JPPIPA 8(3) (2022)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Utilization of Livestock Dung as A Biogas Starter from Water Hyacinth to Suppress Water Weeds

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DOI: 10.29303/jppipa.v8i3.1632

Article Info
Received: May 10, 2022
Revised: July 11, 2022
Accepted: July 20, 2022
Published: July 31, 2022

Abstract: Animal manure and water hyacinth will become waste in the environment if not utilized. One form of utilization of both is to make it as raw material for biogas. The aims of this study were: to determine the effect of the type of manure on the process of forming biogas from water hyacinth, which is related to: 1) the speed of biogas formation, 2) the temperature of the *slurry*, 3) the pH of the *slurry*, and 4) the volume of biogas produced. This study was designed with a completely randomized design (CRD), consisting of five (5) treatments, namely Treatment 1 (P_1) cow dung + water hyacinth + water, (P_2) buffalo dung + water hyacinth + water, (P_3) manure goat + water hyacinth + water, (P_4) horse manure + water hyacinth + water, and (P_5) broiler chicken manure + water hyacinth + water. Each treatment was repeated 4 times to obtain 20 experimental units. In this study, the composition of the mixture of raw materials was used as follows: 8 kg of chopped water hyacinth (2 cm) + 3 kg of animal dung + 2 liters of water. This is based on the results of research by Sari *et al*. (2014) which showed that the composition was good enough to produce biogas made from water hyacinth. The composition of the raw material mixture is as follows: 8 kg of chopped water hyacinth (2 cm) + 3 kg of animal dung + 2 liters of water. The variables observed in this study were: the rate of gas formation, slurry pH, slurry temperature, and the volume of gas produced. The research was conducted at the Biology Science Education Laboratory, Faculty of Tarbiyah and Teacher Training, UIN Mataram. The time of research was carried out from March to October 2018. The results showed that the type of manure only had a significant effect on the amount of biogas formed, but did not significantly affect the time of gas formation, *slurry pH, and slurry* temperature. Thus, the five types of manure can be used as a starter in the manufacture of biogas made from water hyacinth.

Keywords: Manure; Biogas; Water Hyacinth

Citation: Jayadi, E. M., & Nurrahmah, N. (2022). The Utilization of Livestock Dung as A Biogas Starter from Water Hyacinth to Suppress Water Weeds. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1286–1293. https://doi.org/10.29303/jppipa.v8i3.1632

Introduction

Batujai Dam is one of the prides of the people of Kota Praya and its surroundings. The dam, which is located between Kota Praya (the capital of Central Lombok Regency, NTB) and Penujak District, was inaugurated in 1982. The main function of this dam is to irrigate agricultural land which was previously a rainfed area. According to Cendana News, the Batujai Dam is capable of irrigating 3,500 hectares of land and agricultural crops, which includes 5 villages, namely: Batujai Village, Gelondong Village, Wage Village, Penujak Village and Tanak Awu Village (Kristiawan, 2019; Miftayugi et al., 2022). Another function, which is no less important than this dam, is to maintain the ground water level, a place for freshwater fish cultivation, and as a place for recreation.

One of the serious problems faced by the Batujai Dam to date is the occurrence of siltation due to the sidementation process. Based on data released by the

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Dam Center of the Ministry of PUPR, it is known that the capacity of the Batujai Dam, which was originally 25 million cubic meters when it was initially built in 1982, has now decreased drastically to 17 million cubic meters, even in the dry season it is only 5 million cubic meters (BWS NTB, 2020). The main cause is silting due to sidementation piles and the presence of water weeds whose development is very massive, namely water hyacinth. A report from Antaranews.com stated that the current depth of the dam has been reduced from 16 meters, when it was operational in the early 1980s, to 6 meters, and almost 35% of the inundation area is covered by the water hyacinth population (Ekaputra & Ekaputra, 2004)

Water hyacinth is a type of aquatic plant that develops very quickly, so it is classified as an invasive weed that can affect biodiversity and human health (Ilo et al., 2021). Evidence of its rapid breeding ability is as reported by (Banerjee, 2013; Njogu et al., 2015) that under favorable conditions, water hyacinth can reach a growth rate of 17.5 metric tons per hectare per day. Craft et al., (2003); Parolin et al., (2012) also reported that water hyacinth does have extreme growth, which is capable of producing 2 tons of biomass per acre (0.4 hectares) and the population can be doubled in a relatively short period of time, namely 5-15 days.

Auchterlonie et al., (2021); Chen et al., (2010) said that water hyacinth is an aquatic plant native to the Amazon that currently spreads almost all over the world, from North America, Europe, Asia, Australia, Africa, to New Zealand. In Indonesia, according to Tjondronegoro & Pantjawarni, (1999) this plant becomes a weed in natural lakes and artificial lakes. The spread, starting from Sumatra, Java, Kalimantan, Nusa Tenggara, to Irian Jaya.

The negative impact of the presence of water hyacinth in a dam (reservoir), is not only limited to the silting process due to sidementation, but will also cause other negative impacts. These impacts include: clogging irrigation canals, increasing water loss through the process of evapotranspiration, making water transportation difficult, and reducing fishery yields, as well as reducing the aesthetic value of the aquatic environment. Enyew et al., (2020); Villamagna & Murphy, (2010) reports that water hyacinth is reported as an ecologically dangerous invasive weed

Given the huge negative impact, real efforts are needed to suppress the water hyacinth population as well as to conserve the aquatic environment on this aquatic weed on an ongoing basis. There are various studies that have been carried out to utilize water hyacinth in order to achieve the intended goal, for example through mechanical efforts, including: making it a medium for plant growth (Sittadewi, 2007; Wardani & Widiana, 2018), poultry feed (Lu et al., 2008), composting (Wardani & Widiana, 2018), and biogas raw materials (Bhattacharya & Kumar, 2010; Laili, 2016; Yonathan et al., 2012). In addition to these mechanical efforts, there are also several control measures using biological weed control agents, for example: the use of the grasshopper *Cornops aquaticum* in South Africa (Oberholzer & Hill, 2001), the predatory beetle *Neochetina* spp., in Lake Victoria, Kenya (Ochiel et al., 2001), also beetles of the *Neochetina eichhorniae* and *N. bruchi species* in Wenzhou, China (Julien et al., 2001). Although various efforts have been made, the presence of water hyacinth remains difficult to control.

Indeed, the existence of water hyacinth in the waters has its own important value related to the sustainability of aquatic ecosystems, namely as a producer. In addition, Ghosh et al., (1982) also stated that water hyacinth has a higher hemicellulose content compared to other organic compounds, so it has great potential to be used as an alternative energy source. Kristiawan, (2019; Prabawa & Nurmilatina, (2017) reported that dry water hyacinth contains 64.51% cellulose, 15.61% pentose, 7.69% lignin, 5.56% silica and 12% ash. Meanwhile, the results of the chemical analysis of fresh water hyacinth conducted by (Ratri et al., 2020) showed the following compositions: 36.59% organic matter, 21.23% organic C, 0.28% total N, 0.0011% total P and 0.016% total K.

Like water hyacinth, livestock manure is also a waste that will pollute the environment if not handled properly. Some of them can even be a source of disease that can endanger human health. Supar & Tati, (2005) mention several types of diseases that endanger human health due to microbial contamination from livestock manure and processed food from livestock, including anthrax, salmonellosis, brucellosis, tuberculosis, clostridiosis, and diseases caused by Staphylococcus aureus contamination.

From various studies that have been carried out previously, one of the practical efforts that have the potential to be developed, especially around the Batujai Dam area is to use both as biogas raw materials. This is because water hyacinth has a relatively high cellulose content, relatively fast population growth, and is easy to obtain, also in accordance with the government's commitment which is currently actively promoting the development of potential new and renewable energy resources (EBT) which is the application of the program. *Green Economy*. Another reason is the availability of livestock manure, as *a starter*, which is a local raw material, which is also relatively available in the Central Lombok region, especially in the Batujai Dam area. However, it is possible that not all livestock manure has the potential to be used as *a starter* because the composition of the chemical content is different.

The purpose of this study was to determine the effect of the type of manure on the process of forming biogas from water hyacinth, which is related to: 1) the speed of biogas formation, 2) the temperature of the *slurry* , 3) the pH of the *slurry* , and 4) the volume of biogas produced.

Method

Location and Time of Research

The research was conducted at the Biology Science Education Laboratory, Faculty of Tarbiyah and Teacher Training, UIN Mataram. The time of the research was carried out from March to October 2018.

Population and Sample

The population in this study were all water hyacinth and livestock manure around the Batujai Dam. Meanwhile, the sample referred to in this study is a number of water hyacinth and livestock manure used in 20 biogas reactors.

Experimental Design

This study was designed with a completely randomized design (CRD), consisting of five (5) treatments, namely Treatment 1 (P_1) cow dung + water hyacinth + water, (P_2) buffalo dung + water hyacinth + water, (P_3) manure goat + water hyacinth + water, (P_4) horse manure + water hyacinth + water, and (P_5) broiler chicken manure + water hyacinth + water. Each treatment was repeated 4 times to obtain 20 experimental units. In this study, the composition of the mixture of raw materials was used as follows: 8 kg of chopped water hyacinth (2 cm) +3 kg of animal dung +2 liters of water. This is based on the results of research by Sari, (2014) which showed that the composition was good enough to produce biogas made from water hyacinth.

Research Variables

There are 3 variables observed in this study, namely: the rate of gas formation, slurry pH, slurry temperature, and the volume of gas produced.

a. Gas Formation Speed: is the time required for gas formation, which is calculated in hours. Observations were made since the biogas installation series was activated until the initial gas formation.
b. pH: is the degree of acidity of the mixture of materials used (*slurry*) in the biogas reactor. Measurements were carried out 2 times, namely: day 0, and day 30.
c. Temperature. Observations were made twice, namely the first day, and the 30th day, using a pH meter.
d. Volume of gas produced: is the amount of gas produced in one cycle of biogas production, and carried out on day 30. Observations were made using a *pressure gauge.*

Data Collection Method

There are two data collection techniques used in this study, namely observation and documentation. Observation techniques were used to observe/measure the research parameters, namely: speed of biogas formation, volume of biogas formed, and *slurry pH*; while the documentation technique is used to obtain information related to the condition of the Batujai Dam, and livestock waste around the research site.

Data Analysis Method

Observational data will be analyzed by *Analysis of Variance* (ANOVA) at a significance level of 5% using *the SPSS program*. If there is a significant difference between treatments (F count > F table 5%), a further test will be carried out with BNT at the same significant level.

Data Validity Test

Before analyzing the data, the validity of the data was first tested, in this case the data normality test. The aim is to ensure that the data are normally distributed (as a condition of the ANOVA test); with the SPSS program using the *Shapiro-Wilk formula*

Result and Discussion

When Gas is Formed

Observation of the time of biogas formation is intended to determine which of the five treatments produces biogas the fastest. Observations started from the first day.

The results showed that the fastest time for biogas formation was the treatment with horse manure (P4), which was on the 2nd day, while the longest time was treatment with buffalo dung (P3) and chicken manure (P5), i.e. the third day. 6 days (Figure 1). Each treatment requires a different length of time to start forming biogas. In general, the average time required to start gas formation is on day 4.

Although the time of gas formation varied between treatments, the results of data analysis showed that there was no significant difference between treatments. This means that the type of manure has no significant effect on the formation of biogas. Thus, the five types of manure can be used as a starter in the formation of biogas made from water hyacinth.

The optimum depends on the temperature and duration of the digestion process. For water hyacinth, for example, at a temperature of 30-35^{0}C, optimum CH_4 production occurs on day 5 or day 7, depending on the volume of water hyacinth used as bait. After the 8th day, the production of CH_4 gas will decrease.

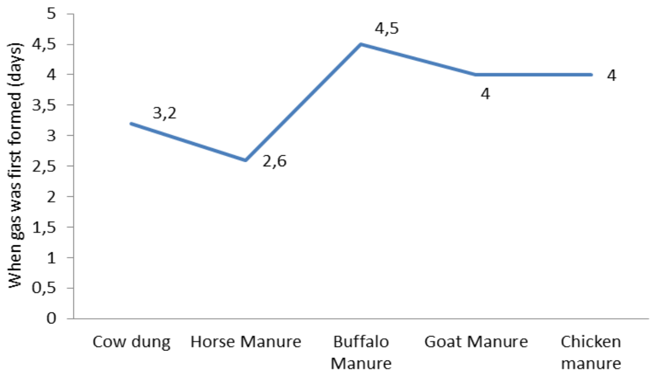

Figure 1. When biogas is formed (days)

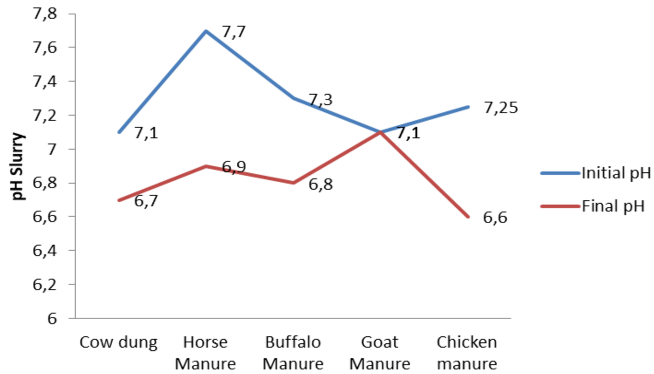

Figure 2. Initial temperature and final temperature of treatment

The temperature in the digester in this study ranged from 27.25 - 27.75 ° C, so it is relatively lower when compared to the optimum temperature for the formation of CH_4 gas made from water hyacinth, as stated by Mulyati (2015), which is 30-35 ° C. CH4 gas has started to form from day 2 to day 6. This indicates that the five types of manure used as treatment are able to work normally as a starter in accelerating the decomposition process of organic matter even though the temperature is still below optimum conditions.

pH of slurry

The pH of the slurry analyzed was the final pH. The initial pH is only used to ensure that the slurry pH is in accordance with the pH required by anaerobic microorganisms to carry out fermentation. Observational data showed that the pH range of the five types of manure was between 7.13 - 7.7. The lowest pH was found in cow dung (7.13), and the highest pH was in horse manure (7.7) (Figure 2). If referring to the results of previous studies, that the whole anaerobic process occurs at a pH between 5.5-8.5 Luden, (2003) and a pH range of 6-8 Budiyono, (2013) then this initial pH range is still in accordance with the conditions pH required by anaerobic microorganisms to carry out fermentation. Thus, the fermentation process to produce biogas will be able to take place normally with this initial pH range. Further, Budiyono, (2013) stated that the pH in the reactor does not have to be tightly controlled, even though the methane-forming bacteria are very sensitive to pH.

In the final pH observation, the five types of animal manure used, all decreased. The lowest pH of the slurry was in the treatment with chicken manure (6.59), while the highest pH was in the treatment with goat manure (7.09). Although there was a difference in the final pH, the results of the data analysis showed that the five treatments were not significantly different. Thus, these five types of animal manure can be used as a starter in the process of making biogas.

From the pH range owned by the five treatments, it shows that there is no pH that is too extreme, because it is still close to neutral, which is in the range of 6.59-7.09. This range is not too far from the optimum pH range required by methane-producing bacteria for fermentation, which is between 6.8-7.2 (Rajeshwari et al., 2000). Luden, (2003) even stated that the optimum pH range was higher, which was between 7.2-8.2.

Based on the pH range produced by the 5 types of animal manure which is still within the optimum range, it proves that the five of them do not experience obstacles to produce biogas when used as a mixture of water hyacinth, because they are still within the limits of the range that can be tolerated.

The pH factor plays a very important role in anaerobic decomposition because at an inappropriate pH range, microbes cannot grow optimally and can even cause death. In the end, this condition can inhibit the recovery of methane gas. The optimum degree of acidity for microorganism life is 6.8-7.8 (Simamora et al, 2006). However, especially for methane-producing bacteria, the optimum pH range is close to neutral, which is between 6.8-7.2 (Rajeshwari et al., 2000).

The degree of acidity (pH) of a good digester is in the range of 7-8.5. Meanwhile, the degree of acidity in most bio-materials is in the range of 5-9. In the fresh water hyacinth bio material, it generally has a pH of 7.7. Then after being put into the digester and mixed with water, the acidity drops to 6.58.

The results of research by Jonathan *et al*. (2013) showed that biogas can be formed at pH 5.0, and the closer to pH 7.0, the more significant the increase. However, if it reaches pH 8.0, the amount of biogas formed will decrease. At neutral pH, the activity of methane bacteria will be more optimal so that the amount of biogas formed is maximized. On the other hand, the further away from neutral pH (either decreasing or increasing), the activity of methane bacteria will decrease, which results in a decrease in the amount of biogas produced.

Slurry Temperature

The results of observations of the initial temperature showed that the temperature ranged from 27.25 - 27.75 ° C. The lowest temperature (27.25 ° C) was in the slurry treated with chicken, goat, and smelly manure; while the highest slurry was 27.75 ° C in horse manure. In the final temperature observations, there was a decrease in temperature in the slurry of cattle, horses, and chickens; while the goat and buffalo slurry were the same as the initial temperature (Figure 3).

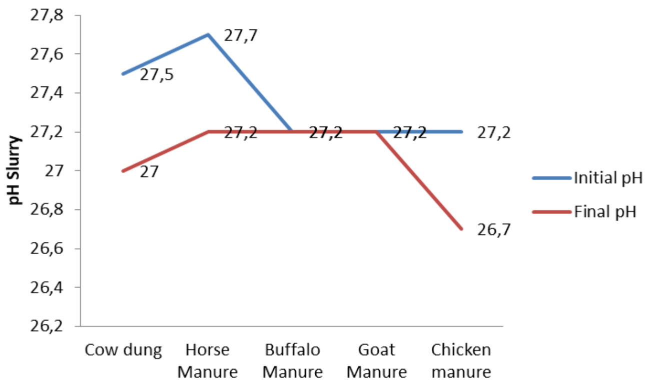

Figure 3. Initial temperature and final temperature in the five treatments

The results of data analysis showed that there were no significant differences between the initial and final temperatures. This means that the type of animal manure used has no effect on changes in temperature during the study.

The rate of formation of CH_4 gas in a biogas reactor is strongly influenced by temperature. This temperature will be related to the ability of the bacteria in the reactor. Psyhrophilic bacteria 0 - 7^{0}C, mesophilic bacteria at a temperature of 13–40^{0}C while thermophilic bacteria at a temperature of 55-60^{0}C (Luden, 2003). The optimal temperature for the digester is in the range of 30-35^{0}C This temperature range combines the best conditions for bacterial growth and methane production in the digester with a short processing time.The same mass of material is digested twice as fast at 35^{0}C than at 15^{0}C and produces nearly 15 times more gas at The process time is the same (Anggraeni et al., 2013). So, the process temperature needs to be maintained with a maximum threshold of 35^{0}C, so that it doesn't evaporate a lot so that anaerobic bacteria can live during the biogas formation process.

If it is related to the temperature requirement for methanogenic bacteria , both the initial temperature (27.25 - 27.75^{0}C) and the final temperature (26.75-27.25 ^{0}C) are in accordance with what is needed by these bacteria, namely as stated by (Haryati, 2006), that satisfactory gas production is in the mesophilic region between 25 - 30°C. The data from the initial and final temperatures show that the fermentation process in the digester takes place normally. However, the initial and final temperatures in this study are actually not in optimal conditions so they need to be further increased, as stated by (Anggraeni et al., 2013) that the optimal temperature for the digester is in the range of 30-35^{0}C.

Changes in temperature are one of the factors that greatly affect the anaerobic fermentation process. The reason is that anaerobic bacteria are very sensitive to temperature changes. The activity of bacteria in multiplying and degrading substrates is 2-3 times faster than that of bacteria at room temperature, if given an increase in temperature (Dacosta, 2011). According to (Sastrohamidjojo, 2018), an increase in the activity of anaerobic bacteria when the temperature rises is due to the faster collisions between the substrate molecules.

Acidogenic bacteria and methanogenic bacteria are two types of bacteria that play a very important role in the biogas digester (Julien et al., 2001). Both have different roles. Acidogenic bacteria convert organic acids into hydrogen, carbon dioxide and acetic acid; and methanogenic bacteria that produce methane from acetic acid, hydrogen and carbon dioxide. These two bacteria need to be in balance. These bacteria are able to utilize organic matter and produce methane and other gases in their life cycle under anaerobic conditions (Haryati, 2006).

As a producer of methane gas, metatogenic bacteria are very sensitive to temperature because they have a specific temperature tolerance range. If this temperature range is not reached during the fermentation process, then the biogas production is not optimal. Haryati, (2006) states that satisfactory gas production is in the mesophilic area, which is between 25-30°C. However, the optimum temperature is around 35°C. If the temperature is too high or too low, these bacteria are inactive, and even gas production will stop if the temperature drops to 10^{0}C. Usually biogas produced outside the 25-30^{0}C range has higher CO_2.

Volume of Biogas Produced

Observations showed that the weight of biogas produced varied between treatments. The highest weight was in the treatment with goat dung (0.7 g), and the lowest was in buffalo dung (0.3 g) (Figure 3.4). After being analyzed, it is known that there is a significant difference between treatments. This means that the type of manure has a significant effect on the weight of the biogas produced.

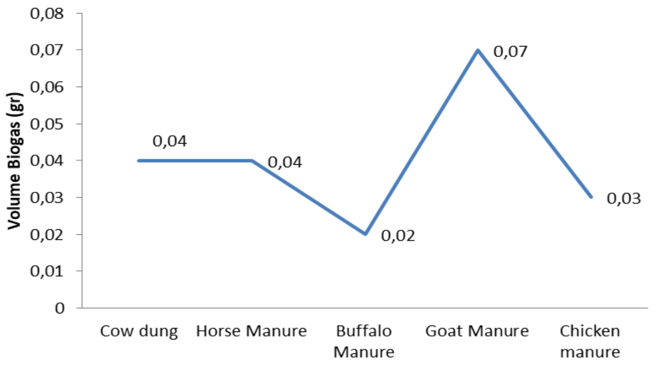

Figure 4. Volume of Biogas Formed

The difference in the results obtained from this study was caused by the difference in the pH of the *slurry* in the five types of impurities used. From the pH observations (Figure 3.4), it can be seen that the pH of goat manure is the highest, which is 7.09, resulting in the highest volume of biogas (0.7 g), while the other pH values are all below 7.0.

It is known that pH conditions greatly affect the population of acidogenic bacteria, which play a role in converting organic acids into hydrogen, carbon dioxide and acetic acid; and methanogenic bacteria, which play a role in producing methane from acetic acid, hydrogen and carbon dioxide. If the pH is close to neutral, as happened in the slurry from goat manure (7.09), a larger population of metatogenic bacteria will be available to convert the acetic acid produced by acidogenic bacteria, so that the volume of biogas produced is also greater. On the other hand, under neutral pH conditions, such as that found in *slurry* from chicken, horse, cow, and buffalo manure; causes the production of acetic acid produced by acidogenic bacteria to accumulate due to the limited population of metatogenic bacteria to convert it into methane gas. Thus, the volume of biogas produced from the four digesters is relatively less than the digester with goat dung starter. Budiyono, (2013) states that at the stage of methane gas formation, the bacteria that play a role are methanogenic bacteria. These bacteria will utilize the results of the second stage, namely acetate, formate, carbon dioxide, and hydrogen as a substrate to produce methane, carbon dioxide, residual gases such as H2S and water. Metatogenic bacteria are obligate anaerobic bacteria and are very sensitive to environmental changes, especially pH. In contrast to acidogenic and acetogenic bacteria, methanogenic bacteria belong to the genus *Archaebacter.*

The failure of the anaerobic digestion process in the biogas digester could be due to the unbalanced population of methanogenic bacteria against acidic bacteria which causes the environment to become very acidic (pH less than 7.0) which further inhibits the survival of methanogenic bacteria. Optimal acidity conditions in anaerobic digestion are around pH 6.8 to 8.0, the rate of digestion will decrease at higher or lower pH conditions (Haryanti et al., 2020; Haryati, 2006).

Conclusion

Based on the results and data analysis, it was concluded that the type of manure only affected the amount of biogas formed, but did not affect the time of gas formation, slurry pH, and slurry temperature. Thus, the five types of manure can be used as a starter in the manufacture of biogas made from water hyacinth.

Acknowledgements

This research was carried out to completion because of the support from the LPPM of the State Islamic University (UIN) Mataram and the Biology Science Tadris Study Program at UIN Mataram.

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