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Analisis Sifat Kimia dan Status Kesuburan Tanah pada Lahan sawah di Kecamatan Sakti Kabupaten Pidie, Provinsi Aceh

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Abstrak

Evaluasi sifat kimia dan status unsur hara sangat penting untuk menjaga agar kondisi lahan sawah tetap mendukung produksi. Penelitian ini bertujuan untuk evaluasi sifat kimia serta status kesuburan tanah pada lahan sawah di Kecamatan Sakti Kabupaten Pidie, Provinsi Aceh. Penelitian ini menggunakan metode deskriptif kuantitatif melalui pengamatan di lapangan dan analisis tanah di laboratorium. Luas areal sawah yang dievaluasi adalah 2.331 hektar dengan jumlah titik pengamatan ada delapan titik pada kedalaman 0-20 cm. Setiap titik pengamatan diambil sebanyak empat sub-sampel kemudian dikompositkan. Indikator kimia tanah yang dianalisis sebagai parameter untuk menilai status kesuburan tanah antara lain: kapasitas tukar kation (KTK), kejenuhan basa (KB), C Organik, dan kandungan total P_2O_5 dan K_2O total ekstrak HCl 25%. Hasil penelitian menunjukkan bahwa karakteristik kimia tanah yaitu pH H_2O , KTK, KB, serta cadangan P_2O_5 dan K_2O tanah bervariasi antara lokasi sampel. Secara umum lahan sawah di Kecamatan Sakti Kabupaten Pidie mempunyai pH tanah masam hingga netral (5,51-7,00), C-organik sangat rendah hingga sedang (0,46-2,26%), KTK sedang hingga tinggi (22,8-44,4 cmol kg^{-1}), dan KB rendah hingga tinggi (35,4-53,3%). Cadangan P_2O_5 tanah di seluruh lokasi tergolong sangat tinggi (64,4-169,28 mg/100 g), sedangkan cadangan K_2O bervariasi dari rendah hingga tinggi (18,72-44,76 mg/100 g). Status kesuburan tanah di areal sawah Kecamatan Sakti memiliki dua kriteria yaitu rendah dan sedang. Untuk meningkatkan status kesuburan tanah, dapat dilakukan dengan pemanfaatan jerami setempat dari sisa panen.

Kata Kunci: Tanah sawah, sifat kimia, status kesuburan tanah

Analysis of Chemical Properties and Soil Fertility Status in Paddy Fields in Sakti Subdistrict, Pidie Regency, Aceh Province

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Abstract

Evaluation of chemical properties and nutrient status is very important to ensure the condition of rice fields continues to support production. This research aims to evaluate the chemical properties of soil and the status of soil fertility in rice fields in Sakti District, Pidie Regency, Aceh Province. This research uses quantitative descriptive methods through field observations and soil analysis in the laboratory. The area of rice fields evaluated was 2,331 hectares with a total of eight observation points at a depth of 0-20 cm. Four sub-samples were taken from each observation point and then composited. Soil chemical indicators analyzed as parameters to assess soil fertility status include cation exchange capacity (CEC), base saturation (KB), Organic C, and total P₂O₅ and K₂O content of 25% HCl extract. The research results showed that soil chemical characteristics, namely pH H₂O, CEC, BS, as well as soil P₂O₅ and K₂O reserves varied between sample locations. In general, rice fields in Sakti Sub-district, Pidie Regency have acid to neutral soil pH (5.51-7.00), very low to moderate organic C (0.46-2.26%), medium to high CEC (22, 8-44.4 cmol kg⁻¹), and low to high BS (35.4-53.3%). Total P₂O₅ of soils at all locations was classified as very high (64.4-169.28 mg/100 g), while total K₂O varied from low to high (18.72-44.76 mg/100 g). The soil fertility status in the rice fields of Sakti Sub-district has two criteria, namely low and medium. To improve soil fertility status, this can be done by using local straws from harvest residues.

Keywords: Paddy soils, chemical properties, soil fertility status

INTRODUCTION

Sakti is the Subdistrict that is included in the rice production area in Pidie Regency, Aceh Province. The area of rice fields in Sakti Subdistrict reaches 2,331 hectares spread across 49 villages (BPS, 2021). According to data obtained by the Pidie Agriculture and Food Service (2021), rice production in Sakti Subdistrict, Pidie Regency, Aceh Province (Indonesia) in 2020 was 6.43 t ha⁻¹ and in 2021 it was 6.28 t ha⁻¹. Even though lowland rice productivity in Sakti District is already above the average national rice productivity (5.24 t ha⁻¹) if we look at the potential rice yield, rice production in this region can still be increased. Most farmers in Sakti Subdistrict choose to plant rice twice a year. With two harvests a year, soil nutrients will be intensively transported with each harvest, which can reduce soil productivity. Yields will decrease due to continuous harvesting without good soil maintenance, and ultimately the soil can no longer show its productivity.

Rice fields are not the same as dryland because the main condition of rice fields is closely related to standing water over a long period. Flooding can change the chemical, physical, and biological properties of soil. This characteristic is what differentiates dry land from rice fields. Flooding of rice fields can cause changes in soil properties over a long period, so the level of development of the soil profile and soil quality can change (Rajamuddin, 2009). Soil properties are an indicator that determines

the level of soil capacity, including the productivity of rice fields. The overall chemical reaction that occurs between soil components and materials added in any form, such as organic or inorganic fertilizer, plays an important role in determining soil fertility. The value and availability of nutrients on agricultural land tend to decrease due to leaching, evaporation, and harvest transportation (Prasetyo et al., 2007).

Soil fertility is the ability to provide sufficient and balanced nutrients to ensure optimal plant development and yields (Pinath et al., 2015). Rice fields in Sakti District are used twice a year. Land use over a long time causes a decrease in soil properties, which can lead to low soil fertility status. The chemical properties of rice fields also change every season due to different land uses. If rice fields are planted continuously, the nutrients in the soil will run out. Information about soil characteristics and fertility status is needed to increase rice field productivity.

Understanding the concepts of soil fertility and quality is very important for the successful management of agricultural land to ensure long-term productivity. According to the problems above, what must be done is to evaluate soil characteristics and fertility. This step is important because the condition of rice fields in Pidie Regency and especially in Sakti District, based on information from local farmers, has never been evaluated, for example through soil tests or fertilization trials. Fertilizer doses used by farmers are not based on the results of soil analysis and farmers generally apply recommended doses based on information from the relevant agencies or local field instructors. This paper presents the results of evaluating several chemical properties and soil fertility levels in rice fields in Sakti Subdistrict, Pidie Regency, Aceh Province.

MATERIALS AND METHODS

The research was carried out in Sakti Subdistrict, Pidie Regency, Aceh Province in an irrigated rice field area of 2,331 hectares. The map of the research location in Sakti Subdistrict, Pidie Aceh Regency can be seen in Figure 1. Soil collection activities were carried out in December 2023.

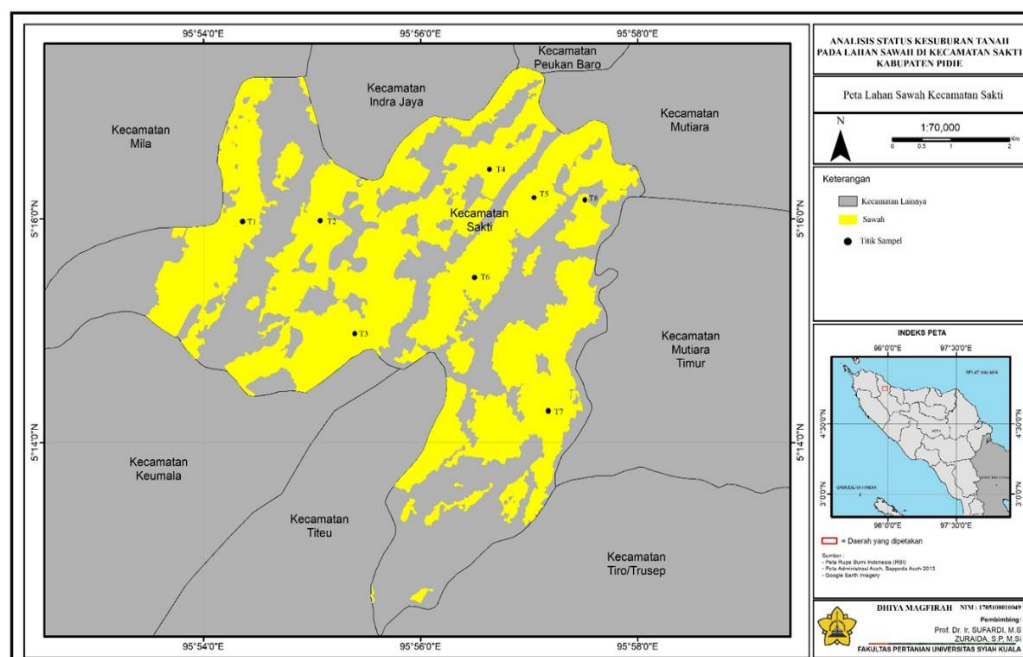


Figure 1. Map of the location of rice fields in Sakti Subdistrict, Pidie Regency, and soil sampling points

Soil samples were returned using a soil auger with a depth of 0-20 cm on the soil surface. One kg of each soil sample was taken and then put into plastic. Soil sampling consists of eight sample points and each sample point takes four soil sub-samples to be composited into one soil sample. The sampling locations can be seen in Table 1.

Table 1. Sampling locations and coordinates

No	Soil sample	Site name	Coordinate points	
			N	E
1	T1	Cot Sukon	5°16'23.5"	95°54'16.1"
2	T2	Balue Kulu	5°16'30.4"	95°54'47.2"
3	T3	Beutong Perlak	5°15'18.5"	95°55'26.6"
4	T4	Lam Ujong	5°13'59.8"	95°57'11.9"
5	T5	Mali Mesjid	5°16'02.0"	95°57'11.9"
6	T6	Mns Bale	5°15'24.6"	95°56'25.7"
7	T7	Cumbok Niwa	5°14'30.6"	95°57'07.9"
8	T8	Mali Cot	5°16'18.8"	95°57'41.1"

N/E = North latitude/ East longitude

This research uses quantitative descriptive methods based on field observations and soil analysis at the Soil and Plant Research Laboratory, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Indonesia. The chemical parameters for determining the observed fertility status are pH (H₂O) measured electrometrically, organic C (Walkley & Black method), cation exchange capacity (CEC) using the 1N NH₄OAc pH7 method, potential or total P₂O₅ and total K₂ O, and percentage Base saturation (BS) is calculated from the comparison of the number of base cations of 1N NH₄OAc pH7 extract with the CEC value of the soil multiplied by 100. The assessment of soil fertility status uses criteria developed by PPT (2005).

RESULTS AND DISCUSSION

Soil pH and C-organic

Based on the results of soil reaction analysis (pH) and organic C of paddy soil at the research location, it can be seen in Figure 2 shows the pH of H₂O at the location which is classified as acidic to neutral. Based on the results of soil pH measurements, the research area is considered good for rice plants because rice is a type of plant that is tolerant of soil acidity up to pH 5.5 (Sufardi, 2019). As the most important chemical characteristic of soil as a plant-growing medium, the pH value will be a parameter to determine how many nutrients are available to plants (Syachroni, 2019). Djaenudin et al. (2003) stated that the pH of H₂O that is very suitable for rice plants is 5.5 to 8.2, and 4.5 to 5.5 is quite suitable. This is not a problem for rice fields that are flooded with water because they experience chemical changes, including changes in soil pH. The pH of acidic rice field soil will approach neutral after being flooded with water, while the pH of alkaline soil will decrease until almost neutral. Soil acidity is an indicator of soil fertility status because it shows the condition of soil nutrients which can influence plant growth, as well as the solubility of various nutrients available to plants (Harahap et al., 2021).

Figure 2 also shows that the soil C-organic content at the research location is also quite diverse and is classified as very low to medium criteria. However, looking at the data in Figure 2, it can be stated that most of the soil has an organic C content that is below the low limit (<2.0%) and there are only two sample points (T5 and T6) that are above or close to the limit. low. The difference in organic content at the research location, which represents the organic matter content of the soil, is thought to be due to

variations in rice management systems between farmers. Some farmers often take out rice straw waste which has an impact on reducing the organic material content in rice fields, but some farmers pile straw on their land and some burn it. Most rice fields are indicated to have very low levels of organic matter due to poor nutrient management and there is no return of straw to the land. The research results of Bolly & Apelabi (2022) show that the low level of organic fertilizer applied to paddy fields can be a factor in the low organic C content of the soil.

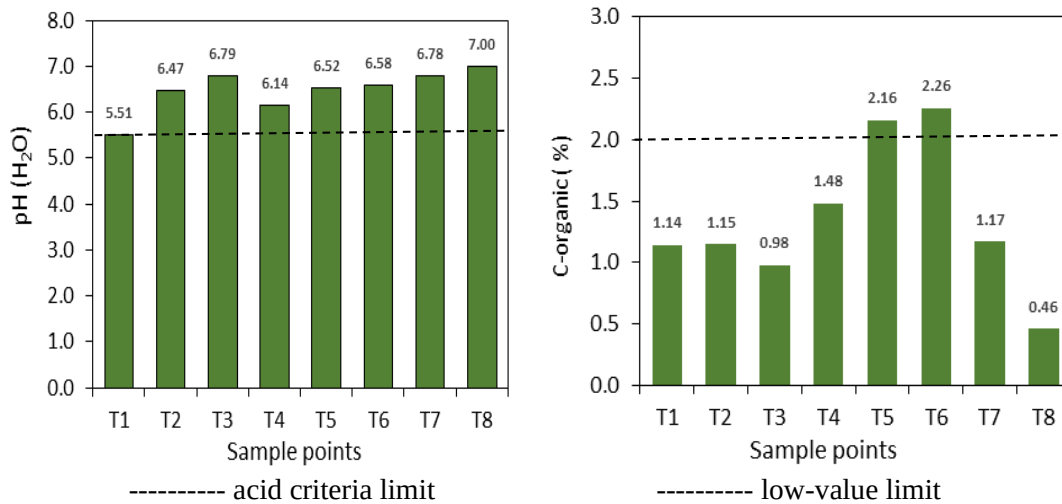


Figure 2. Soil pH (H₂O) and C-organic values at each observation point in the rice fields of Sakti Subdistrict, Pidie Regency

CEC and BS

According to the findings of the CEC and BS analysis of paddy field soil at the research location, Figure 3 reveals that the soil's CEC value ranges from medium to extremely high. The CEC of rice fields in the study area is generally good because the soil CEC is high, which means that the soil fertility indicators are likely to be high.

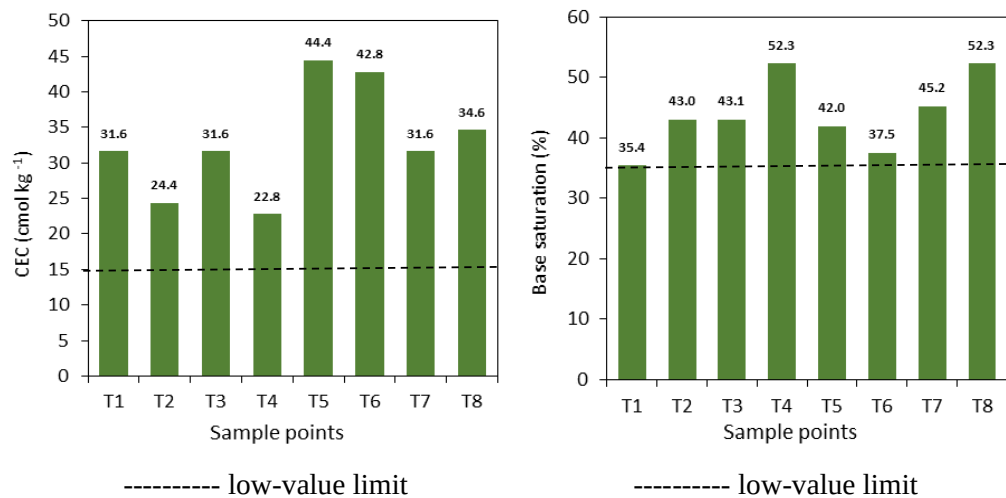


Figure 3. Cation exchange capacity (CEC) and base saturation (BS) of soil at each observation point in the rice fields of Sakti Subdistrict, Pidie Regency

According to Adiningsih (2004), soil with a high CEC can store a large amount of nutrients and hence offer nutrients to rice plants. Elements including Ca, Mg, K, Na, and pH all have an impact on soil's high CEC. The CEC value for all soil samples

evaluated at the research location may be seen in this picture. The CEC value of the soil was above the low criteria line. A soil is said to have a low CEC if the value is lower or equal to 16 cmol kg^{-1} (PPT, 2005). Cation exchange capacity is an indicator of soil fertility conditions because the number of cations available to plants and the amount of cation exchange that plants can carry out are influenced by the presence of colloids in the soil. Soil with high cation exchange absorbs and carries nutrients more efficiently than soil with low cation exchange limits (Jawang, 2021). Soil with a high CEC value and a high proportion of clay and humus fractions has a high CEC and water-holding capacity and high aggregate stability due to the bonds of the soil particles. Soil organic matter content and clay content are other factors that influence high CEC (Maulana et al., 2012).

Figure 3 also shows that the percentage of family planning at the research location is classified as low to high. The lowest BS value was 35.4% (found at T1) and the highest was at T4 and T8. In general, all sample points have BS values above the lowest limit ($>35\%$). Base saturation is related to soil pH. The same thing is also supported by the statement of Suseno et al., (2018) which shows that pH and base saturation are interrelated. Usually, soil with a low pH has a low BS, while soil with a high pH usually has a high BS. The BS value can also be influenced by standing water which causes the depletion of base cations in the soil. Cations dissolve into water during the soil washing process and are no longer in the root zone (Pinatih et al., 2015).

Total P_2O_5 and Total K_2O

Figure 3 depicts the findings of the total P_2O_5 and K_2O analysis of rice field soil at the research site, which demonstrate that the total P_2O_5 content is quite high and well above the low limit. As a result, the P nutrient at the research site may be adequate for the demands of rice plants. The application of phosphate fertilizer (SP-36) and manure each planting season can result in high P soil conditions.

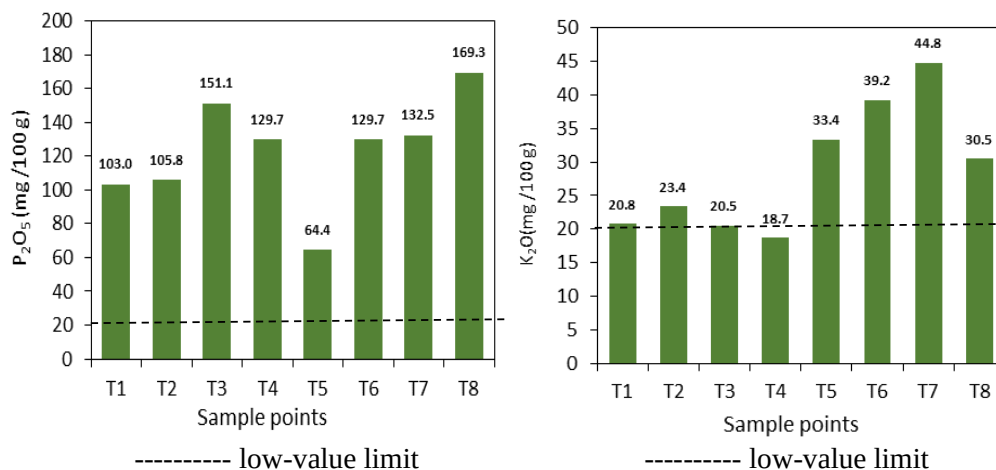


Figure 4. Total P_2O_5 and total K_2O content of soil (25% HCl extract) at each observation point in rice fields in Sakti Subdistrict, Pidie Regency

This can cause an accumulation of P in the soil (Sufardi, 2019). In the soil, phosphate compounds do not dissolve easily and are even adsorbed on soil mineral particles (Mengel & Kirkby, 2013) so that over a long time they can become residues (Yang & Yang, 2021). Therefore, it is recommended to reduce the use of P fertilizer on rice fields with soil that has a high P classification. The amount of P_2O_5 contained in it is not entirely determined by the amount of P component present. Various factors, for

example, plant absorption capacity, soil pH, and phosphorus given to the soil through fertilizer can influence high P conditions (Hanafiah, 2010). The P content is generally also within the high limit at neutral pH conditions. Some fertilizers applied to the soil cannot be utilized by plants because the fertilizer reacts with other soil materials. Plants need 0.3 to 0.5% P of their dry weight to grow optimally (Prabowo & Subantoro, 2018).

Figure 4 also shows that the total K₂O content at the research location varies from low to high criteria (18.72-44.76 mg/100 g). The lowest total K₂O was found in sample T4 while the highest was found in sample T7. Figure 4 also shows that half of the rice field soil samples have a total K₂O content at the low limit while the rest are above the low limit. This data shows that the potential availability of potassium nutrients for rice plants in the rice fields of Sakti District, Pidie Regency is not uniform. This difference is thought to be related to the land management system. Apart from the soil management system, the difference in total potassium content can also be related to the content of organic matter sourced from straw. Leaching of potassium in the soil is thought to be the cause of low K₂O levels in the research location, especially in areas where straw was not returned. As discovered by Mu'min et al. (2016) irrigation systems or flooding can also have an impact on the total amount of potassium in the soil. Excessive irrigation systems can cause percolation, which dissolves potassium in the soil, resulting in leaching. Because K mineral deposits are balanced with K in the soil and irrigation water, and the decomposition of organic matter can meet K needs, rice generally reacts poorly to K fertilization. Rice fields with high K status are produced by continuous K preparation. Continuous P fertilization results in an imbalance of soil nutrients which will cause leveling off in rice fields (Sofyan et al., 2004).

Soil Fertility Status

Table 2 shows that the fertility status of rice fields in Sakti District, Pidie Regency can be divided into two, namely low fertility status and medium fertility status. Research locations that have low fertility status are caused by low soil C-organic and K₂O content or at least two limiting factors found at that location. Organic C levels are considered very low to moderate, possibly causing the low fertility status of paddy fields according to the variables that determine soil fertility status.

Table 2. Assessment of soil fertility status at each soil sample point in the rice fields of Sakti Sub-district, Pidie Regency

Sample point	CEC (cmol kg ⁻¹)	BS (%)	Total P ₂ O ₅ (mg/100 g)	Total K ₂ O (mg/100 g)	Organic C (%)	Fertility status
T1	High	Low	Very high	Low	Low	Low
T2	Medium	Medium	Very high	Medium	Low	Low
T3	High	Medium	Very high	Low	Very low	Low
T4	Medium	High	Very high	Low	Low	Low
T5	Very high	Medium	Very high	Medium	Medium	Medium
T6	Very high	Medium	Very high	Medium	Medium	Medium
T7	High	Medium	Very high	Low	Low	Medium
T8	High	High	Very high	Medium	Very low	Medium

Overall, paddy fields at research sites have low organic carbon levels, resulting in low soil fertility. The paddy fields at the research site are planted constantly to reduce soil nutrient levels rather than alternately with other crops, which is one of the reasons for their low fertility. In general, constantly irrigated soil causes nutrients to decrease

owing to leaching and flows along with irrigation water, such as exchangeable cations of Na-exch, Ca-exch, Mg-exch, and K-exch, which are vulnerable to leaching (Sari et al., 2022). The existence of limiting variables determines whether a place is fruitful. Plants can get enough nutrients from fertile soil, and there are no limiting conditions that can slow their growth. According to Yusron et al. (2018), low fertility status (R) shows that the plant responds to the application of fertilizer, without the addition of fertilizer, production will decrease and the plant will show signs of deficiency and plant growth without fertilizer will be abnormal, the possibility of death is small even though it does not change.

CONCLUSION

Soil parameters, such as pH H₂O, cation exchange capacity (CEC), base saturation (BS), and total soil P₂O₅ and K₂O, differ between sample locations in the rice fields of Sakti Subdistrict, Pidie Regency, Aceh Province. Rice fields in the Sakti Subdistrict contain soil pH that varies from slightly acidic to neutral, medium to very high CEC, and moderate to high BS. P₂O₅ potential is quite high, whereas K₂O ranges from low to high. The soil fertility in the rice fields of Sakti Subdistrict, Pidie Regency, is graded as low to medium. Rice fields with low fertility are the result of low C-organic content. To increase the fertility of rice fields, it is required to return rice straw to the soil or add organic resources.

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