BIOENERGY POTENTIAL FROM OXIDATION DITCH ALGAE REACTOR ON THE UTILIZATION TO REDUCE MUNICIPAL DOMESTIC WASTEWATER

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ABSTRACT

The issue of fossil fuels scarcity encourage government to make the target that on 2025 there are 17% national energy requirements will be provided by the renewable energy which stated in UU No. 5/2006. Bioenergy, including energy from biomass is expected to meet 5% of renewable energy has been determined. Microalgae is one of the potential biomass expected to produce biodiesel because of the fast growth rate, high oil quality, and easily found in fresh water. The purpose of this study is to determine the potential of algae as a raw material to produce biodiesel. In this research, the species of algae used is Chlorella sp that bred in Oxidation Dicth sewage treatment using artificial wastewater and gray water from "Mawar" canteen in Islamic University of Indonesia. Then the algae were obtained from the breeding is extracted into oil using the solvent n-hexane as a catalyst. Furthermore, the oil derived from algae separated from the solvent n-hexane using water bath evaporator which uses the principle of evaporation by utilizing the boiling point of the solvent. lgae contained in waste treatment greywater can be used as raw material for biodiesel that produce algae oil 1,925 ml per 10 liters of water containing algae that developed during the 13-day period for algae cultivation in fat (lipid) and fatty acids (FAs) are is the main raw material of biodiesel maker, as well as the specialty of biodiesel derived from microalgae which can be updated (renewable), non-toxic, and biodegradable. The results obtained from the algae extraction is crude oil. This kind of oil can not be said as biodiesel, it has to take the further process to make the algae oil change into biodiesel.

Keywords: Microalgae, Greywater, Oxidation ditch, Bioenergy

1. INTRODUCTION

The scarcity of conventional fuels, the increasing of greenhouse gas emissions, also the high oil prices, are the series of issues that need to be solved by developing alternative biomass feedstock. The idea of utilization of the biomass has been widely promoted and reviewed a wide range of practitioners, scientists and stakeholders in the development of renewable energy. Similarly, in Indonesia, targets related science and technology development in the RPJMN 2010-2014 are food security and energy security. In a national research agenda, Indonesia has reserves of various energy sources, although not in large numbers. Priorities in the energy sector is the achievement of national energy security that ensures continuity of national growth through institutional restructuring and optimization of the utilization of alternative energy (National Research Agenda, 2010).

Microalgae as alternative sustainable energy development is one of the alternative sources of lipid raw materials. Microalgae has high photosynthesis efficiency to produce biomass, have a rate of productivity and rapid growth when compared to other crops that produce lipid, and also cultivation of microalgae do not require large tracts of land so it would not compete with food crops production. Microalgae also has the ability to fix CO_2 in the atmosphere or the carbon dissolved in the cell during the growth while simultaneously capturing the sun's energy with an efficiency of 10-50 times greater than the other terrestrial plants, which certainly is a golden opportunity to reduce the carbon (Ferrell & Reed, 2010; Brennan & Owende, 2010). Algae contain a high of vegetable oil, even some of them, have the oil content of more than 50% (Briggs, 2004). The content of vegetable oil identified fatty acid compounds which is large amount in algae (Cohen, 1999). In experiments conducted by Zuhdi (2003) with the raw material of palm oil and castor oil, fatty acid would processed into biodiesel. The more the content of fatty acid in the ingredients, the greater the biodiesel produced (Zuhdi, 2003).

The main purposes of this research are learning the process of making biofuel or biodiesel from algae in the processing of municipal greywater in oxidation ditch algae reactor and also studying the potential of biofuels or biodiesel from oxidation ditch algae reactor contain municipal greywater. The artificial wastewater will be made in this research. The parameter to be tested is oil content in algae. Additional variables such as Dissolved Oxygen (DO), temperature, pH, Mixed Liquor Susupended Solids (MLSS), temperature, and light will be considered.

2. METHODOLOGY

2.1. Make artificial wastewater in oxidation ditch reactor

The use of artificial wastewater has the purpose to obtain the characteristics of the waste that suitable with algae. The ways to make artificial wastewater is adding NPK fertilizer in water. The use of artificial wastewater is because of NPK and urea fertilizer have the content of three of macro nutrients N, P, and K but it also contains micro-nutrients CaO and MgO. The fifth element is very important for plant to growth, because basically algae are plants in the primitive biosphere so that have the basic charachteristics like algae in general.

2.2. Seeding and Acclimatization

Seeding has the purpose to obtain the desired concentration of algae for the research. Algae culture seeding results then going through a phase of acclimatization, which has aims to adjust the conditions of algae results of seeding with wastewater. Seeding and acclimatization have been done in the first stage in order to obtain algae that is ready to use in a reactor, so it aim to get the high concentration of chlorophyll-a. Seeding is done by adding sugar and NPK fertilizer. This sugar act as COD and NPK as nutrient content. Acclimatization is to align the algae with its original condition. The results of seeding and acclimatization can only be seen visually only, where at the initial seeding the sample color is light green. After a few days the color of the sample turns into dark green. It indicates that the algae grow quickly, so it will be ready to do the running.

2.3. Methods of sampling and sample preservation

It was conducted based on the method of sampling and preservation at SNI 06-2412-1991 about the sampling method of water quality.

2.4. Methods of algae classification

Before observation, prepare the microscope, pipette, glass and bottle sentifuce. Classification of phytoplankton is done is by using a pipette to take a 10 ml sample of water of algae and inserted in a tube sentrifuce, then rotated during 15 minutes at a speed of 2000 rpm. Furthermore, sediment in the bottom of the sentrifuce tube observed by drop it in the glass slide. The samples were observed with microscope with a magnification of 1600 times. The result of observation is the fitoplaktons are the most dominant type in the sample.

2.5. Methods of MLSS / MLVSS

It refers to SNI 06-6989.3-2004 about testing the total suspended solids Total Suspended Solid (TSS) by gravimetry.

2.6. Methods of Chlorophyll-a

The reference used is the SNI 06-4157-1996 about testing levels of phytoplankton chlorophyll-a in the water with a spectrophotometer. The formula for calculating the concentration of chlorophyll-a phytoplankton is:

$$\text{Chlorophyll-a} = \frac{(26{,}7\ (A-B) \times Ve)}{Vs \times L}\ \text{mg/ m}^3$$

Number of 26.7 = Correct constant uptake entry
A = Difference in optical density before acidification
B = Difference in optical density after acidification
Ve = volume of test objects (l)
Vs = Volume of the sample (m^3)
L = Transparent part or cuvette width (cm)

2.7. Methods of oil testing

It refers to the SNI 6989.10:2011 about the test of vegetable oil and mineral gravimetrically. Where after biomass is harvested by the filter method, centrifugation, and flocculation, then dried. The commonly extraction are using solvent extraction with hexane, ethanol or a mixture of hexane-ethanol. Extraction of algae oil can be taken by using ether benzene and hexane, then separated using the principle of evaporation.

3. RESULTS AND DISCUSSION

3.1. Analysis of Chlorophyll-a in Algae

Chlorophyll-a is the most common pigment contained in phytoplankton so that the phytoplankton concentration is often expressed as the concentration of chlorophyll-a (Parsons et al, 1984). On the Chlorophyll-a testing, it performed using Spectrophotometer Double Beam where maximum light absorption of chlorophyll-a at the range of 430 nm to 662 nm. The test results of each type of waste for 13 days is in Table 4.1 below.

Table 3.1 Result data of Chlorophyll-a

Days	*Grey Water* (mg/L)	Artificial Wastewater (mg/L)
0	0,10	0,48
1	0,16	0,51
4	0,21	0,64
7	0,35	0,77
10	0,41	0,96
13	0,59	1,03

From the table above, the value of chlorophyll contained in the greywater day 0 is 0.10 mg/l and increased steadily in each test day up to day 13 is 0,59 mg/l. It also happens to artificial waste where on day 0 is 0,48 mg/l rise each day of testing up to day 13 is 1,03 mg/l. Differences of enhancement in the greywater is slower than in the artificial waste, it can be occurs because the nurtient of artificial waste is a mixture of urea and NPK, while in the grey water nutrient is from food that comes from residual waste in "Mawar" canteen Islamic University of Indonesia.

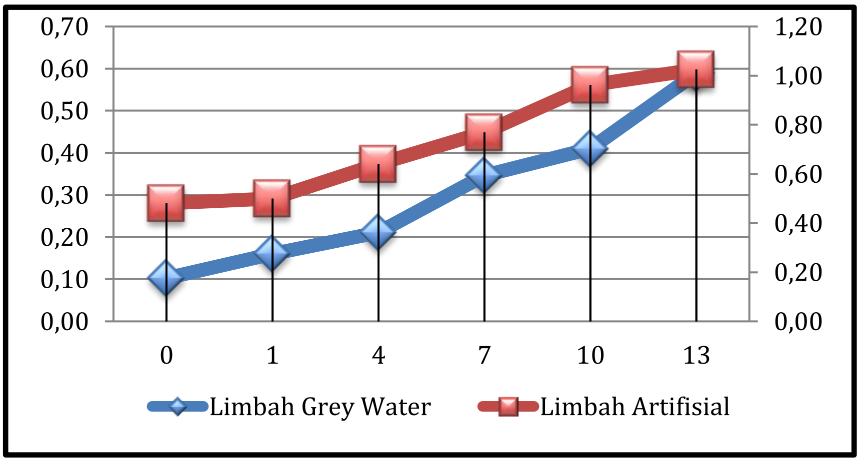

Figure 3.1 Difference of chlorophyll-a concentration of greywater and artificial waste

3.2. TSS Analysis

In the analysis of TSS or Total Suspended Solids is done using methods Gravimetry which aims to determine the concentration of microorganisms in the wastewater algae either artificially or gray water so that the comparison of the biomass and algae in the reactor in a test. From the analysis of this TSS concentration obtained indicate the number of biomass in the waste water where the higher the number, the higher biomass alganya amount contained in waste water. As a result the following are the results obtained from the analysis of the concentration TSS in Table 4.2, which comes from both the waste.

Table 3.2 Result data of TSS

MLSS	*Greywater (Mg/L)*	Artificial waste (Mg/L)
0	75	188
1	89	201
4	110	308
7	186	397
10	162	415
13	277	493

The increase of TSS numbers both wastewater from day 0 to day 13 are 369.33% on greywater and 262.23% on artificial wastewater. On day 0, greywater TSS enhancement on the day 13, but on the day 10 the value TSS decreased because of the algae concentration decreased, therefore it has to add nutrients so that algae can grow optimally. In contrast to artificial wastewater, the rate of algae growth is more regular. The difference between these two type of wastewater is nutrient contained in those wastewater. The difference of TSS value from both the wastewater are shown in the figure below.

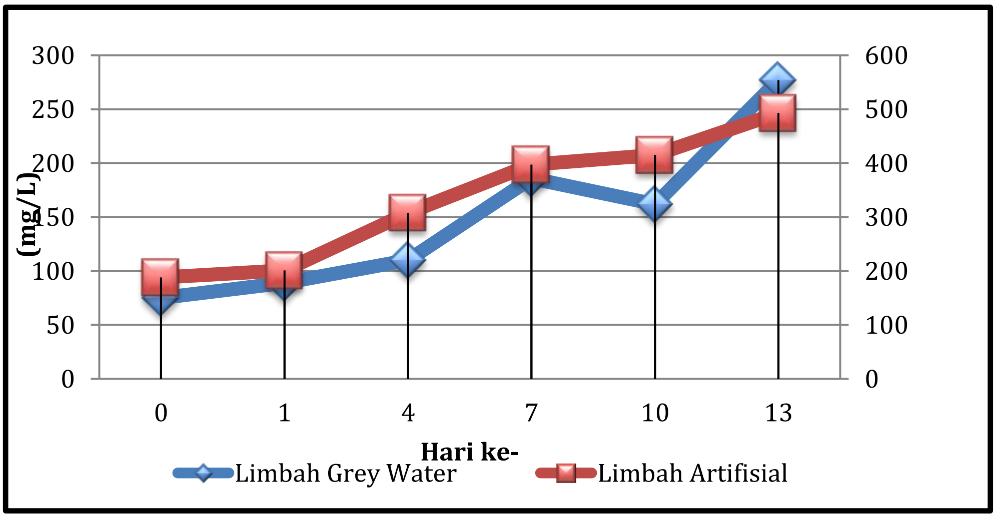

Figure 3.2 Difference of TSS of greywater and artificial waste

3.3. Correlation of TSS towards Chlorophyll-a

Conditions TSS concentration in the reactor is influenced by the rate of growth and concentration of algae in wastewater. It can also be seen from the concentration of chlorophyll-a who has been in testing. The TSS correlation to chlorophyll-a levels can be seen with the abundance of algae, which in high phytoplankton abundance in the reactor to produce TSS more than phytoplankton abundance is lower. This happens because the more green algae colour in the reactor, the greater the production TSS tested in the reactor. Also those two analysis are influenced by the presence of nutrients contained in each wastewater at the reactor.

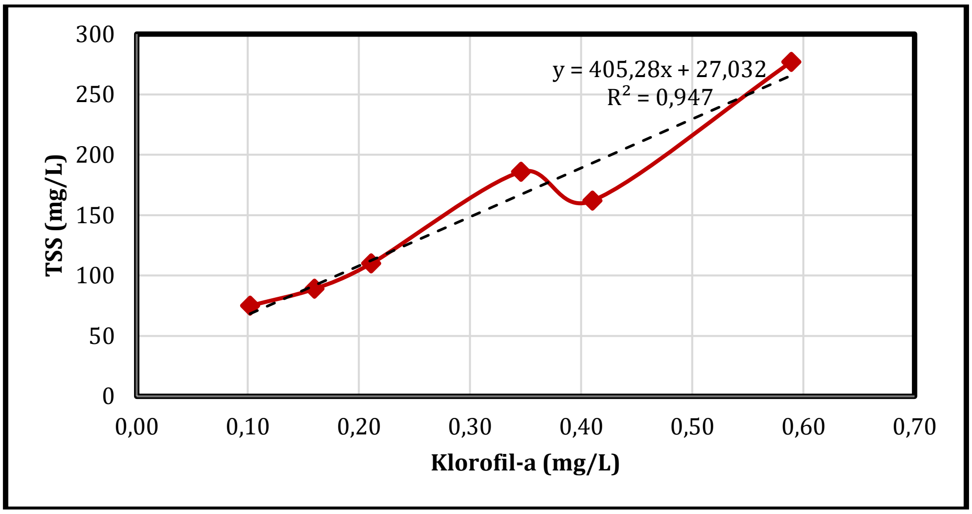

Figure 3.3 Correlation of TSS towards Chlorophyll-a with greywater

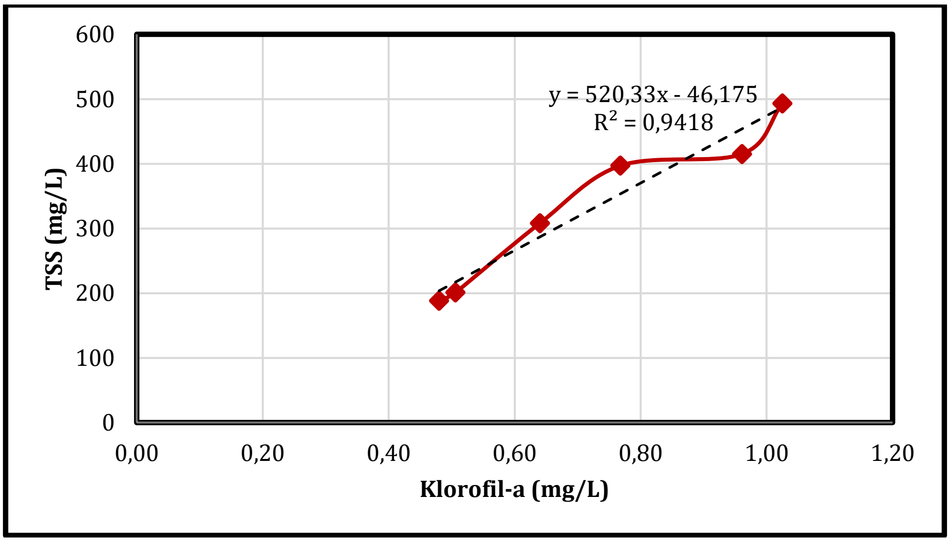

Figure 3.4 Correlation of TSS towards Chlorophyll-a with artificial wastewater

Correlations also can be calculated as shown in two table below. Correlation between TSS and Chlorophyll-a in greywater and in artificial wastewater respectively 0,973163826 and 0,970472738. The positive sign mean that there is a positive correlation between the results of the analysis. Figures contained in this calculation shows that the higher concentration of chlorophyll-a, the greater also TSS in the reactor.

Table 3.3 Correlation between TSS and Chlorophyll-a in greywater

	MLSS/MLVSS (mg/L) X	**Chlorophyll-a (mg/L) Y**
MLSS/MLVSS (mg/L) X	1	
Chlorophyll-a (mg/L)Y	0,973163826	1

Table 3.4 Correlation between MLSS/MLVSS and Chlorophyll-a in artificial wastewater

	MLSS/MLVSS (mg/L) X	**Chlorophyll-a (mg/L) Y**
MLSS/MLVSS (mg/L) X	1	
Chlorophyll-a (mg/L)Y	0,970472738	1

3.4. Extraction Algae Oil

Microalgae can be utilized as an alternative biofuel because it contains high amount of carbohydrates and lipids. The processes are pressing or microalgae extraction that cultivated during 13 days and then harvested. After that microalgae separated from water, then do the extraction process to get oil contained in algae. The extraction process is done using a set of soxhlet and n-hexane solvent. This process is carried out for approximately 5-6 hours to get maximum results from microalgae (Dayananda et al., 2006). Extraction result still contain a mix of crude oil with n-hexane, they should be separated using a rotary evaporator and a water bath with a temperature of 700 C. Rotary vacuum evaporator is an instrument that uses the principle of distillation.

Table 3.5 Result of crude oil extraction from algae

No	Day	Number of Crude Oil (gram)	Number of Crude Oil (ml)
1	0 (pure algae)	1,84	2
2	1	0,792	0,86
3	8	1,392	1,513
4	13	1,771	1,925

In table above, it can be seen that an numbers of crude oil in algae increased. It is influenced by the amount of algae present in wastewater.

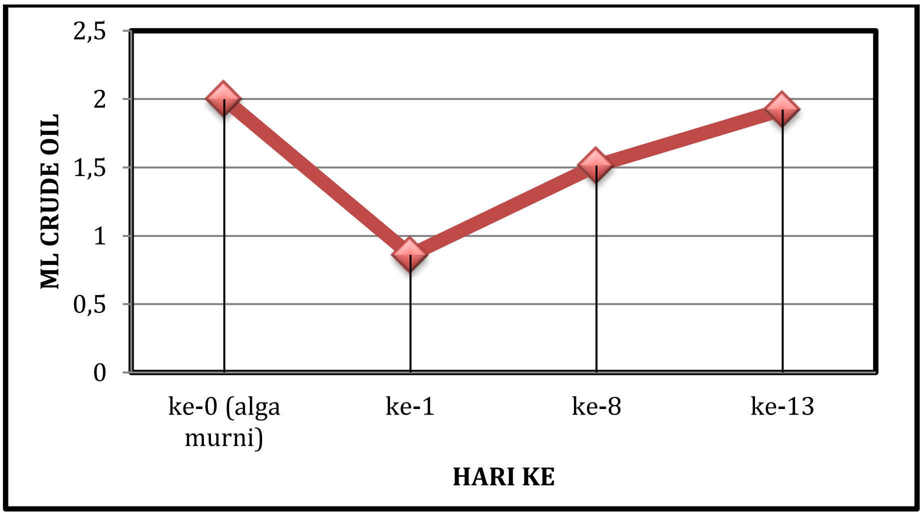

Figure 3.5 Result of crude oil extraction from algae

3.5. Potential of Algae Oil

After getting the results of crude oil, then continue with esterification and transesterification. It is the process changes into methyl ester with alcohol compound. In addition to the extraction process with n-hexane, the extraction process can also be carried out with chloroform-methanol-water {1:1:0.9, v/v/v] before doing transesterification (Dunstan ef al, 1992). From that process, it can produce the biodiesel which can be added to diesel fuel.

Table 3.6 Result of previous research by Rachmaniah et.al (2010)

Component	Analysis result of Chlorrela sp	
	Wet	Dry
Oil	4,24 ml	17,18 ml
Water	71,8 ml	N.A
Others	23,48 ml	N.A

N.A : Not Analyzed

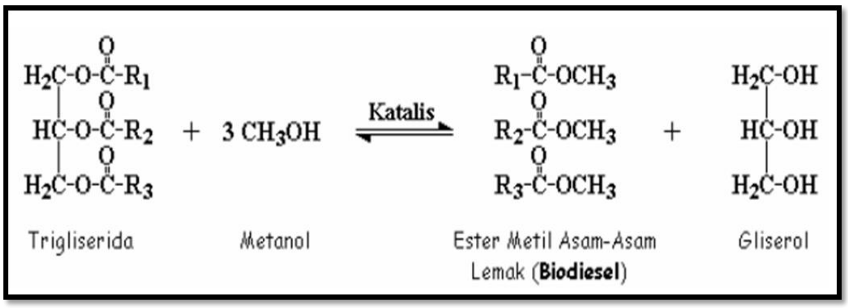

Figure 3.6 Transesterification Process

3.6. Correlation Algae Oil towards Chlorophyll-a

Conditions of chlorophyll-a concentration in the reactor is influenced by the rate of growth and concentration of algae in wastewater. It is also affect the result of the algae oil extraction that has been in testing. The correlation of chlorophyll-a towards the extraction of algae oil can be seen with the level of abundance of algae, where in high phytoplankton abundance in the reactor will produce more chlorophyll-a than the lower abundance of phytoplankton. This happens because the more green algae in the reactor, the greater of production of chlorophyll-a as well as the extraction of algae oil. Those two results are influenced by the presence of nutrients contained in each wastewater at the reactor. The correlation of both of that can be seen in figure below.

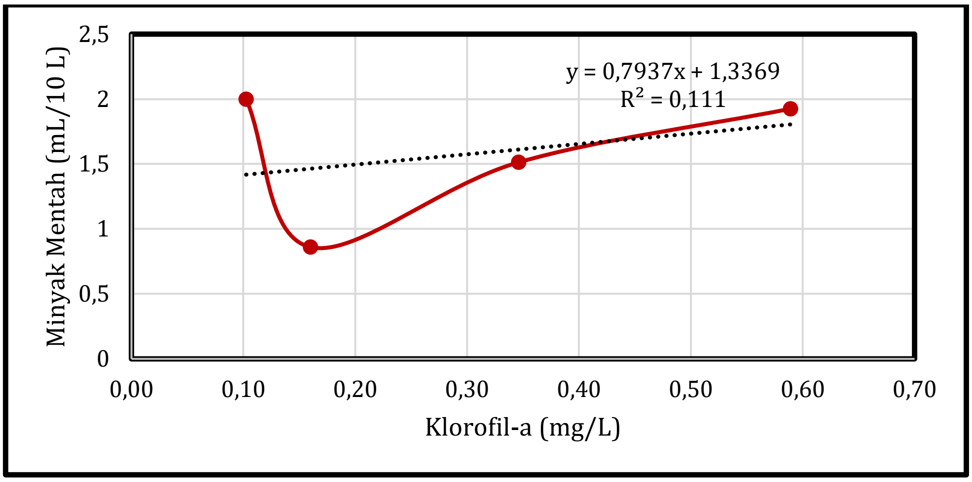

Figure 3.7 Correlation of chlorophyll-a towards algae oil extraction with greywater

The correlation can be calculated as shown in table 3.7 below which shows the correlation between chlorophyll-a and oil. The numbers contained in this calculation shows the relationship of the concentration of chlorophyll-a, which the greater of chlorophyll-a concentration so the higher result of algae oil extraction.

Tabel 3.7 Correlation between TSS and Algae Oil

	MLSS/MLVSS (mg/L) X	Algae Oil (mg/L) Y
Chlorophyll-a (mg/L) X	1	
Algae Oil (ml/L) Y	0,292741597	1

4. CONCLUSIONS

From this research, it can be conclude that algae contained in wastewater treatment is have a huge potential to be biodiesel feedstock. Also, algae contained in the wastewater treatment can be made as a biofuel raw materials that produce algae oil 1,925 ml or 0,0129% per 10 liters of water containing algae during 13 days because it contain lipid and fatty acids. Biodiesel derived from microalgae have the advantages including renewable, non-toxic, and biodegradable. Oil content contained in algae is strongly influenced by the amount of nutrients contained in wastewater and it proved by correlation between the concentration of chlorophyll-a and MLVSS influenced by nutrients with oil produced from algae.

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