as carbon sequestration is inevitable to decelerate the global warming process. The aim of the study is to estimate carbon sequestration by phytoplankton in tropical lake and reservoir, case study in Maninjau Lake (0°19'S; 100°12'E), West Sumatera Province and Pluit Reservoir (6°6'58.13"S; 106°47'54.69" E), Jakarta Province, Indonesia. The study was conducted in eleven sampling points to represent the lake during in May–July 2016 in Pluit Resevoir and in May-July 2017 in Maninjau Lake. Plankton nets were used for sampling phytoplankton. The determination of sampling points are based on the Indonesian National Standard 6989.57: 2008 regarding the method of sampling of surface water. Phytoplankton sampling was carried out by filtering water samples as much as 100 liters from 50 cm surface water by using a plankton net (25 µm mesh size). To find out the ammount of carbon sequestration an analysis was carried out to measure the abundance of phytoplankton communities and the concentration of chlorophyll-a. The results of this study revealed the abundance of phytoplankton in Maninjau Lake range 78-273-cell/l belonging to 4 classes and carbon sequestration average was 0.0504 mgC/m^3. However, in Pluit Reservoir abundance range was 72-800 cell/l belonging to 2 classes with carbon sequestration average 0.1181 mgC/m^3. The study concluded that phytoplankton could give the information about the carbon sequestration rate and as instrumental in formulating efficient strategies related to carbon sequestration.

Keywords: Carbon Sequestration, Chlorophyll-a, Phytoplankton, Lake and Reservoir

1. INTRODUCTION

During the 21st century a steady increase in the atmospheric carbon dioxide concentration has been observed. The concentration of anthropogenic CO_2 in the atmosphere that is predicted to increase year on year are primarily due to fossil fuel use, with land-use change providing another significant but smaller contribution, which enhances the natural greenhouse effect and warms the planet, where the global surface temperatures will increase from approximately 2°C and 4°C compared to 1990 [1,2,3]. Furthermore, Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions have grown between 1970 and 2004 by about 80%, from 21 to 38 Gigatonnes (Gt), and represented 77% of total anthropogenic GHG emissions in 2004 [4].

Impact of increased CO_2 will change water supply and local weather pattern, changes the planting season of food crops and rising sea level pose an increasing threat to coastal communities. Global warming has the potential to result in more wildfires, droughts and tropical storms, changing weather affects the agricultural industry and the human food supply. Carbon emissions contribute to increasing temperatures and decreasing precipitation. It takes only a small change in temperature to have enormous environmental effects; temperatures at the end of the last ice age were only cooler than today's temperatures by 2.5 to 5 degrees Celsius [5, 6, 7].

Some of strategies to lower carbon dioxide (CO_2) emissions to mitigate climate change come in three flavors: reducing the amount of energy in using primarily fossil fuels for development [8]. through more efficient technology or through changes in lifestyles and behaviors; expanding the use carbon negative oil, that the CO_2 is sourced from the fermentation emissions from an ethanol plant [9] and biological sequestration is basically performed by living organisms including plants and many microorganisms which lead to carbon capture and storage via various biological processes. Enhancement in phytoplankton CO_2 fixation is an added advantage along with Carbon Sequestration [10].

Lake has an ecological function to maintain the ecological balance of fresh water and as a carbon sink. Lakes also can be considered as a key ecosystem for managing carbon stocks and in the process of photosynthesis phytoplankton release oxygen into the water.

Phytoplankton absorb and scatter light, warming the topmost layers of the waters, and they produce volatile organic compounds, but their most significant role is moving carbon around the waters, on a scale large enough to affect levels of carbon dioxide in the

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Phytoplankton absorb and scatter light, warming the topmost layers of the waters, and they produce volatile organic compounds, but their most significant role is moving carbon around the waters, on a scale large enough to affect levels of carbon dioxide in the

atmosphere. This is how plankton plays a part in the natural greenhouse effect. Therefore, it was necessary to conduct the research on the estimation of carbon sequestration in lake by phytoplankton. This study aims to estimate the potential of carbon dioxide sequestration in lake. The results of this study are expected to obtain the amount of potential data on the amount of carbon stock in the lake.

2. MATERIALS AND METHODS

2.1 Location and Time

This study was conducted in 2 (two) aquatic ecosystem those were Maninjau Lake and Pluit Reservoir, both of them located in Indonesia. Maninjau Lake (0°19' S; 100°12'E) is a natural lake located in West Sumatra Province (Sumatra Island). The functions of Maninjau Lake are as a catchment area, water recreation area, and fish breeding area. Inlet channel comes from Batang Antokan River while its outlet channel flows into 3 small rivers namely Batang Tumayo, Batang Amparan, and Batang Kurambik. Around Maninjau Lake there are recreation areas, housing, laundry, hotels, and restaurants.

Meanwhile, Pluit Reservoir (6°6'58.13"S; 106°47'54.69" E) is a man-made ecosystem located in Jakarta Province (Java Island). The functions of this reservoir are as recreation facilities, water catchment area. This reservoir holds water from the Ciliwung River, Krukut River, Angke River, rainwater, and waste from surrounding reservoir. Around Pluit Reservoir there are recreation areas of settlements, commerce, industry and services, as well as offices.

Determination of sampling point based from the Indonesian National Standard (SNI) No. 6989.57:2008 about surface water sampling method, which consist natural water resources, at locations that have not or less pollution occurred, polluted water source, at the locations that has received the waste, utilized water source, the location where tapping the water source, and location of water entry to reservoir or lake.

The samples were collected monthly May – July 2017 in Maninjau Lake and May- July 2016 in Pluit Reservoir at 11 sampling point scattered along the waters were representing main inlet, main outlet and the activities both of waters surounding as show in Table 1 below:

Table 1 Sampling Point Coordinate

Sampling Point	Maninjau Lake	Pluit Reservoir
1	0°19'28.1" S; 100°13'06.2" E	6°7'29.123" S; 106°48' 5.610" E;
2	0°17'23.7" S; 100°13'36.8" E	6°7'25.668" S; 106°48' 2.792" E
3	0°17'29.4" S; 100°09'09.4" E	6°7'19.607" S; 106°47' 55.376" E
4	0°18'23.6" S; 100°09'53.2" E	6°7'23.170" S; 106°48' 6.838" E
5	0°20'57.3" S; 100°09'58.7" E	6°7'3.370" S; 106° 48' 4.658" E
6	0°22'21.2" S; 100°09'53.8" E	6°7'1.998" S; 106° 47' 42.409" E
7	0°23'35.9" S; 100°12'06.1" E	6°6' 53.333" S; 106° 48'7.590" E
8	0°18'56.0" S; 100°06'36.8" E	6°6'57.000" S; 106°47' 42.353" E
9	0°16'41.5"S; 100°11'22.5" E	6°6'51.856" S; 106°47'54.065" E
10	0°18'50.2" S; 100°11'33.8" E	6°6'44.951" S; 106°47'58.369" E
11	0°22'53.9" S; 100°11'40.2" E	6°6'41.234" S; 106°47' 50.664" E

2.2. The Abundance of Phytoplankton

The phytoplankton sampling were done 3 months in each waters. Phytoplankton sampling was carried out by filtering water samples as much as 100 liters from 50 cm surface water by plankton net (25 µm mesh size). Filtered water samples were stored in the sample bottle, and then preserved with Lugol's solution immediately after sampling and kept in cooler box. The samples of phytoplankton were brought to be identified and classified by a binocular microscope at a magnification of ×400 and identification book [11]. Phytoplankton abundance is the number of individuals or cells per unit volume was calculated using the following equation [12]:

$$\mathbf{N = n \ x \ \frac{Vr}{Vo} \ x \ \frac{1}{Vs}} \qquad (1)$$

N= phytoplankton abundance (cell/l); n= number of observed phytoplankton; Vr= volume of filtered water (30 ml); Vo= concentrate volume of Sedgwick Rafter Counting Cell (ml); Vs= volume of filtered water sample (100 l).

2.3. Chlorophyll-a Concentration

Chlorophyll-a was counting using the following equation [13]:

$$\text{Chlorophyl} - \text{a}\left(\frac{mg}{m^3}\right) = \frac{\{(11,85(E664) - 1.54(E647) - 0.08(E630)\} x\ Ve}{Vs} \quad (2)$$

2.4. Carbon Sequestration

Carbon absorption for the phytoplankton was calculated using carbon conversion factor for chlorophyll-a of phytoplankton. Total carbon calculated by the following equation:

$$\text{Value of Chlorophyll} - \text{a}\left(\frac{mg}{m^3}\right) x \text{ mol } CO_2 = mg\frac{CO_2}{m^3}$$
$$mg\frac{CO_2}{m^3} x \frac{12}{44}\left(\frac{ArC}{CO_2}\right) \rightarrow \frac{mgC}{m^{3*}} \quad (3)$$

*Converting mg/m^3 to determine the potential of carbon sequestration in the waters and the amount carbon sequestration in a certain time period.

3. RESULTS AND DISCUSSION

The results of identification and classification found several classes of phytoplankton as follows: in Pluit Reservoir consist 4 classes and from Maninjau Lake consist 3 classes as in Table 2.

Table 2 The results of phytoplankton identification in waters

Phytoplankton	Total Genera	
	Maninjau Lake	Pluit Reservoir
Chlorophyceae	5	8
Cyanophyceae	4	7
Bacillariophyceae	-	13
Euglenophyceae	-	5
Chrysophyceae	7	-

The abundance of phytoplankton varied with different sampling point. In Maninjau Lake the average abundance during the study ranged from 78-273 cells/l, whereas in Pluit Reservoir the average abundance ranged from 72 to 800 cell/l. The dynamics of abundance show in Fig. 1 and Fig. 2.

The species abundance of phytoplankton were species has a high tolerance, in addition supported by water conditions and affected by changes in the aquatic environment as well. One factor that can affect plankton abundance is the availability of nutrients, especially nitrate greatly determines the abundance of phytoplankton species in a waters and as the limiting factor for phytoplankton growth in freshwater ecosystems. On the other side, phosphate was the primary nutrient for phytoplankton growth. Water conditions contain enough nutrients needed for the development of phytoplankton nitrate and phosphate generally derived from household and industrial waste disposal.

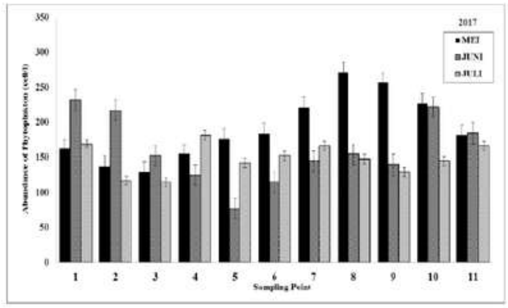

Fig. 1 The Abundance of phytoplankton in Maninjau Lake (2017)

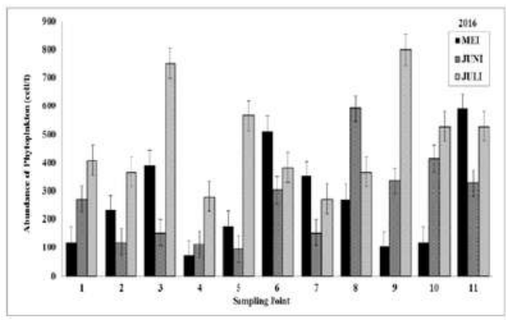

Fig. 2 The Abundance of phytoplankton in Pluit Reservoir (2016)

The correlation of chlorophyll-a to nitrate and phosphate concentration is significant [15]. The results of water quality analysis to nitrate and phosphate concentrations show that waters conditions contain sufficient nutrients needed for growth of phytoplankton, as shown in Table 3, but not for optimal growth. The optimal growth of phytoplankton requires a nitrate concentration ranging from 0.9 to 3.5 mg/l [16,17] and phosphate concentration ranging from 0.9 to 3.5 mg/l. Therefore, both of waters condition is inadequate for phytoplankton growth. Although the air temperature is sufficient for photosynthesis.

Table 3. Value of water quality parameter

Parameter	Maninjau Lake	Pluit Reservoir
Nitrate (mg/l)	0.02-0.40	0.31- 1.53
Phosphate (mg/l)	0.12-0.54	0.21 – 1.72
Temperature (^{O}C)	27.0-32.0	27.3-28.3

The pigment that plays a high role in the process in of photosynthesis is chlorophyll-a [18]. Fig. 3 and Fig. 4 show that the chlorophyll-a concentration is influenced by the type of phytoplankton. Types of phytoplankton containing lots of chlorophyll-a are class Chlorophyceae and Cyanophyceae, whereas another type of phytoplankton contains another type of other pigment. There is a linear correlation between the abundance of phytoplankton with chlorophyll-a concentration [19,20].

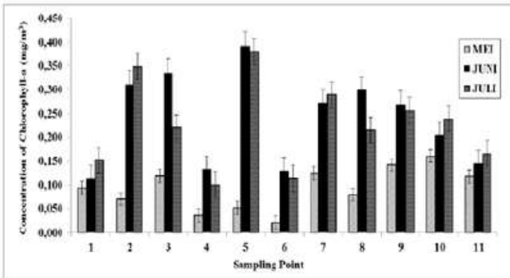

Fig. 3 Chlorophyll-a concentrations (mg/m^3) in Maninjau Lake (2017)

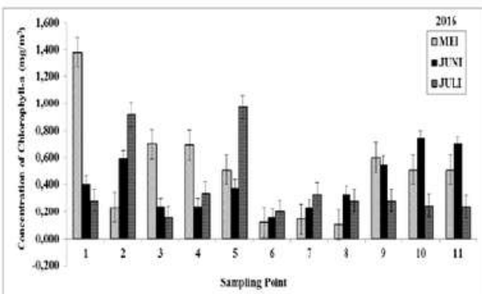

Fig. 4 Chlorophyll-a concentrations (mg/m^3) in Pluit Reservoir (2016)

With the type of phytoplankton mentioned above, it show that the chlorophyll-a concentration was obtained from Chlorophyceae and Cyanophyceae, which in each aquatic contain 0.088-0.275mg/m^3 in Maninjau Lake and 0.159-0.687 mg/m^3 in Pluit Reservoir. The results obtained in the tropical country are smaller, although physical factors allow for the process of photosynthesis when compared with the results of studies that have been carried out in sub-temperate condition by other researchers such as Superior Lake (mean = 0.99 mg/m^3), Michigan Lake (mean = 0.88 mg/m^3), and Huron Lake (mean = 0.77 mg/m^3) [22], and also in Taihu Lake, China, Chl-a estimation on July-August of 2005 and March of 2011 chlorophyll-a ranges of 5.0–156.0 mg/m^3, 4.0–98.0 mg/m^3 and 11.4–35.8 mg/m^3, respectively [21].

This is due to several factors namely the area of water, there is water pollution, rain day. The carbon sequestration in lake and reservoir show in Table 4.

The small absorption of carbon that occurs in Lake Maninjau with an average value of 0.0504 mgC/m^3 and in Pluit Reservoir 0.1181 mgC/m^3 caused by the small value of chlorophyll-a concentration.

Table 4 Carbon Sequestration (mgC/m^3) estimates for the lake and resevoir

Sampling Point	Carbon Sequestration (mgC/m^3)	
	Maninjau Lake	Pluit Reservoir
1	0.0327	1.8733
2	0.0664	0.9298
3	0.0613	0.9963
4	0.0245	1.1514
5	0.0749	1.1499
6	0.0241	1.4286
7	0.0624	1.8255
8	0.0539	1.5520
9	0.0606	1.2996
10	0.0549	1.3602
11	0.0390	1.3172
Average	0.0504	0.1181

4. CONCLUSION

Based on the results obtained in this study, in relation to the issue of climate change and global warming, it is necessary to maintain the ecological function and water quality of lake and reservoir in order to absorb more CO_2. The abundance of phytoplankton in Maninjau Lake range 78-273-cell/l consist 4 classes, the carbon sequestration average 0.0504 mgC/m^3. However, in Pluit Reservoir abundance range 72-800 cell/l consist 2 classes the carbon sequestration average 0.1181 mgC/m^3. The concluded that phytoplankton could be gives information about the carbon sequestration rate and as instrumental in formulating efficient strategies related to carbon sequestration and reduction of greenhouse gas emissions in tropical country.

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