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Pistia stratiotes Ability to Use Organic Compounds in the Test of Media Culture

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ABSTRACT

Apu-apu plant (*Pistia stratiotes*) is able to grow rapidly in culture medium given inorganic compounds. *P. stratiotes* cultured in a culture medium that has been given NPK fertilizer. *P. stratiotes* cultured in a culture medium that has been given NPK fertilizer. A CRD with 5 concentrations of inorganic fertilizers tested, i.e., 0 (Co); 15 (T1); 20 (T2); 35 (T3); and 50 g/10 L (T4). Observation of growth and decrease of the inorganic compound in culture medium was done 5 times, every 3 days. The results show that the best growth was identified in plants grown in T4. At the end of the experiment, 18.8 g BW with a daily growth rate was 17.9% of the baseline value of BW. On the 7th day of the experiment, the decrease was 0.187 mg/L (N) and 0.237 mg/L (P). So *P. stratiotes* were able to absorb relatively high N and P from water and use it for its growth.

Keywords: *Pistia stratiotes*, Growth, Inorganic materials absorption

INTRODUCTION

Pistia stratiotes is a species of water plants most commonly found in the public waters in Pekanbaru City, Riau. These aquatic plants usually grow in waters that have been polluted, especially those that contain a lot of organic waste, due to the large amount of waste disposal of the food industry, households, markets and so forth [1]. The waste has resulted in an increase in the content of inorganic compounds in general waters. As a result, the content of inorganic compounds in general waters around the city of Pekanbaru to be high and this, in turn, will affect the balance of the ecosystem of public waters [2].

Based on reports from previous researchers, public waters in Riau province at this time have many that experienced pollution, mainly due to the inorganic and organic material into the water in excess. Sajna et al. [3] states that the high content of inorganic compounds in waters can affect the abundance of organisms, but for certain organisms, such waters condition is still tolerable, although later there will be species domination in the ecosystem [4]. In an effort to control the imbalance of the ecosystem, and reduce the concentration of pollutants (organic and inorganic) in the common waters it can be done by utilizing the biological function of water plants, one of which can use *Pistia stratiotes* plants as phytoremediation [5].

The ability of *Pistia stratiotes* to decrease the content of organic and inorganic materials present in waters is very large and is environmentally friendly. The biological function of the *Pistia stratiotes* enables it to absorb the organic and inorganic compounds in the waters, and this capability varies greatly depending on the size of the plant [6]. One characteristic of hyper accumulator plants such as *Pistia stratiotes* is resistant to nutrients in high concentrations. Its root ability to absorb the soil from the ground is quite high when compared with other aquatic plants and it also has the ability to transplant and accumulate organic and inorganic materials from root to its canopy [7,8]. In addition, *P. stratiotes* have the ability to directly absorb C, O, H, from the air, N, P, K, S, Ca and Mg from pollutants and soil through their root organs. The ability of *Pistia stratiotes* to absorb the organic and inorganic compounds is due to the process of ion movement between the cells and penetrates its cell membranes [9]. Than Bey et al. [10] reported that the effect of feeding on fish pellets on the growth of *Pistia stratiotes* was able to reduce high levels of ammonia in the waters. However, the study still does not explain the ability of *Pistia stratiotes* to absorb nutrients N and P is. In this connection, this experiment wanted to know

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clearly about the ability of *Pistia stratiotes* to absorb the nutrients (N and P).

MATERIALS AND METHODS

This research was conducted in February-March 2018 and tested at Aquatic Biology Laboratory Faculty of Fisheries and Marine University of Riau. Testing of *Pistia stratiotes* on N and P was done by using a completely random design with 1 factor and 5 levels. Then the pH, DO and temperature conditions during the experiment were observed.

Experimental design

In this experiment was used Completely Randomized Design. Treatment is an inorganic compound with 5 levels (dose 0, 15, 20, 35, 50 g) and repeated 5 times. Observations are made every 3 days for 15 days. The observed responses were changes in root length (cm), leaf (mm), number of leaves (sheets/plants), new shoots (fruit), biomass (wet weight) and *Pistia stratiotes* ability to absorb nitrate and phosphate compounds in experimental media [11,12]. The experimental container uses a circular plastic jar. While the *Pistia stratiotes* test sample used was 7 g weight, which was cultured in water as much as 10 L/container and on the bottom of the container was given 200 g of soil substrate from the reservoir in public waters.

Data analysis

Data of measurement result of NO_3, PO_4, pH, temperature were analyzed descriptively. Daily growth rate calculator (LPH) *Pistia stratiotes* used the formula:

$$\alpha = \frac{Wt - Wo}{t}$$

Information:

α=Daily growth rate (g/day);

Wt=Final weight of *Pistia stratiotes* (g)

Wo=Initial weight of *Pistia stratiotes* (g)

t=Length of maintenance (days)

The ability of *Pistia stratiotes* in absorbing organic compounds is calculated using the formula:

$$\text{Rate P} = \frac{\text{Nutrient}_{early} - \text{Nutrient}_{end}}{T_{end} - T_{early}}$$

While analyzing the change of wet weight (biomass) using SPSS Ver.17 with a significance level α=1%.

RESULTS AND DISCUSSION

Pistia stratiotes water growth

Biomass increase: From the experimental results, it is known that the highest growth of wet weight of *Pistia stratiotes* occurred at 50 g treatment with the average of 18.8 g wet weight increase. At the 0 g treatment is known to be very slow growth with an average of 7.8 cm. The height of this wet weight growth is due to absorption of N and P elements from the culture medium so that it affects growth and is very good for the growth of *Pistia stratiotes*. Idris [38], the increase of biomass in aquatic plants can occur due to the presence of luxury consumption which is marked by the decrease of nutrients in the waters. Excessive Luxury consumption is a common response to water plants in accumulating N and P elements higher than normal and used for growth, as a form of food reserves to support its growth activity **(Table 1 and Figure 1)** [13].

Table 1. Wet growth of *Pistia stratiotes*.

Days	Treatment				
	P0	P15	P20	P35	P50
1	7	7	7	7	7
3	9	11.4	11.6	11.2	12.8
6	10	13.2	13.2	14.8	16.8
9	11.4	15	15.2	17.4	19.6
12	13.6	19.2	18.6	21.6	23
15	14.8	21.2	20.8	23.6	25.8
Total	7.8	14.2	13.8	16.6	18.8
Percentage (%)	111	203	197	237	269

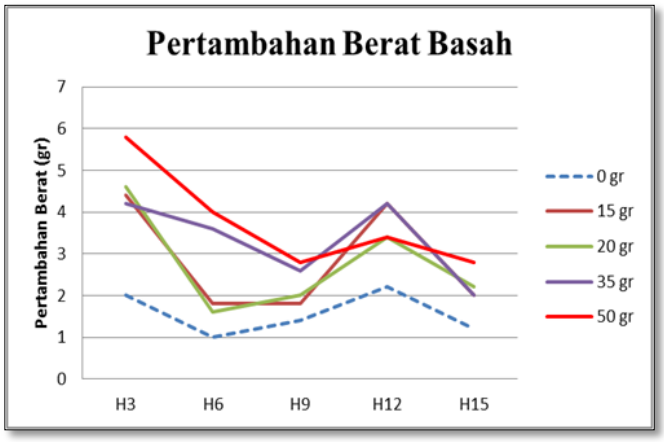

Figure 1. Wet weight gains of *Pistia stratiotes*.

Added new shoots: The result of the measurement of the new shoot increase is known to increase the most shots occur on the 15th day (5-12 shots) and at least occur on the 3rd day (1-2 shots). Many of its new buds are caused by growth activity as a result of the absorption of organic compounds present in the culture medium. While the small shoots are caused at the time of the 3rd day the plant is still adaptable and the energy obtained from organic compounds is still used for the growth of leaves and other organs and yet for shoot formation. Where the increase of inorganic compounds on the test medium tends to increase the new shoots in the *Pistia stratiotes* [14].

The highest number of shoots was found in the 50 g treatment with a shoot-increase range of 4-11 fruit/plants. The treatment of inorganic compound 0 g is the least shoot growth (0-4 fruits/plant), and this new shoot comes from stolen. A stolen is more formed on test media containing nutrients. Bey et al. [10], more stolen is formed on the test water which contains many nutrients (inorganic material) in high concentration so that the number of tillers produced more and more. The formation of saplings in the *Pistia stratiotes* plant comes from stolen.

Rijal [15] said that *Pistia stratiotes* are a plant that can breed not only generatively through pollination on flowers, but also vegetative. Breeding can be done because it is able to form stolen. The stolen can be cut off at the end and will be released and grow into a new individual. These aquatic plants can grow rapidly, as they can be done by generative and vegetative by using stolen so that with these abilities, plants can grow and can expand and form large colonies that can cover the entire surface of the waters available to them [16] **(Table 2 and Figure 2)**.

Table 2. The growth *Pistia stratiotes* of shoots number.

Treatment		Days					
		1	3	6	9	12	15
P0	Mean	0	0,8	1,4	2,2	3	3
	Range	0	1-2	2-4	2-4	2-4	2-4
P15	Mean	0	1,6	3	4,2	4,8	6,8
	Range	0	1-2	3-5	2-7	3-9	**5-12**
P20	Mean	0	1,4	3	4,2	5,8	7,6
	Range	0	1-2	2-5	3-8	3-10	3-10
P35	Mean	0	1,4	3,6	5,2	6,2	7,6
	Range	0	1-2	2-5	3-7	3-9	3-12
P50	Mean	0	1,4	3	4	5,6	7,8
	Range	0	1-2	2-4	3-6	3-8	4-11

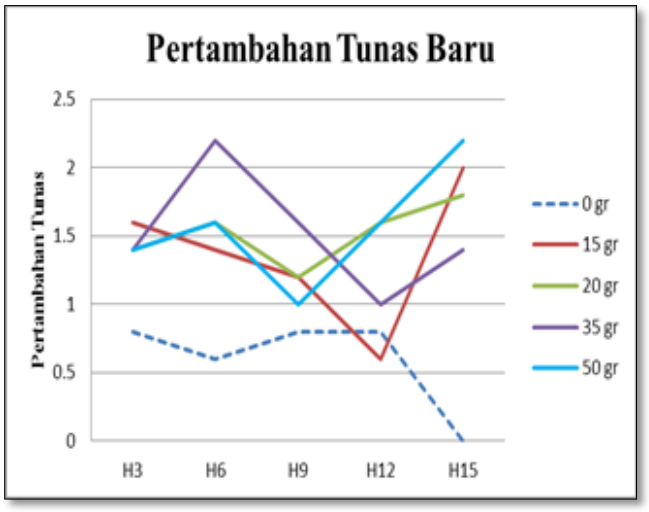

Figure 2. The growth of *Pistia stratiotes* of shoots number.

The growth of root length: The measurements on the longest root growth length of roots are 31.6 mm and the mean of 22 mm. This longest root addition is due to the ability of *Pistia stratiotes* to absorb the organic compounds optimally. While the shortest root growth occurs because in concentrations 20 and 35 the *Pistia stratiotes* cannot absorb organic compounds optimally. Sridhar [17] said that the tendency that increased doses of inorganic compounds on the test medium will prolong the growth of the *Pistia stratiotes* water roots. N nutrient elements will be absorbed through the roots first by the *Pistia stratiotes* water plant for the sake of growth [18].

At the 50 g treatment known to occur the largest growth of root length, with a total average growth of 13.2 cm. While the longest root length growth is on the treatment of 0 g inorganic compounds with a total growth rate of 10.4 cm. This can happen because the elements of nitrate and phosphate in the test medium affect root growth in plants. Sitrabio [19] said that the function of phosphorus (P) element for plants is for root growth, flowering, ripening fruit/seed/grain. The P element also serves for the preparation of cell nuclei, fats, and proteins. In addition, P element also serves to stimulate cell plant defense and enlarge cell tissue.

The treatment of inorganic compounds with a dose of 50 g has the longest root growth. This is caused by *Pistia stratiotes* water plants using N-nutrient elements in the test medium for root length growth. Walstad [20] explains that many N compounds in the waters will be able to accelerate the growth of roots but also can damage the plant because it can be toxic to the roots [21]. The *Pistia stratiotes* water plant utilizes the excess of N elements in test media for root growth **(Table 3 and Figure 3)**.

Table 3. The growth of *Pistia stratiotes* of root length.

Days	Treatment				
	P0	**P15**	**P20**	**P35**	**P50**
0	18.2	18.4	18.4	18.2	18.4
3	21.6	22.4	22	22.2	22.4
6	26	27.2	26	26	26
9	27	28.8	27.8	27.2	28
12	27.6	30.2	28.6	28.6	29.2
15	28.6	31.6	30.4	30.4	31.6
Total	10.4	13.2	12	12.2	13.2
Percentage (%)	57	72	65	67	72

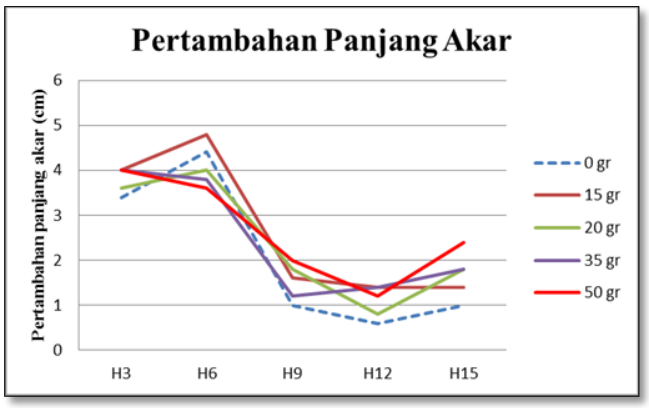

Figure 3. The growth of *Pistia stratiotes* of root length.

Increase in number of leaves: The highest number of leaves was found in the treatment of inorganic compound 35 g with a leaf range of 10-14 sheets/plant. While the least leaf growth was found in the treatment of 0 g with a leaf range of 11-13 sheets/plant. In the treatment of inorganic compound, 35 g is the highest leaf addition. This occurs because of the presence of excess nitrogen elements in the treatment of inorganic compounds 35 g. Sitrabio [19], nitrogen function for plants is for vegetative growth (to enlarge, enhance and green the leaves), nitrogen also serves to arrange chlorophyll and leaves [22]. Lack of nitrogen elements will cause the plant will experience slow growth/dwarf. The leaves will be yellowish-green, the size of the leaves narrow or small, and the leaves will quickly fall. Leaf number growth is one of the vegetative growth parameters for *Pistia stratiotes* [14].

Leaf growth is more likely to grow in high concentrations of inorganic compounds so that the number of leaves produced is also more numerous, but the number of leaves decreases with increasing dose of inorganic compounds on the test media, there has been a change of inorganic compounds into glutamine [23]. In the test medium, the ammonium changes into glutamine that takes place rapidly in the leaves will accelerate the formation of new leaves. The impact will be the number of leaves that many in a relatively short time **(Table 4 and Figure 4)**.

Table 4. Increasing number of leaves.

Treatment		Days					
		0	3	6	9	12	15
P0	Mean	5.4	7	9	10.4	11.6	12.4
	Range	5-6	6-8	9-12	9-12	11-12	11-13
P15	Mean	5.4	7.2	9.2	11.2	12	13
	Range	5-6	7-8	8-10	10-12	11-13	12-14
P20	Mean	5.4	6.4	8.2	10.2	11.6	13
	Range	5-6	6-7	7-10	9-12	10-12	12-14
P35	Mean	5.2	6	7.6	9.4	10.4	12
	Range	5-6	5-7	6-9	8-10	9-12	10-14
P50	Mean	5.2	6.8	8.4	10	10.8	12.2
	Range	5-6	6-7	7-9	9-12	9-13	10-14

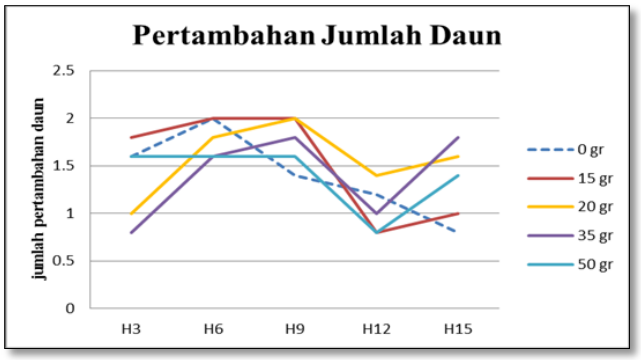

Figure 4. Number of leaf amount of *Pistia stratiotes*.

Leaf long growth: The long growth of leaves is seen from the increase of leaf length every 3 days for 15 days of research. The result of leaf length increases every 3 days is determined by the calculation of the initial leaf length less the length of leaf growth and then divided by the leaf length at 100%. Then, the largest increase in leaf length was found in the 15 g treatment with an increment percentage of 29.30% for 15 days of observation. While the smallest leaf length increase is in the treatment of inorganic compound 0 g with the percentage of leaf length increase of 19.31%. Based on observations known that inorganic compounds contained in the culture medium have affected the growth of *Pistia stratiotes* leaf length. N nutrients that are absorbed by water plants *Pistia stratiotes* more widely used to increase leaf length growth. The nitrates are nutrients needed by plants to grow and develop, while nitrate is a toxic compound that can kill water organisms [24]. The presence of nitrate in the waters is greatly influenced by industrial discharges, explosives, pyrolysis, and fertilization. Nitrate levels are typically low but nitrate levels can be very high in groundwater in nitrate/nitrogen fertilized areas.

From this experiment, it is known that leaf length growth is faster in giving the dosage of inorganic compound 15 g, but the higher the inorganic compound is given it inhibits the growth of leaf length (20 g, 35 g and 50 g). Fertilizers or inorganic compounds are given can only accelerating the growth of shoots, root length and wet weight in the *Pistia stratiotes* water plant **(Table 5 and Figure 5)**.

Table 5. Length of leaves (mm).

Days	Treatment				
	P0	**P15**	**P20**	**P35**	**P50**
0	31.2	29.7	30.3	29.1	32.6
3	32.5	32.1	32.3	31.1	34.1
6	34.5	35.9	34.9	33.9	37.6
9	36.2	38.7	38.2	36.3	40.2
12	37.6	40.5	39.6	37.7	41.2
15	38.7	42.1	41.2	39.8	42.9
Total	7.4	12.3	10.9	10.5	10.3
Percentage (%)	24	41	36	36	35

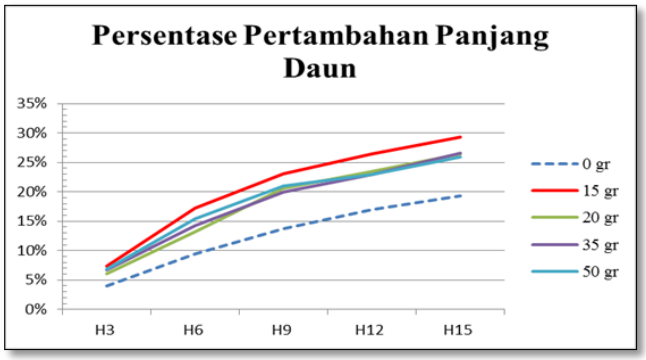

Figure 5. Percentage increase in the long leaves (%).

Daily growth rate: The percentage of daily growth of *Pistia stratiotes* on the treatment of several doses of inorganic compounds showed that the fastest daily growth occurred at 50 g treatment, with the growth of 18% per day. While at 0 g showed very slow growth (7.5% per day). Very slowly this growth is due to differences in the level of inorganic compounds given to the *Pistia stratiotes*. Besides environmental factors such as turbidity, temperature and availability of nutrients in the water can have an effect on water plants [25-27] **(Table 6 and Figure 6)**.

Table 6. Daily growth rate (g/days).

Measure	Treatment				
	P0	P15	P20	P35	P50
Daily length (g/days)	0.52	0.95	0.92	1.1	1.25
Percentage (%)	7.5	13.5	13.1	15.8	17.9

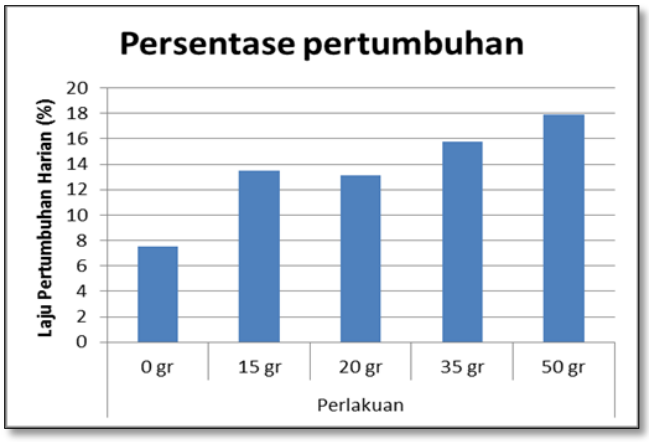

Figure 6. Daily growth rate in percentage (%).

Influence of inorganic compound growth on growth: Based on the result of variance analysis test with SPSS application ver.17, at 35 g and 50 g of the inorganic compound showed the very real difference (Ho: rejected, F count <F table). The accepted hypothesis is that alleged inorganic compounds dissolved in the culture medium affect the growth of *Pistia stratiotes*. The administration of inorganic compounds in *Pistia stratiotes* showed the very different effect on the treatment of 35 g and 50 g **(Figure 7)**.

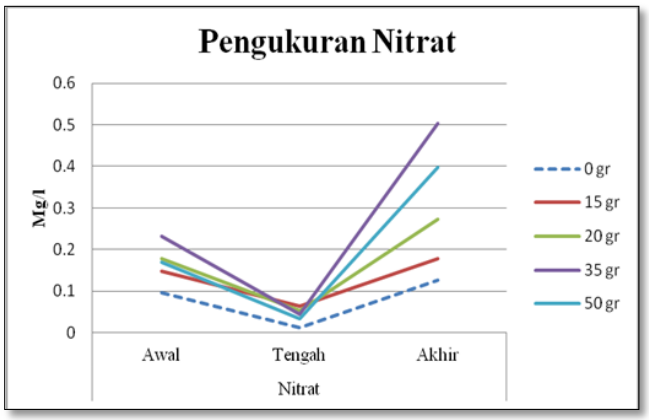

Figure 7. Measurement of nitrate content in test medium (mg/l).

Absorption of *Pistia stratiotes* water plant on nutrient elements (N and P): The most drastic *Pistia stratiotes* water absorption decreased to 7th day (middle), with N absorption (0.122 mg/L) and P (0.054 mg/L). After the 7th day until the 15th shows the elements of N and P increase again, because on observation day 9 and 12 shows the leaves of dead water plants and roots that fall into the bottom of the water. The leaves that fall to the bottom of these waters will become the envelope of nutrients in the culture medium. In addition, *Pistia stratiotes* also decreased in growth, ranging from growth of weight and root length because *Pistia stratiotes* have reached maximum absorption on the 7th day. Increased morphological size of *Pistia stratiotes* is due to its ability to absorb nutrients in the water medium used for its growth. Nutrients that are needed in sufficient quantities for plants are N and P. Other very important elements are K, Ca, Mg and S. This is possible because each plant has different capabilities to absorb and translocate nutrients [28]. In addition, each test plant has a maximum limit of nutrient absorption of different elements, so that when the nutrient absorption of plants to nutrients has reached the maximum limit, how much nutrients that exist in the planting medium, the plant will not absorb again [29].

Plants derive the ingredients necessary for growth through the roots by absorbing water from the surrounding environment by isotonic means. Roots also absorb minerals along with water absorption [30]. The transport of water and mineral salts is carried out by absorption by root cell cells, after passing through the root cells, which dissolves into the wood vessels (xylem) and then there will be vertical transport from root to stem to leaf, then taken to all parts of the plant by plant tissues, i.e., phloem [31].

Figure 8 shows that the more roots absorb the nutrients the darker the root color of the *Pistia stratiotes*. Dewi et al. [32], on root morphological observation, it is known that *Pistia stratiotes* roots begin to change color at the observation interval where the roots of plants are reddish or brown so that the petals are finally released from the stem. This happens because the root of *Pistia stratiotes* is part of the plant that first interacts directly with the water media, so the root organ will be quickly damaged compared to other organ parts of the plant in response to toxins from outside the plant body especially for aquatic plants [33]. In addition, the longer phytoremediation time also showed a change in the color of leaves that began to look yellowish green and in some plants appeared new shoots. Furthermore, Hall and Okali [34] said that leaf color changes to yellowish in some species can be caused by contamination of organic matter. The growth of new roots and buds may be the way plants survive [5] **(Table 7)**.

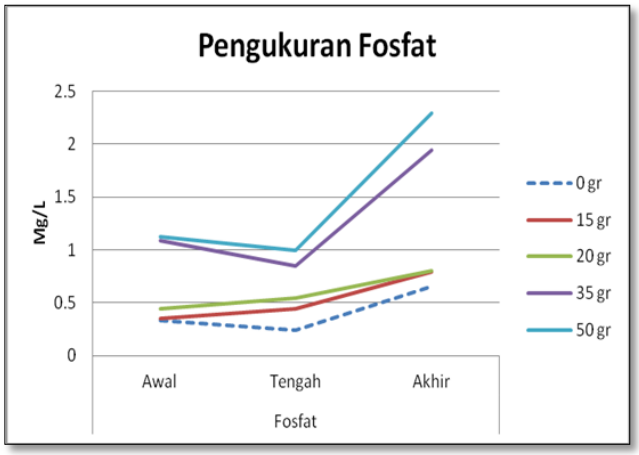

Figure 8. The measurement results on the phosphate content of the test medium.

Table 7. The decrease of nutrient elements (N and P).

Nutrient	Time	Treatment					Mean
		P0	P15	P20	P35	P50	
Nitrate	Early	0.0958	0.1479	0.1792	0.2313	0.1688	
	Middle	0.0125	0.0646	0.0542	0.0438	0.0333	
	End	0.1276	0.1792	0.2729	0.5021	0.3979	
	Decrease	0.0833	0.0833	0.1250	0.1875	0.1355	0.1229 (75%)
	Rate of Decline	0.0119	0.0119	0.0178	0.0267	0.0193	0.0176
Phosphate	Early	0.3319	0.3540	0.4425	1.0841	1.1261	
	Middle	0.2367	0.4403	0.5465	0.8473	0.9934	
	End	0.6546	0.7965	0.8031	1.9496	2.2898	
	Decrease	0.0952	0.0863	0.1040	0.2368	0.1327	0.0548 (20 %)
	Rate of Decline	0.0136	0.0123	0.0148	0.0338	0.0189	0.0078

Water quality in culture media: Measurement of supporting parameters such as temperature and pH is done to determine the environmental conditions that can support the growth of *Pistia stratiotes* water plants. Research results on water quality parameters can be seen in **Table 8**. Based on **Table 8** it can be seen that the increase of pH value at the end of observation is caused by photosynthesis of *Pistia stratiotes* water plants. Mara in Priyono [35], that in the process of photosynthesis intensive (daytime), free CO_2 in water will be used up. Under these conditions, bicarbonate (HCO_3) converts to CO_2 and ions of OH+ [36]. The dominance by these hydroxyl ions results in increased pH in the waters [37] **(Figure 9)**.

Table 8. Measurement of water quality in culture media.

Parameter	Time	Treatment				
		P0	P15	P20	P35	P50
Temperature	Early	29	29	29	29	29
	Middle	28	28	28	28	28
	End	28	28	28	28	28
pH	Early	6	6	6	6	6
	Middle	6	6	6	6	7
	End	6	6	7	7	7
Nitrate	Early	0.0958	0.1479	0.1792	0.2313	0.1688
	Middle	0.0125	0.0646	0.0542	0.0438	0.0333
	End	0.1276	0.1792	0.2729	0.5021	0.3979
Phosphate	Early	0.3319	0.3540	0.4425	1.0841	1.1261
	Middle	0.2367	0.4403	0.5465	0.8473	0.9934
	End	0.6546	0.7965	0.8031	1.9496	2.2898

Figure 9. Water roots plant water *Pistia stratiotes*.

The value of N and P analysis on the test media showed that on the 7th day there was a drastic decrease due to rapid absorption by the *Pistia stratiotes* water plants. Absorption of N and P is used for aquatic plants for the growth of these aquatic plants [3]. After the 7th day of N and P again rises due to the introduction of new organic matter from loose leaves. According to Idris [38], the presence of fluctuating nitrate in test media is a combination of dispersion by aquatic plants and the process of nitrification of ammonia and nitrite [39]. This is thought to occur because of the absorption of ammonia by low water plants and the ammonia undergoes a nitrification process that produces nitrate [40].

CONCLUSION

The growth of *Pistia stratiotes* in culture medium given inorganic compounds shows the growth of water plants biologically. The longest leaf growth and the fastest number of leaves occur in the treatment of inorganic compounds 15 g/10 L of water. In the treatment of inorganic compounds, 50 g/10 L can affect the weight gain of wet, root length, and new shoots. The fastest daily growth is in the 50 g treatment, with the growth of 18% per day. The result of SPSS ver.17 analysis showed that the effect was very different from the inorganic compound treatment of 35 g and 50 g/10 L water.

Pistia stratiotes were able to decrease N-nutrient N by 75% from initial nitrate and decrease of nutrient P by 20% up to day 7 (centre). After the 7th day the *Pistia stratiotes* aquatic plants must be removed from the waters, otherwise, the nutrients in the water will increase again due to the entry of nutrients from the *Pistia stratiotes* plant. Based on the research results, *Pistia stratiotes* showed nutrient absorption which is the result of decomposition of organic matter characterized by increasing biomass. Therefore, *Pistia stratiotes* water plants can be utilized as nutrient absorbent phytoremediation material (N and P) in the waters.

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