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THE QUALITY INDEX ASSESSMENT OF FLOOD-AFFECTED RICE FIELDS IN THE COASTAL AREA OF BENGKULU, INDONESIA

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ABSTRACT

Floods can reduce soil quality because the entry of additional material which results in the loss of top soil due to the process of cleaning up flood residues in rice fields. The entry of mud deposits into rice fields can disrupt the balance of nutrients in the soil. This research aims to determine the relationship between the type of flood and the soil quality of coastal rice fields. The research method uses a purposive random sampling survey method. After having laboratory soil analysis results, the data was then analyzed using Principal Component Analysis and Minimum Data Set. Sea water flood has a Soil Quality Index of 4.30 with good soil quality criteria, while for rice fields affected by river water flooding with an IKT value of 3.77 the soil quality is rather good and areas not affected by flooding have an IKT value of 4.71 with very good quality criteria. The results of the analysis show that the rice fields can be improved by managing rice fields affected by river and sea water flooding in a better way, such as using a good soil management system, using organic fertilizer and liming.

Keyword: *flooding criteria, rice, productivity, soil quality*

ABSTRAK

[ANALISIS PENILAIAN INDEKS KUALITAS TANAH SAWAH TERDAMPAK BANJIR DI PESISIR PANTAI BENGKULU]. Banjir dapat menurunkan kualitas tanah dikarenakan masuknya material tambahan mengakibatkan menurunnya kualitas tanah akibat proses penggenangan dan pemindahan substansi bagian tanah pada lahan sawah. Masuknya endapan lumpur ke dalam areal persawahan dapat mengganggu keseimbangan unsur hara di dalam tanah. Penelitian ini bertujuan untuk menentukan hubungan antara karakteristik banjir terhadap kualitas tanah sawah di kawasan pesisir. Metode penelitian menggunakan metode survey dengan metode pengambilan sampel menggunakan purposive random sampling; data diinterpretasikan dengan Principal Component Analysis (PCA) dan Minimum Data Set (MDS). Hasil penelitian menunjukkan bahwa banjir air laut memiliki nilai IKT 4,30 dengan kriteria kualitas tanah baik, sedangkan untuk lahan sawah yang terkena banjir air sungai dengan nilai IKT 3,77 kualitas tanah agak baik dan wilayah yang tidak terkena banjir memiliki nilai IKT 4,71 dengan kriteria kualitas sangat baik. Hasil analisis menunjukkan lokasi penelitian dapat ditingkatkan dengan pengelolaan tanah sawah yang terkena banjir air sungai dan air laut harus dilakukan dengan cara yang lebih baik, seperti penggunaan sistem pengolahan tanah yang baik, penggunaan pupuk organik dan pengapuran

Kata kunci: *kriteria banjir, kualitas tanah, padi, produktivitas*

INTRODUCTION

Global climate change has affected rice productivity in Indonesia, including through rising air temperatures on the earth's surface, extreme rainfall, rising sea levels which cause direct and indirect flooding due to obstruction of river flows, and several other natural disaster phenomena (Hanifah & Putri, 2022).. Flooding is an event or condition where an area or land is submerged due to a rapid increase in the volume of water (Hapsoro & Buchori, 2015). In the agricultural sector, the frequency of floods that submerge rice fields results in failure or reduced rice production in the affected areas (Helmi *et al*., 2016).. According to Ali *et al*. (2023) there are several factors that cause floods, such as being caused by human activity, natural conditions that are permanent (static), and natural events that are dynamic. Apart from that, flooding can also occur due to surface water runoff that overflows and the volume exceeds the drainage capacity such as drainage or water bodies. The five factors that cause flooding in Indonesia include rain, damage to watershed retention, errors in planning for river channel development, silting of rivers, and regional planning errors in the construction of facilities and infrastructure.

The city of Bengkulu is one of the areas that is prone to disasters because its location and geographical conditions are included in areas that are prone to disasters, such as floods, landslides, volcanic earthquakes, tectonic earthquakes and fire disasters. This region is located on the west coast of the island of Sumatra which directly faces the Indonesian Ocean and geographically is between 3045-3059 South Latitude and 10214'-10222' East Longitude with an area of 539.3 km^2 consisting of a sea area of 387.6 km^2 and land area 151.7 km^2. Almost every year, Bengkulu Province experiences floods 2 -3 times. The flood disaster that occurred in Bengkulu province in May 2019 was the worst disaster in recent years and was declared a national disaster with a total impact of 1,225 houses damaged, 1,187 housing units submerged, 7 educational facilities heavily damaged, 1 educational facility lightly damaged, 7 educational facilities submerged in mud, 40 infrastructure points were submerged, 3000 hectares of rice fields & gardens were damaged and 857 livestock died so that the total loss was estimated at IDR 144 billion (Nurrohman, 2022).

The flood phenomenon can reduce soil quality because the entry of additional material results in the loss of top soil due to the process of cleaning up flood residue in rice fields. The entry of mud deposits into rice fields can disrupt the balance of nutrients in the soil. Soil quality is the ability of a soil to play a role in maintaining plant productivity,and maintaining water availability and supporting human activities (Kurniawan *et al*., 2021). According to Triadiawarman *et al*. (2022), soil quality assessment is measured based on indicators of changes in soil function in response to soil management. Several indicators are assessed in the soil quality evaluation process, namely indicators that describe important soil processes based on the physical, chemical and biological properties of the soil. Ramadani *et al*. (2023) argue that soil quality is measured based on observing the dynamic conditions of soil quality indicators. Measuring soil quality indicators produces a soil quality index, where in the assessment there is a selection process for the soil properties

Paying attention to the constraints that exist, especially on coastal land, it is necessary to carry out a more in-depth study of the quality of the soil on this land. Furthermore, soil that frequently experiences flooding will affect its quality in providing optimal growth space for plants. Therefore, this research is important to carry out in order to maintain the sustainability of rice cultivation, especially in the coastal areas of Bengkulu City.

MATERIALS AND METHODS

This research was carried out from June to September 2023 in the rice fields of Rawamakmur Village, Muara Bangkahulu District, Bengkulu City. This research location is located at 3°136' 45.83" North Latitude- 102°156' 99"South Latitude. According to BMKG data taken from the Bengkulu Climatology Station, Bengkulu City has high rainfall, namely 3000-3500 millimeters (mm) per year and has 2 maximum monthly rainfall, peaks, namely in March and December.

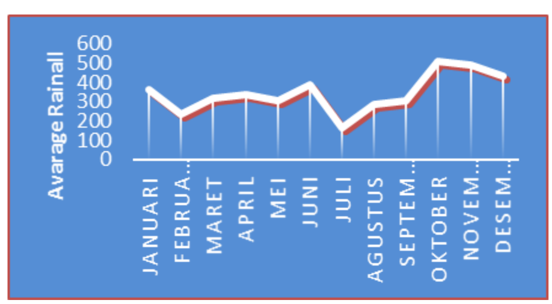


Figure 1. Monthly rainfall average (mm/month) of Bengkulu Province (BPS, 2023)

This research uses a survey method by taking soil samples using a purposive random sampling method with a research map as shown in Figure 1. The rice fields in this area are divided into 3 flood criteria, namely, river water flooding, sea water flooding and not being affected by flooding. During the field survey, intact (undisturbed) soil was taken using a sample ring which was used to analyze the physical properties of the soil and disturbed soil using a soil drill which was used to analyze the chemical and biological properties of the soil. Nine soil samples were taken with 9 observation points.

Analysis of soil samples from the research location was carried out at the Soil Science Laboratory, Faculty of Agriculture, University of Bengkulu and data analysis used Principal Component Analysis (PCA) to determine selected indicators as key parameters or Minimum Data Set (MDS) for calculating the Soil Quality Index (SQI). Soil quality assessment consists of several stages, namely : (1) Select several soil properties that greatly influence soil function using PCA; (2) Determine the selected indicators as key parameters or MDS to calculate the SQI and determine the weight (weighted coefficient) according to its function in the PC; (3) Determine the score for each selected indicator, namely a score of 0 (Very bad) and a score of 5 (Very good) according to performance; (4) Selected indicators that have been given a score are then integrated into the calculation of the SQI. SQI is obtained by adding up the results of multiplying the factor weight (Pi) and the score for each soil quality indicator according to (Rachman *et al*., 2020) which is the sum of the scores for each soil quality indicator with the equation :

$$SQI = \sum_{i=1}^{n} \overline{Pi}\, X\, \overline{So}$$

Notes :

Pi : Proporsion/coeffisient weight

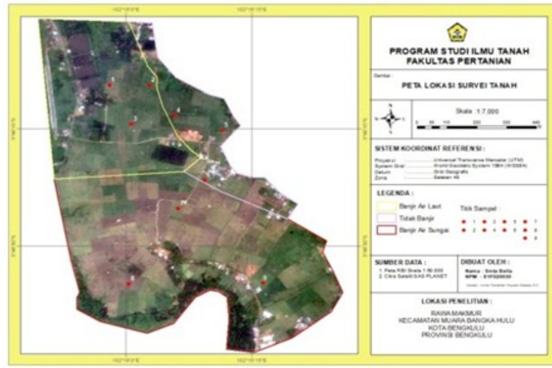
So: Minimum Data Set (MDS) parameter score

n : Numbers of Indicator selected

SQI : Soil Quality Index

The parameters observed in this research are analysis of the physical properties of the soil, such as soil texture using the hydrometer method, volume weight using the sample ring method, specific gravity using the pycnometer method. Meanwhile, for analysis of soil chemical properties such as pH H_2O and pH KCl using the pH meter method, C-organic using the Walkey & black method, EC using the EC meter method, N-total using the Kjeldahl method, P-total using the P-bray II, CEC using the ammonium acetate extraction method pH-7, C-Respiration using the incubation and titration method.

Figure 2. Location of soil sampling in the flood affected rice fields in the coastal area of Bengkulu



RESULTS AND DISCUSSION

Soil Physical Properties

Physical properties are parameters related to the soil's ability to maintain plant bodies and retain water in the soil. The physical properties of flood-affected rice fields in Rawa Makmur sub-district, Bengkulu city are quite varied (Table 1). Changes in the physical properties of soil are also greatly influenced by the occurrence of illuviation and/or eluviation of chemicals or soil particles due to muddying processes and changes in drainage. Silting is carried out by cultivating the soil in a flooded state, when the soil is plowed and then harrowed so that the soil aggregates are destroyed into very soft mud. River floods and sea water floods can affect the physical properties of the soil because they can deposit sediment in the soil which can change the soil structure and soil consistency.

Table 1. Soil Physical Properties

Flood Water Souces	Soil sample	Texture	Bulk Density (g cm^{-3})	Spesific Gravity (g cm^{-3})
Sea water flood	1	Sandy clay	2.21	9.06
	2	Sandy clay	2.08	8.88
	3	Sandy clay	2.11	8.99
River water flood	4	Sandy clay	2.26	9.04
	5	Sandy clay	2.21	9.08
	6	Sandy clay	2.15	8.87
Not flooded	7	Sandy clay	2	9.19
	8	Sandy clay	2.21	8.87
	9	Sandy clay	2.08	8.9

Texture is one of the physical properties of soil that greatly determines other physical properties of soil, especially those related to soil porosity, the ability to absorb and release nutrients and water and the soil's ability to support plant growth. The soil texture at the research location is a klei texture. Based on the texture class, each rice field plot falls into the medium category. Fine to medium textures are more commonly found in paddy fields. The klei texture can hold water very tightly so that water can be available for plants, whereas soil with a coarse texture has difficulty holding water so it is very wasteful of water if cultivated for rice fields (Agustina *et al*., 2012).

Soil bulk density is the total weight of soil per unit total volume of soil, which includes the pore space in the soil. The volume weight of soil can be expressed as weight per unit volume of dry soil or weight per unit volume of wet soil. The weight of the soil volume influences the ease of root penetration in the soil, soil drainage and aeration, as well as other physical soil properties. The volume weight of

soil varies from one point to another due to variations in organic matter content, soil texture, root depth, soil structure, type of fauna, etc. The research results show that the volume weight value is in the range of 1.00 to 1.26. Soil Specific Gravity is the ratio between the weight of soil grains and the weight of water. The specific gravity value of soil is usually calculated to determine the quality of soil at a point. This type of soil gravity is useful for the agricultural and plantation sectors, as well as in knowing the physical properties of the soil. At the research location, the results of measuring the specific gravity of the soil were at a value of 1.87 to 2.19.

Soil Chemical Properties

Soil chemical properties are parameters related to soil fertility and the distribution of nutrients in the soil. The chemical properties of flood-affected rice fields in Rawamakmur, Bengkulu City are quite varied. The diversity coefficient can show high parameters among the rice field plot samples. The smoother the soil surface or the higher the clay content of the soil, the higher the CEC of the soil due to its ability to hold water and nutrients will be easily absorbed in soil colloids. The base saturation value correlates with organic C levels in the soil. Based on the results of soil pH measurements at the research location, it shows that the soil pH value of each samples is classified as acid. River floods and sea water floods can affect the chemical properties of soil because they can cause changes in nutrient levels in the soil, can change pH conditions and existing mineral content, and sea water floods can increase EC levels in the soil.

Table 2. Soil Chemical Properties

Flood Water Souces	Soil sample	pH-KCl (1:1 ratio)	pH-H_2O (1:1 ratio)	C-org (%)	EC MS. cm^{-1}	N-tot (%)	P-Bray mg. kg^{-1}	CEC Cmol. kg^{-1}
Sea water flood	1	4.06	6.27	4.85	173.8	0.36	4.98	31.67
	2	3.98	6.15	2.75	41.7	0.23	4.03	31.08
	3	3.71	4.94	5.48	211	0.39	3.93	34.87
River water flood	4	3.83	5.68	2.46	56.6	0.2	3.64	34.19
	5	3.75	4.68	3.72	43.3	0.26	4.23	36.96
	6	3.68	5.78	3.86	41.4	0.23	3.08	35.31
Not flooded	7	3.86	5.32	5.97	252	0.37	3.32	39.83
	8	3.87	5.35	2.63	140.7	0.13	3.41	28.8
	9	4.39	5.73	2.42	61.8	0.12	4.16	28.15

Soil pH content also influences the availability of available P content. The K-total content is influenced by the high and low CEC of the soil. The higher the CEC value of the soil, the higher the ability to bind potassium in the soil and vice versa. The K element has the property of being easily mobile so it will be easily leached by rainwater from the root zone, especially in soil that has a low cation exchange capacity, so K fertilization is needed in these conditions.

Soil EC (Electrical Conductivity) is an indicator used to measure the levels of dissolved salts in the soil. Soil EC is a value that shows the electrical conductivity of the soil, which is connected to the salt content. Soil EC values are usually measured in mS/cm. At the research location, EC levels were in the high category.

Nitrogen is the main nutrient for plant growth which is needed in large quantities. Nitrogen is absorbed by plants in the form of ammonium (NH_4^+) and nitrate (NO_3^-). Total nitrogen in the study area ranges from 0.12 to 0.39%, which is classified as low to medium. Nitrogen levels can be influenced by organic matter. If organic matter is high then nitrogen in the soil will also be high and vice versa. The study area has poor to moderate organic matter. Low nitrogen content can be influenced by three factors, namely washing with drainage water, evaporation, and absorption by plants (Pratama, 2020).

Available P is the soil P element that can be dissolved in water and citric acid, with P dissolved in water being the P element that can be absorbed by plants. The P element that is ready to be taken up by plants is in the form of H_2PO_4-, HPO_4^2- and PO_4^3- in the soil solution. The P content in the study area is

3.08–4.98 ppm which falls into the very poor and poor categories. Where factors that influence the availability of P in soil are organic C, soil pH, Fe, Al and Ca content, and physical characteristics of the soil (Niki *et al*., 2022).

Cation Exchange Capacity (CEC) is an indicator in determining soil fertility status, because there are soil colloids that can determine the amount of cations that can be absorbed and exchanged with the amount available to plants. The results of the analysis of paddy field soil showed that the CEC with a value of 28.15–39.83 me/100g was in the high category. CEC is positively correlated with the availability of organic matter in the soil (Lantoi *et al*., 2016). High organic matter results in an increase in the amount of soil colloids so that the CEC in the soil has a high nutrient status

C-organic or organic carbon is a carbon compound originating from living things which shows the level of organic matter contained in the soil. Organic C- in the study area ranges from 2.42 to 5.48%, which is included in the moderate to good category. The decomposition of organic matter is influenced by aeration and drainage of rice field soil. Good aeration and drainage will affect soil microbes so they can break down organic matter. Paddy fields have poor aeration and drainage due to soil processing, namely muddying. Poor soil aeration affects the activity of soil microbes in decomposing organic matter.

Soil Biological Properties

Soil biological properties are aspects of soil quality that relate to living things found in and on the surface of the soil such as microorganisms. These living creatures have an important role in the decomposition of organic materials, mineralization processes, immobilization and nutrient cycling. The biological properties of soil also influence the stability of soil fertility and health. Soil C-respiration is a process that involves the use of oxygen (O_2) or the release of carbon dioxide (CO_2) by bacteria, fungi, algae and protozoa which are involved in gas exchange in soil metabolic processes. Soil respiration is defined as the use of oxygen or release of carbon dioxide by soil microorganisms, which is a good indicator of soil quality. The research results showed that soil respiration at the research location (Table 3) was correlated with soil organic C. This is caused by factors such as soil temperature, soil water content, soil pH, and litter content which influence the activity of soil microorganisms. The consequences of sea water floods and river water floods can cause changes in the physical and chemical properties of soil, such as changes in texture, permeability, porosity and nutrient levels which can reduce the activity of soil microorganisms so that when flooded the biological properties of the soil are also disturbed.

Principal Component Analysis

Determination of indicators of soil physical, chemical and biological properties that greatly influence soil function is determined using PCA statistical analysis.

Table 4 shows a collection of soil quality indicators resulting from PCA. The results of PCA show that there are three indicators of soil quality. The order of significance of the soil quality indicators is determined by the magnitude of the eigenvalue. The four soil indicators are porosity, pH KCl, organic C and available P. The MDS is a collection of data resulting from the reduction of soil quality

Table 3. Soil Biological Properties

Flood Water Souces	Soil sample	C-respiration tonnes $CO_2.ha^{-1}.year^{-1}$
Sea water flood	1	1.53
	2	1.61
	3	7.02
River water flood	4	1.15
	5	2.33
	6	3.36
Not flooded	7	5.81
	8	4.18
	9	2.26

Tabel 4. Results of Principal Component Analysis

Principal Component	PC-1	PC-2	PC-3
Eigen value	6.146	4.244	2.272
Proportion (%)	36.152	24.967	13.364
Cumulative	36.152	61.119	74.483
Weight proportion	0.933	0.408	0.179
Loading Factors	PC-1	PC-2	PC-3
Bulk density	-0.604	0.174	0.464
Spesific gravity	0.619	0.288	0.654
pH_KCl	-0.169	-0.862	0.086
pH_H_2O	-0.307	-0.536	0.113
C_organik	0.933	0.189	0.112
EC	0.894	-0.145	0.049
N_total	0.815	0.219	0.334
P	0.026	-0.553	0.657
CEC	0.523	0.765	0.207
C_respiration	0.755	0.215	-0.489

indicators which can best describe the function of the soil for compiling a Soil Quality Index. The soil quality index is prepared based on weighted values obtained from the division between variance percentage and cumulative percentage. The weighting factors produced by PC1, PC2, and PC3 are respectively 0.933; 0.408; 0.179. Selection of MDS using PCA by statistical software to consider PC that have an eigenvalue ≥ 1 and have ≥ 5% of the total accumulated variables. The component matrix minimizes the number of variables with higher loading values in each PC and makes it easier to interpret the results (Martín-Sanz *et al*., 2022). Pearson correlation was calculated to reduce variable redundancy in the MDS. In terms of correlation, the variable with the highest loading value is selected as the indicator and if there is no correlation in the same PC.

PCA in the rice fields which influences the chemical properties of the soil are pH KCl, C-organic and P-available. For those that were not selected in the research area because there was uniformity. This uniformity can be seen by the low diversity coefficient. Indicators that have high uniformity will not appear as MDS.

Minimum Data Set (MDS)

A collection of soil quality indicators resulting from PCA extraction is presented in Table 5. The MDS is a collection of data resulting from the reduction of soil quality indicators which can best describe the function of the soil for compiling a SQI. The soil quality index is prepared based on weighted values obtained from the division between % variance and % cumulative. The four main components with six MDS indicators are presented in Table 5. The resulting weighting factors PC1, PC2, and PC3 are respectively 0.933; 0.408 and 0.179. With indicators namely C-organic, pH KCl, P-Bray.

Tabel 5. Minimum Data Set (MDS) matrix

PC	% Variance	% Cumulative	Weighting	MDS Indicator
1	36.152	36.152	0.933	C-organik
2	24.967	61.119	0.408	pH KCl
3	13.364	74.483	0.179	P-Bray

Table 3 is a collection of soil quality indicators resulting from PCA extraction. The MDS is a collection of data resulting from the reduction of soil quality indicators which can best describe the function of the soil for compiling a SQI. The SQI is prepared based on weighted values obtained from the division between % variance and % cumulative. The four main components with six MDS indicators are presented in Table 4. The resulting weighting factors PC1, PC2, and PC3 are respectively 0.933; 0.408 and 0.179. With indicators namely C-organic, pH KCl, P-Bray.

Soil Quality Index (SQI)

Soil quality assessment is carried out using a soil quality index approach which is calculated based on the value and weight of each soil quality indicator. The scoring criteria of soil characteristics and SQI assesment category are presented in Table 6 and 7. The results are shown in Table 8.

It can be seen from Table 8 that the final SQI score varies for sea water flood with an SQI value of 4.30, which means that in rice fields affected by sea water flood, the soil quality is still relatively good, while for rice fields affected by river water flood with the SQI value is 3.77, the soil quality is considered

Table 6. Soil evaluation criteria for scoring (BBSDLP 2009 (Rachman *et al*.. 2020)

Parameter	Scores				
	1	2	3	4	5
	Very bad	Bad	Moderate	Good	Very good
P-Bray (ppm)	<4	5-7	8-10	11-15	>15
C-organic (%)	<1	1-2	2-3	3-5	>5

Soil reaction	Very acid	Acid	Slightly acid	Neutral	Slightly alkali	Alkali
pH KCl	<4.5	4.5-5.5	5.6-6.5	6.6-7.5	7.6-8.5	>8.5

Table 7. Soil Quality Index assesment category (Rachman *et al*.. 2020)

Score	Soil Quality Indeks Value	Soil Quality Indeks Status
1	x 2.0	Very bad
2	2.0 < x 2.5	Bad
3	2.5 < x 3.0	Slightly bad
4	3.0< x 3.5	Average
5	3.5 < x4.0	Slightly good
6	4.0 < x 4.5	Good
7	x 4.5	Very good

slightly good and the rice fields that are not affected by flooding have a SQI of 4.71 which is very good soil quality. The rice fields studied are close to rivers and are also located on the coast, so these rice fields have a high chance of flooding due to river water or sea water.

Flooding on this land is caused an increase in the frequency and intensity of high rainfall, or floods from upstream areas flowing to downstream areas. Table 6 shows that sea water flooding has higher soil quality than river water flooding. According to the (BPDLD, 2005) this is because sea water floods can cause less damage compared to river water floods because sea water is better at forming higher layers of soil. This can ensure the stability of paddy soil and help prevent soil erosion. In addition, rice fields affected by sea water flooding can be easier to restore because sea water has lower mineral content than river water. This can simplify the process of cultivating rice fields and help improve soil quality.

Table 8. Soil Quality Index Assessment

Flood Water Sources	Minimum Data Set (MDS)			SQI	Status
	Weight (Pi)				
	0.933	0.408	0.128		
Sea water flood	4	1	1	4.3	Good
River water flood	3	2	1	3.77	Slightly good
Not flooded	4	2	1	4.71	Very good

The quality of rice fields affected by sea water flooding is better than rice fields affected by river water floods because sea water floods that enter rice fields tend to be cleaner and more protected from industrial pollution or human activities. Apart from that, rice fields affected by sea water flooding are easier to improve the quality of the soil than when flooded by river water. Rice fields affected by river flooding are generally more affected by industrial pollution and human activities, resulting in poorer quality. This is caused by factors such as degradation of water quality due to activities of dumping waste into rivers and mining upstream of rivers which result in river water quality being disturbed. So many dangerous substances settle in rice fields when river water floods.

The impact of this flood causes a decrease in the productivity of rice fields because the chemical elements in the soil are disturbed. In terms of limiting factors, the most frequently encountered is low available phosphorus (Pt) content. According to Rachman *et al*. (2020) the element phosphorus (P) is an essential element for plants because it is a limiting factor that influences plant growth and production. In rice plants, the P element plays a role in encouraging root growth and development, triggering flowering and fruit ripening, especially in low climate conditions, encouraging the formation of many clumps/tills and supporting better grain formation and having better nutritional content in relation to P levels. in seeds.

Total organic N at the research location is also low. N is very necessary to support plant growth and production, especially through the formation and quality of leaves, chlorophyll content and leaf greenness, plant growth rate, dry plant weight, grain weight per plant, and so on. The organic carbon content is included in the medium category, this shows that there is still a lack of use of organic material in rice fields. (Mahir Rachman *et al*., 2020) stated that the use of organic materials on agricultural land is still limited to dry land with non-rice crops. In fact, organic material is very useful for improving the condition and quality of the soil, improving the physical, chemical and biological properties of the soil in addition to its very obvious role, namely increasing the content of essential nutrient elements in the soil that are needed for plant growth and production.

From table 6, areas with the criteria of not being affected by flooding have better quality than areas affected by sea water floods and river water floods due to several factors. Areas that are not affected by flooding will not experience damage such as erosion, sedimentation and damage to the top soil layer of the soil. Plants that grow on land that is not affected by flooding will be much better because the soil still contains a layer of top soil which contains the soil nutrients that plants need. Furthermore, the condition of land that is not affected by flooding is better because the land does not experience damage caused by flooding.

CONCLUSION

Good SQI values in rice fields affected by sea water flooding can be caused by effective soil management interventions such as the use of salt-resistant rice varieties, appropriate fertilization, and land processing technology that can reduce the negative impact of salinity. This implementation can help maintain the productivity of rice fields even though they are affected by sea water intrusion. The SQI value is Slightly good in rice fields affected by river flooding due to the high frequency of flooding which causes soil compaction and leaching of nutrients. With proper flood management, such as creating good drainage channels and conservation agricultural practices, these rice fields can still be maintained in fairly good condition. The SQI value is very good for rice fields not affected by flooding because the soil has higher stability in terms of moisture, salinity and nutrient availability. With proper management, this rice field can achieve excellent SQI values because it is not affected by disturbances caused by flooding.

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