Study on chemical and biological properties of paddy soils in Nagari Taram, Harau District, Lima Puluh Kota Regency

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Abstract. Intensive cultivation of paddy soil without giving rest to the soil for years will affect the chemical properties and the presence of microorganisms in the soil. This study aims to examine some of the chemical properties of paddy soil such as pH, CEC, Total organic carbon, exchangeable bases, Total N, Available P, silica content and calculating the population and respiration of microorganisms at various slopes. This research is located in Nagari Taram, Harau District, Limapuluh Kota Regency. The study used a survey method in four stages, namely preparation, pre-survey, main survey and sampling, laboratory analysis and data processing. Samples were taken on rice fields that have been cultivated for approximately 100 years at a depth of 0-20 cm at 5 slopes those are 0-3%, 3-8%, 8-15%, 15-25% and 25-45%. Based on the results of the data analysis it is known that differences in slope affect the chemical and biological properties of the soil. The higher the slope, the decreased several soil chemical properties such as pH, C-organic, P- available, total N, CEC and silica. Soil microorganism populations varied for each slope. The highest bacterial and fungal populations were found on land with a slope of 0-3%, while the highest respiration of soil microorganisms occurred on lands with a slope of 3-8% that is 13.8 mg / kg / day.

Keywords: incepticol, paddy soil, slope, soil microorganisms

1. Introduction
Nagari Taram is located in Harau District, Lima Puluh Kota Regency, West Sumatera Province, Indonesia. Nagari Taram has 934 hectares of rice fields, about 23.69% of the rice field area of Harau District [1]. The rice fields in Nagari Taram are irrigated rice fields so that farmers never think about the water needs of the fields that will be cultivated or planted throughout the year. Intensive cultivation of lowland soils without coverage for years will affect the chemical properties of the soil and the presence of microorganisms in the soil.

Until now, there is no report about chemical and biological properties about soil in the rice fields of Nagari Taram. So, we did a study with the purpose to examine some of the chemical properties of paddy soil [Inceptisol] in the form of pH [H2O], CEC, Organic Carbon, Exchangeable Bases, Total N, Available P, Silica, and calculate the population of microorganisms and respiration of microorganisms in paddy fields of various slope.

2. Materials and Methods
The research was conducted from April to October 2020 using a survey method. Soil sampling was conducted in Nagari Taram, Harau District, Lima Puluh Kota Regency, West Sumatera. The analysis
was carried out at the Laboratory of Chemistry and Soil Biology, Faculty of Agriculture, Andalas University.

The sampling technique was the stratified random sampling method based on the area of the study at a depth of 0-20 cm based on the slope. Analysis of soil chemical properties in the laboratory includes pH \([H_2O]\), Organic Carbon, Total N, Available P, SiO\(_2\), Cation Exchange Capacity, Base Cations and analysis of soil biological properties including bacterial and fungal populations, and respiration of microorganisms.

3. Result and Discussion

3.1. pH of paddy soil in Nagari Taram

| Slope | Sample | pH \([H_2O]\) | Criteria |
|-------|--------|---------------|----------|
| 0-3%  | A.1    | 4.54          | Acid     |
|       | A.2    | 4.59          | Acid     |
|       | A.3    | 4.56          | Acid     |
| 3-8%  | B.1    | 5.27          | Acid     |
| 8-15% | C.1    | 4.97          | Acid     |
| 15-25%| D.1    | 4.47          | Very acidic |
| 25-45%| E.1    | 4.36          | Very acidic |

Table 1 shows that paddy soil pH is ranging from acid to very acidic. The pH value ranged from 4.36 to 5.27. The lowest pH [4.36] was found in rice fields with a slope of 25-45%. The highest pH [5.27] value was found in fields with a slope of 3-8%. The high pH on the 3-8% slope is influenced by the application of fertilizers. Fertilization management is different in terms of the dosage of fertilizers used, especially urea, which uses inappropriate amounts and in large quantities and continuously \([\pm 100\ years]\), resulting the increased value of ammonium saturation which can change the acidity of the paddy soil. Besides fertilizer, the difference in slope also affects the pH value of the paddy soil in the study area.

3.2. C-Organic, available P, and Total N content of paddy soil in Nagari Taram

| Slope | Samples | C-Organic [%] | Available P [ppm] | Total N [%] |
|-------|--------|---------------|-------------------|-------------|
| 0-3%  | A1     | 1.63 [Less]   | 58.06 [High]     | 0.25 [Sufficient] |
|       | A2     | 1.52 [Less]   | 47.09 [High]     | 0.24 [Sufficient] |
|       | A3     | 1.49 [Less]   | 54.94 [High]     | 0.24 [Sufficient] |
| 3-8%  | B1     | 1.53 [Less]   | 57.63 [High]     | 0.19 [Less] |
| 8-15% | C1     | 1.27 [Less]   | 30.61 [Sufficient] | 0.17 [Less] |
| 15-25%| D1     | 1.09 [Less]   | 21.07 [Sufficient] | 0.07 [Very Less] |
| 25-45%| E1     | 1.01 [Less]   | 16.69 [Sufficient] | 0.09 [Very Less] |
The content of C-organic in paddy soil in Nagari Taram ranges from 1.01 - 1.63% belonging to the low criteria. This low C-organic content is due to the use of C elements by rice plants to support their growth and it is used by microorganisms as their energy source. This low C-organic content indicates that the paddy soil in Nagari Taram is in poor condition.

The available P nutrient content of paddy soil in Nagari Taram has sufficient to high criteria. The P nutrient content ranged from 16.69 to 58.06 ppm. The variation in the available P content in paddy soil is assumed due to different management of paddy fields by farmers such as fertilizers containing P. Besides, the available P-value is also influenced by the position and topography of the paddy fields.

Then, the N-total content of paddy soil is in moderate to very low level that ranging from 0.09 - 0.25%. The N-total value of the soil is low, which is expected because of the very low organic matter. If the organic matter is low, the total N in the soil will also be low. The low N-total value in the soil apart from the above factors is also influenced by leaching. This is in line with statement by Triyono et al. [2], which states that in a flooded state the N nutrient will be leached.

3.3. Cation Exchange Capacity [CEC] and Base Saturation of paddy soil in Nagari Taram

| Slope    | Sample | CEC [me/100g] | Base Cations [me/100g] |
|----------|--------|---------------|------------------------|
| 0-3%     | A1     | 21.06952 [Sufficient] | 9.07 [Very Less] |
|          | A2     | 20.25586 [Sufficient]  | 9.08 [Very Less] |
|          | A3     | 18.42498 [Sufficient]  | 9.69 [Very Less] |
| 3-8%     | B1     | 17.41987 [Sufficient]  | 12.19 [Very Less] |
| 8-15%    | C1     | 10.75965 [Less]       | 17.08 [Very Less] |
| 15-25%   | D1     | 7.359963 [Less]       | 23.80 [Less] |
| 25-45%   | E1     | 6.625019 [Less]       | 25.69 [Less] |

The data in Table 3 shows that the value of cation exchange capacity in paddy soil has sufficient to low status. The lowest value is found at the slope of 25-45%. This is in line with the low value of C-organic at the slope. While the base saturation is low to very low that ranges between 25.69 - 9.07%. This value is influenced by the pH of the paddy soil which is acid to very acidic.

3.4. Silica content of paddy soil in Nagari Taram

| Slope    | Sample | SiO₂ [ppm] |
|----------|--------|------------|
| 0-3%     | A.1    | 91.57 [Sufficient] |
|          | A.2    | 90.35 [Sufficient] |
|          | A.3    | 88.47 [Sufficient] |
| 3-8%     | B.1    | 93.12 [Sufficient] |
| 8-15%    | C.1    | 50.43 [Less] |
| 15-25%   | D.1    | 47.44 [Less] |
| 25-45%   | E. 1   | 39.12 [Less] |
Management of paddy fields in Nagari Taram also affects the content of silica elements in paddy soil [3]. From the results of the analysis, the silica content of the paddy fields in Nagari Taram was classified as insufficient to sufficient, with the $\text{SiO}_4$ nutrient content varying between 39.12 - 93.12 ppm. The value of silica in the soil is influenced by the types of soil [4]. The paddy soil in the study area is classified as young soil, namely inceptisol.

3.5. Biological properties of paddy soil in Nagari Taram

The data in Table 5 shows the micropopulation of soil organisms. Both bacteria and fungi is higher at a slope of 0-3%. The position of land with a high slope will experience more erosion which results in a low content of soil organic matter which is a source of energy for microorganisms [5] [6]. The highest micro-respiration of soil organisms is on land with a slope of 3-8% which is 13.8 mg/Kg/day $\text{CO}_2$. The activity of soil microorganisms is influenced by many factors such as energy sources, lighting and soil average and drainage conditions [7].

| Slope   | Sample | Bacteria Population [CFU] | Fungi Population [CFU] | Respiration [mg/Kg/day $\text{CO}_2$] |
|---------|--------|---------------------------|------------------------|---------------------------------------|
| 0-3%    | A.1    | $8.1 \times 10^6$         | $9.6 \times 10^4$      | 9.3                                   |
|         | A.2    | $5.3 \times 10^6$         | $1.2 \times 10^5$      | 8.4                                   |
|         | A.3    | $1.7 \times 10^7$         | $2.9 \times 10^6$      | 11.7                                  |
| 3-8%    | B.1    | $1.5 \times 10^7$         | $1.3 \times 10^5$      | 13.8                                  |
| 8-15%   | C.1    | $1.1 \times 10^7$         | $2.9 \times 10^6$      | 11.4                                  |
| 15-25%  | D.1    | $5.2 \times 10^6$         | $9.3 \times 10^4$      | 9.5                                   |
| 25-45%  | E.1    | $3.2 \times 10^6$         | $1.1 \times 10^5$      | 7.9                                   |

4. Conclusion

From the research we concluded that the higher the slope, several soil chemical properties such as soil pH, Organic Carbon, Available P, Total N and soil CEC is decreased. The population of soil microorganisms [fungi and bacteria] is higher on land with a slope of 0-3% while the highest soil microorganism respiration is on land with a slope of 3-8%.

Acknowledgments

The author thanks the Agriculture Faculty of Andalas University for financially supporting this research through PNPB in line with research contract number 01/PL/SPK/PNP/FAPERTA-Unand/2020 date 14 May 2020.

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