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AGRO-PRODUCTION SOIL QUALITY INDEX ASSESSMENT FOR FIELDS WITH BIOLOGY INDICATOR IN SHEKI-ZAGATALA REGION, AZERBAIJAN

Prof. Dr. Z.H. Aliyev

Institute of Soil Science and Agrochemistry of the National Academy of Sciences of Azerbaijan

Corresponding author: *Z.H. Aliyev

Tel.: +234 Email: Volqa_5@mail.ru

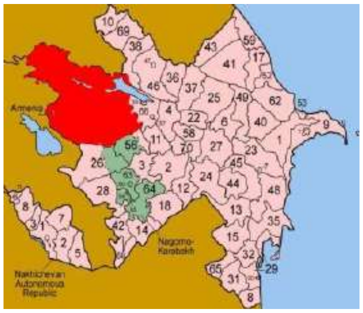
ABSTRACT:

The increased need for rice in the widespread use of rice fields in the Sheki Zagatala region, the management of rice fields, can reduce soil quality. Good governance can improve soil quality, has several management methods, such as organic, semi-organic and conventional tobacco field management, which really affect soil quality. Soil quality assessment is measured by physical, chemical and biological indicators, where each factor has a different effect. Basically, chemical indicators are often used as the main indicators for determining soil quality, while each parameter has the opportunity to be the main indicator. So, biological indicators have the ability to reproduce indicators. The main indicators are obtained from the correlation test (p-values ≤0.05 - <0.01) and analysis of the main components with a high value, eigenvalues> 1 have the potential to be used as minimal data sets. As a result, biological can be used as a minimal data set, such as microbial carbon biomass, respiration, and common bacterial colonies. The Soil Quality Index (SQI) of various tobacco management practices shows very low or low soil quality values. Management of organic systems practices shows a better Soil Quality Index with a score of 0.20 compared to other departments. Organic tobacco management practice shows that this can improve soil quality.

KEYWORDS:

Indicator Biology; Minimum Data Set, Soil Quality Index; Principal Component Analysis.

INTRODUCTION



Increasing food needs give rise to the wide paddy fields to meet food consumption [25][41]. Paddy field intesive management results in changes in soil quality that is low. There needs to be appropiate management to improve soil quality. Soil quality provides physical, chemical, and biological requirements for soul productivity, food quality and health, enviromental safety of animal and human plants [17][15].

Jatipurno Subdistrict is on of the sub-district in Wonogiri Regency. The use of rice fields in Jatipurno has an area of around 1322.14 ha or 25.20% [5] of the total land use area. Based on data from the Research and Development Agency of the Ministry of Agriculture, 3,250 million ha of rice containing organic matter is less than 2% [42]. This fact proves that rice fields have low fertility and soil quality. Long-term use of rice fields in Merauke has a low Soil Quality Index (SQI) of 0.33 [45]. Improper management of paddy fields use of inorganic fertilizers results in enviromental pollution making [49][11][35] the Soil Quality Index low.

Organic farming systems can improve the soil quality of [44] and the environment, especially in relation to biological activities in the soil, Mangunharjo village, Jatipurno, which has organic, semi-organic and conventional management. Evaluation of soil quality in various practices in managing paddy fields is still small. The value of organic and inorganic rice soil quality in the Susukan area has a Soil Quality Index (SQI) value of 0.42 and 0.3 in the medium category [34]. Soil Quality Index (SQI) can be used for soil quality assestment [18] [23] and SQI method easy in use and flexible when used with measurements [38][31][20][24][28]. However, most calculations of soil quality are determined by chemical indicators. Even though each indicator has the same opportunity to be used as the main indicator to determine the soil quality. Indicators that are generally used as indicators of soil quality such as aggregate stability, specific gravity, pH, salinity, CEC, microbial biomass and respiration [29].

The main problems with the implementation of soil quality indices are the classification of organisms at the spesifies level, which needs to be sorted out by specialists and is time comsuming. The species identification of soil organisms must be easy [8] in the biomonitong programme of soil quality. The nature of organic matter is related to the availability of C and microbial biomass. These factors make biological indicators have potential as the main indicator. Biological activities are considered difficult to assess even though they have an important role in the characteristics of a soil [38]. Naturally, soil organisms have an important role to play in managing and improving soil quality in a susitainable manner [5]. Appropriate management will have an impact on the safety of organisms in the soil [22] that can improve soil quality [12]. The transition of land from natural forest to intensive land use results in soil fertility [16] and soil biology index [21]. There is a need for reasearch on the biological parameter of soil as a good indicator [19] the main key to assesing soil quality [1]. The study of these problems is still small so there is a need to develop how much influence biological indicators determine soil quality, especially in the use of paddy fields in the Jatipurno area, Wonogiri. This research is expected to provide appropriate solutions regarding good soil quality, especially the influence of biological indicators on the process of increasing biological activity to improve the quality of paddy fields and increase rice production.

MATERIAL AND METHODS

Study Area

The study area is located in Mangunjarjo village, Jatipurno district, Wonogiri (fig. 1). The research conducted in September-October 2018, with altitude 527 m above sea level. Type of soil in this area is Latosol (Red-brownish). The selected area is management of organic paddy fields with the preparation of manure 3-4 tons/ha, semi-organic management with ethe provision of 1,5 – 2 kg/ha and 65 kg/ha of phonska fertilizer and management of inorganic paddy fields with phonska fertilizzer of 100-125 kg/ha. Age of paddy in three management systems is 35-40 days.

Soil Sampling

The research carried out with a field survey using purposive sampling method (criteria determined by researchers) with 9 sample points three replications. The taking of soil samples using a diagonal methods with 0-25 cm soil layer where there is one determinig point then we draw a diagonal line with a distance of 1 m then composite. Analyses of soil physical and chemical properties were carried out on composite sample from selected soil layer.

Analytical Methods

Soil analyze methods include physics, chemical and biological indicator such as soil texture by the pemipetan method, bulk density was determined by the piknometer method. Potensial hydrogen were measured using pH meter (elektrometic method). Total nitrogen (N-total) was measured by the Kjeldah method. Organic carbon (OC) was determined based on the Walkey Black rapid titration method. Cation Exchange Capacity (CEC), Base Saturation and Avalaible K was determined based on Amonium Asetat 1 N extraction. Exchangble Aluminium was determined based on saturation of potasium chloride. Available P was measured with Olsen method. Respiration measured by titrimetrik method. Biomass carbon was determined by fumigation method. Total kolony measured by pour plate method. All of these analyzes are based on [4]. Data has analyzed using 5% T test and if there were significant results it was continued by Duncan test on 5% levels.

Soil Quality Assessment

Soil quality assessment is a three-step process in the basis which the current tool was develop [2] such as selection of the minimum data set (MDS), data normalization and integration of the indicator scores into soil quality index (SQI). Thats tool can be applied to the variety of climate, soil type, management practices, and end-user goal. Consistent with data normality we used Pearson’s correlation to analyze between soil parameters. Soil physical-chemical and biological characterictics measured with Principal Component Analysis where select Principal Components with eigenvalues >1 [7,8] and/or contribution to explain variability 75%. For each of the PC selected based on criteria above, identify variables with highly weighted factor loadings. Multivariate procedure such as Principal Component Analysis (PCA) [3] and Loading Plot to get Minimum Data Set (MDS). That analyze to determine the most effective factors with influence on plot distribution, multivariate procedure. The selected data is then followed by Scoring (Si) based on [10]. Calculation of soil quality is done by summing the variable scores that have been multiplied by the Weight Index (Wi) [5] then classified according to [9] shown by in (Table 1)

$$IKT = \sum_{i=1}^{n} Wi \times Si$$

Better soil quality and better performance of soil quality indicators, soil having higher index score indicates.

Table 1. Soil Quality Index Classification

Soil Quality Index	Value	Class
Better	0,80-1	1
Good	0,60-0,79	2
Moderate	0,35-0,59	3
Low	0,20-0,34	4
Very Low	0-0,19	5

Figure 1 location of soil sampling

RESULT AND DISCUSSION

Characterictic Soil Biology-Chemical-Physics in Three Sites

Biological, chemical and physical properties have different characteristics depending on the management of the soil. The condition of paddy fields in Jatipurno managed organically has better biological, physical and chemical values compared to semi-organic and conventional management shown by in (Table 3). Analysis of biological indicators such as total colony, carbon biomass and microbial respiration in the management of organic paddy fields in Mangunharjo, Jatipurno has a higher value than semiorganic and conventional management. According to research [8] that giving manure 20kg/ha increases the bacterial population to 105cfu/ml and according to [46] that microbial respiration has a higher treatment with organic giving. The results of the Pearson correlation test showed that Total Colonies were significantly positively correlated with Carbon Biomass; Respiration; N total; P available; K available; and Organic C (r = 0.92 **, P-value = 0; r = 0.699 *, P-value = 0.036; r = 0.814 **, P-value = 0.008; r = 0.886 **, P-value = 0.001; r = 0.678 *, P-value = 0.045; r = 0.951 **, P-value = 0) can be seen in Table 2. According to [46] between soil respiration, carbon biomass and total microorganism have an association with one another which is determined by the organic matter content.

The value of Cation Exchange Capacity in paddy fields in each system organic, semi-organic and conventional has a low CEC value and no significant influence between treatments. Cation exchange capacity is always in line with basic saturation. But the results of CEC analysis with family planning did not correlate significantly. CEC analysis was positively correlated with available (r = 0.766, p-value = 0.016) can be seen in Table 2. Because the mineralization process would increase K cations. According to [43] high CEC is not always followed by high base saturation because CEC in tropical land does not always describe the number of cations that are absorbed by the soil but describes the cations absorbed on the colloidal surface.

Table 2. Soil Characteristics, Biological-Chemical-Physical In Three Site

Sites	Organic	Semi Organic	Anorganic
Variables	Mean	Mean	Mean
Total Colony (CFU/gram)	6.9 x 105 b	1.8 x 105 a	1.2 x 105 a
Carbon Biomass (mikrogram/gram)	36.21±7,81 b	20.80±1,93a	14.72±1,46a
Respiration (lbs CO2 m-2 jam-1)	11.24±5,50 c	8.21±3,94 b	4.34±8,51a
pH	6.37±0,58 b	6.27±0,58 b	6.03±0,12a
Cation Exchange Capacity (CEC) (me/100kg)	14.42±0,46 b	11.94±0,41a	13.30±1,39ab
Base Saturation (BS) (%)	28.79±12,37a	37.04±4,71a	25.15±6,92a
Total Nitrogen (%)	0.4±0,17 b	0.35±0,23a	0.31±0,23a
Organic Carbon (%)	2.37±0,57 [b]	1.13±0,21[a]	0.97±0,11[a]
Available P (ppm)	4.41±0,50 [b]	3.45±0,61 [b]	3.85±0,17[ab]
Available K (ppm)	2.93±0,75 [b]	1.42±0,18[a]	2.26±0,41[ab]
Exchangable Alumunium (%)	1.79±0,62[a]	2.62±0,72[a]	3.06±1,23[a]
Bulk Density (gram/cm-3)	2.15±0,13[a]	2.24±0,61[a]	2.09±0,13[a]

Description: CEC = Cation Exchange Capacity; BS = Base Saturation, Values are mean +- standard eror (n=27), different lowercase letters represent difference significant (P < 0.05).

The available value of organic management has a higher value compared to semi-organic and conventional management. According to [43] that the addition of organic materials such as rice straw and poultry manure has a high K content of 592 kg/ha of organic systems, and inorganic systems 548 kg/ha so as to increase K availability. Correlation test results that Kedia is available have a positive correlation significantly with Organic Carbon, Total Colony and Carbon Biomass (r = 0.732, p = 0.25; r = 0.678, p = 0.045; r = 0.666, p = 0.05) can be seen in Table 3.

The Mangunharjo rice field has Organic Carbon significantly due to management both organically, semiorganically and conventionally. Organic Carbon correlation results were correlated with Total Nitrogen, Available, and Available (r = 0.767, p = 0.016; r = 0.933, p = 0; r = 0.732, p = 0.025) can be seen in Table 2. Rice fields with organic systems have higher Organic Carbon content compared to other paddy fields. Provision of organic matter in rice fields with long periods of time will increase the Organic Carbon content in paddy soils [3].

The pH range is about 4 in both organic, semi-organic and conventional rice fields. According to [33] soil pH affects nutrient availability because H + ions take the place of negative charge on the surface of the soil. The pH value of 6.4 is classified as slightly acidic or tends to be neutral. Low pH will result in Al being mobile [14]. The highest available value obtained in organic treatment. In accordance with the study [4] that there was an increase in P due to the addition of organic matter from 8.93 ppm to 19.56 ppm.

TABLE 3. Pearson's correlation coefficient of biological parameters with chemical and physics parameters

Variable	Respiration	Biomassa Carbon	Total Kolony
Respiration (lbs CO_2 m^{-2} jam^{-1})	-	0.856**	0.699*
Carbon Biomassa (mikrogram/gram)	0.856**	-	0.92**
Total Colony (CFU/gram)	0.699*	0.92**	-
Bulk Density/ (gram cm^{-3})	0.142ns	0.13ns	-0.11ns
pH (pH H_2O)	0.757*	0.653ns	0.543ns
Total Nitrogen (%)	0.725*	0.807**	0.814**
Organic Carbon (%)	0.809**	0.981**	0.951**
Cation Exchange Capacity (CEC) (me/100kg)	0.368ns	0.561ns	0.521ns
Base Saturation (BS) (%)	0.134	0.226ns	0.059ns
Exchangable Alumunium (%)	-0.465ns	-0.664ns	-0.613
Available P (ppm)	0.891**	0.958**	0.886**
Available K (ppm)	0.277ns	0.666*	0.678*

*Significant ($P < 0.05$), ** Significant ($P < 0.01$), ns: No significant (n=27).

The weight of the type is related to congestion on a soil. BJ which has good balanced macro micro pores for developing microbial processes, root penetration, water retention and so on. According to [36] the lower soil density, it will make it easier for the roots to push the soil and break down the soil structure so that it becomes a way of aeration of the soil to hold and bind water and soil nutrients.

Soil Quality Index

Calculation of Soil Quality Index (SQI) with statistical applications in the form of Pearson Corellation Analyze and Principal Component Analysis (PCA). Analysis of the main components will produce PC data (Principal Component) or the main component. This PC data will be used to determine the Minimum Data Set (MDS) for the quality of a soil. Selected Principal Components are that have eigenvalues ≥1 [9]. From each selected PC, the highest values are taken, then it will be used as the weight index of the indicator in calculating the land quality index. This study PC1 to PC3 which is a PC that meets the requirements to become a data set with cumulative 84.3%, meaning that from the 8 indicators used to determine the Soil Quality Index of PC 1 to PC 3 (N-total, pH, available, Respiration, Organik Carbon, Base Saturation, Total Colony and Biomass have been able to represent 84.3% data. The results of MDS analysis using PCA can be seen in (Table 4)

TABLE 4. Principal Component Analyze of soil characteristic on rice field with several systems

Eigenvalue[a]	**6,8848**	**2,0596**	**1,1724**
Proportion	0,574	0,172	0,098
Cumulative	0,574	0,745	0,843
Eigenvectors[b]			
Variable	PC1	PC2	PC3
Capacity Exchange Cation	0,221	-0,49	0,143
Total N	**0,322**	0,183	-0,171
Bulk Density	0,043	0,051	0,263
Available P	**0,361**	0,088	-0,012
Exchangable Al	-0,27	0,097	-0,427
Respiration	**0,317**	0,185	-0,228
Organic Carbon	**0,37**	-0,083	-0,043
pH	0,265	**0,386**	-0,326
Available K	0,248	-0,374	0,179
Base Saturation	0,064	0,328	**0,706**
Total Kolony	**0,355**	-0,11	-0,083
Carbon Biomass	**0,377**	0,007	0,041

[a] Boldface eigenvalues correspond to the PCs examined for the index.
[b] Boldface factor loadings are considered highly weighted and includes in the Minimum Data Set

The indicators used as MDS soil quality are determined with the highest value in each PC that has been adjusted based on the longest plot and predetermined criteria (PC1 to PC3). The indicator with the highest value on PC1 is Ntotal, Available, Respiration, Organic C, Total Colony and Carbon Biomass get the proportion per analysis of 9.57% because it correlates with each other. PC2 consists of pH which has a proportion of 17.2%. Base Saturation on PC3 has a proportion of 9.8%. Determining Soil Quality Index is obtained from the selected PC indicator value to find the index weight value (Wi), where Wi is the proportion divided by cumulative results can be seen in (Table 5). The results of the weighting of the index are used to find the Soil Quality Index (SQI) by multiplying the scoring of the selected MDS analysis.

TABLE 5. Weight Index Calculation Of Minimum Data Set

Minimum Data Set	Proportion	Cumulative	Weight Index[a]
Total N	0,096	0,844	0,113
Available P	0,096	0,844	0,113
Respiration	0,096	0,844	0,113
Organic Carbon	0,096	0,844	0,113
pH	0,172	0,844	0,204
Total Kolony	0,096	0,844	0,113
Carbon Biomass	0,096	0,844	0,113
Base Saturation	0,098	0,844	0,116

[a] Weight index was obtained from proportion devided by cumulative

Soil quality scoring based on [4] can be seen in (Table.6). The results obtained from the calculation of the soil quality index are then classified according to [9]. Class of soil quality is divided into very good, good, medium, low and very low. Calculation of Soil Quality Index (SQI) can be seen in (Table.7)

TABLE 6. Skoring of Minimum Data Set

No	Minimum Data Set	Skoring								
		1	2	3	4	5	6	7	8	9
1	Base Saturation	1	2	3	2	2	2	2	1	2
2	Total N	3	3	3	3	3	3	3	2	2
3	Available P	1	1	1	1	1	1	1	1	1
4	Respiration	2	2	2	2	1	1	1	1	1
5	Organic Carbon	3	2	3	2	2	1	1	2	1

6	pH	2	2	2	2	2	2	2	2	2
7	Total Kolony	2	2	2	2	2	2	2	2	2
8	Carbon Biomass	1	1	1	1	1	1	1	1	1

Sample 1-3 is organic paddy fields; 4-6 is semi organic paddy fields; 7-9 is anorganic paddy fields.

The results (Table.7) obtained the Weight Index or Wi results per analysis from the proportion analysis that appeared in the main compenent multiplied by the scoring. Scoring results of all analyzes at each point were then added and modified according to [9].

TABLE 7. Skoring Soil Quality Index On Rice Field With Several Systems

No	Minimum Data Set (MDS)	Skoring*								
		1	2	3	4	5	6	7	8	9
1	Base Saturation	0,12	0,23	0,35	0,23	0,23	0,23	0,23	0,12	0,23
2	Total Nitrogen	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34
3	Available P	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11
4	Respiration	0,23	0,23	0,23	0,23	0,11	0,11	0,11	0,11	0,11
5	Organic Carbon	0,34	0,23	0,34	0,23	0,23	0,11	0,11	0,23	0,11
6	Potensial Hydrogen	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41	0,41
7	Total Kolony	0,23	0,23	0,23	0,23	0,23	0,23	0,23	0,23	0,23
8	Biomass Carbon	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11
Sum Soil Quality Index		0,19	0,19	0,21	0,19	0,18	0,17	0,17	0,17	0,17

The results of the sample scoring in each analysis can be seen that the state of samples 1 2 and 3 which are included in organic conditions have a higher value of the Soil Quality Index. Larger Soil Quality Index Figures indicate better value of data. Samples 4 5 and 6 which are included in semi-organic species have scoring that is between organic and non-organic. Transition of treatment between organic and non-organic apparently has a positive impact on the quality of a soil. Inorganic treatments in samples 7 8 and 9 have lower scoring compared to organic and semi-organic samples. The use of excessive chemicals without the support of organic inputs will reduce the level of soil quality [6].

The results of the scoring in (Table.6) obtained results that affect base saturation, available P, organic C and respiration which have higher scoring results in organic management compared to semi-organic and conventional management. The addition of organic matter can increase the cations on the soil surface which can provide nutrients for plants [3].

TABLE 8. Soil Quality Index On Rice Field With Several Systems

No	Paddy Field Sites	Soil Quality Index	Soil Quality Classificated
1	Organik	0,20	Low
2	Semi Organik	0,18	Very Low
3	Anorganic	0,17	Very Low

The results of the calculation of soil quality where the quality index is obtained from the scoring calculation multiplied by the index weight. The results obtained by soil quality index on land that has organic treatment have higher soil quality. Organic treatments have a soil quality index of 0.20 (low). The semi-organic sample treatment has a moderate soil quality of around 0.18 (very low). Inorganic or conventional treatments have a soil quality value of around 0.17 which has a very low value. According to [33] the use of paddy fields with organic systems will change the quality of the land to be better if done in the long term. The levels of organic C-elements in organic systems have a higher value that can affect the number of microbes, C microbial biomass and microbial respiration which can increase biological activity to improve soil quality. The difference in management in the Mangunharjo rice field, Jatipurno has a significant difference after the T test can be concluded that organic management has an effect on better soil quality improvement with a p-value of 0.002 with conventional and semi-biological management with a p-value of 0.010.

CONCLUSIONS

The quality of paddy soil in Mangunharjo Village managed organically has better soil quality compared to semi-organic and conventional management with soil quality index values respectively 0.20, 0.17 and 0.15.Biological indicators which include respiration, microbial biomass, and total colonies can be used in determining the paddy soil quality index in Mangunharjo Village, Jatipurno District. Rice production using organic rice systems over a period of more than 6 years has a lower yield compared to the management of semiorganic and conventional rice systems.

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