Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Microbial Respiration Rate And Chemical Properties Of Soil From Different Land Use Applied With Farmyard Manure

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This study aimed to evaluate the effect of farmyard manure application, determine the effect of land use, and know if there is an interaction effect between farmyard manure application and land use on the microbial respiration rate and chemical properties of soils. Soil samples were collected from four land use namely: disturbed grassland, paddy, artificial forest and cornfield. Laboratory incubation was set-up using factorial in Completely Randomized Design with farmyard manure application as Factor A and land use as Factor B. Chemical analyses of samples in terms of soil pH, soil organic matter (SOM), total nitrogen (N), available phosphorus (P) and exchangeable potassium (K) were done. Results of the study revealed that farmyard manure application improved the microbial respiration rate, soil pH, SOM content, total N and exchangeable K of soil. Application of farmyard manure resulted to a decline in soil P within one week after incorporation. Likewise, microbial respiration rate and all chemical properties of soil varied with different land use. There was a significant interaction effect between farmyard manure application and land use on soil pH, SOM, available P and exchangeable K of soil. Farmyard manure application in paddy soil improved soil pH condition and organic matter accumulation. In artificial forest soil, application of farmyard manure led to the enhancement of soil organic matter content. Application of farmyard manure in cornfield resulted to higher exchangeable K.

Keywords: available P, exchangeable K, farmyard manure, land use, microbial respiration rate, soil organic matter, soil pH, total N.

Introduction

Microorganisms abound in the soil and are critical to ecosystem processes such as decomposition of organic residues and recycling of soil nutrient (Magdoff & Van, 2001). Soil microorganisms exist in large numbers in the soil as long as there is a carbon source for energy. A large number of bacteria in the soil exists, but because of their small size, they have a smaller biomass. Actinomycetes are a factor of 10 times smaller in number but are larger in size so they are similar in biomass to bacteria. Fungus population numbers are smaller but they dominate the soil biomass when the soil is not disturbed. Bacteria, actinomycetes, and protozoa are hardy and can tolerate more soil disturbance than fungal populations so they dominate in tilled soils while fungal and nematode populations tend to dominate in untilled or no-till soils (Hoorman and Islam, 2010).

Meanwhile, microbial respiration is vital in maintaining soil ecosystem. This oxidative process occurs within living cells, which releases chemical energy of organic molecules in a series of metabolic steps, involving the consumption of oxygen (O_2) and the liberation of carbon dioxide (CO_2) and water (H_2O). Among the various organisms in the soil, microbes play a fundamental part in the decomposition of organic matter which entails the highest possible source of CO2 available for soil (Pankhurst et al., 1997).

Chemical properties represent the complex chemical reactions and processes occurring in the soils. They represent nutrient availability, deficiency, toxicity, salinity and sodicity just to name a few. Almost all of the properties require field equipment or laboratory analysis for measurement. They include: electrical conductivity, pH, nutrient content, cation exchange capacity, sodium adsorption ratio, C: N ratio, base saturation, exchangeable cations, exchangeable acidity, trace elements and heavy metals (Soil Health Nexus, 2020).

On the other hand, the term land use is used to describe the human use of land. It represents the economic and cultural activities e.g., agricultural, residential, industrial, mining, and recreational uses that are practiced at a given place. Land use differs from land cover in that some uses are not always physically obvious e.g., land used for producing timber but not harvested for many years and forested land designated as wilderness will both appear as forest-covered, but they have different uses (US EPA, 2021).

In crop production, addition of organic materials such as farmyard manure has been practiced to provide additional nutrient source for the growing crops. Farmyard manure is a fertilizer composed of waste products, typically dung and urine, produced by farm animals. The waste products contain a wealth of nutrients, especially nitrogen which is an extremely important element that plants need (Bergstresser, Undated). In particular, the use of carabao manure as an amendment offers potential especially for the emerging organic agriculture community. Carabao manure is derived from the consumption of natural forage crops devoid of heavy metals and other toxins, as compared to animal manures produced using commercial feeds such as chicken dung and swine manure. Likewise, the abundance of carabao manure in the locality being used by gardeners and small scale farmers prompted the researcher to use this amendment. In terms of chemical composition, carabao manure has 1.09% nitrogen, 0.82% phosphorus, 0.70% potassium and 0.19% calcium (Cosico, 1985).

Determination of soil microbial respiration rates is essential in estimating the microbial population in soil. Since soil microorganisms are vital in ecological processes such as organic matter decomposition and nutrient cycling, estimates of their population will likely provide information on the rate of nutrient transformation and nutrient availability under differing land use systems. Hence, this investigation was undertaken.

Materials and Methods

Sampling Sites Identification and Characterization

There were four sampling sites used in the study: a grassland, rice paddy, forest, and corn field located at Sitio Aliwas, Burias, Mambusao, Capiz. The four land use types were selected because they are adjacent to each other and they belong to the same soil type Alimodian clay loam. It was ensured that the sampling sites belong to the same soil type because different soil types can be another factor that would affect the soil's physical and chemical properties.

After identifying the sampling sites, it was visited to seek permission if soil sampling can be done in the area. Upon the approval for the conduct of soil sampling, the land owners were interviewed regarding the years that the area had been devoted for that particular land use. Likewise, the present vegetation in the area was documented.

Soil Sample Collection and Processing

In each sampling site, collection of soil samples was done following the zigzag pattern. The randomly identified sampling points were cleared of unnecessary vegetation and other debris, then soil samples were collected to a depth of 30 cm using a spade. Sampling was done early in the morning in order to finish it in a day. Six subsamples of soils approximately one kilogram each were collected from each type of land use. Within the same day, those samples were brought to the Laboratory ready for incubation experiment on the amount CO_2 evolved.

Processing of Soil Samples for Microbial Respiration

Three subsamples of the freshly collected soil were mixed. From the mixture, three composite samples were taken for microbial respiration rate experiment. This was done separately per land use. Then, each sample was put immediately in a ziplock plastic bag and stored in an ice chest.

Processing of Soil Samples for Chemical Analysis

The remaining three subsample of soil from each land use type were used for determining the chemical properties of soil. Samples were air-dried in the laboratory. After 3 days of air drying, the samples were crushed/pulverized and sifted using a 2mm mesh sieve. Then, the soil material passing the 2mm sieve were collected and placed in properly labelled plastic ready for chemical analysis.

Experimental Design and Treatments

Two factors were tested in this study. Factor A pertains to farmyard manure application (A1 – no application, A2 – with farmyard manure application). Factor B on the other hand refers to the different land use, such as B1 – grassland, B2 – paddy, B3 – forest, and B4 – corn field. Microbial respiration rate experiment employed a factorial in Completely Randomized Design (CRD) with eight treatment combinations replicated thrice. The study was laid – out inside the laboratory. The eight-treatment combinations included in this study are as follows: A1B1 – Grassland soil with no farmyard manure application, A1B2 – Paddy soil with no farmyard manure application, A1B3 – Forest soil with no farmyard manure application, A1B4 – Corn field soil with no farmyard manure application, A2B1 – Grassland soil with farmyard manure application, A2B2 – Paddy soil with farmyard manure application, A2B3 – Forest soil with farmyard manure application, and A2B4 – Corn field soil with farmyard manure application.

Determination of Microbial Respiration Rate

This was determined following the procedure in the Soils Laboratory Manual (Revised 2014) of the Soils and Agro-Ecosystem Division, College of Agriculture of the University of the Philippines Los Baňos, with minimal modifications to suit the condition of the current study.

Incubation for CO2 evolution. Fifty grams of soil to be tested was weighed and placed in a wide mouthed jar with cap. Then, 0.5 gram of farmyard manure was added. The soil and farmyard manure were mixed thoroughly. At the same time, 50 grams of soil without farmyard manure was incubated in another bottle. A beaker containing 30 mL of 0.3N NaOH was placed in the center of each bottle. The cap was screwed tightly and the soil was incubated at room temperature for one week.

Determination of CO2 evolved. After a week of incubation, the bottle was opened and the contents of the beaker were transferred to a 125mL Erlenmeyer flask. It was added with 3 drops of phenolphthalein and 1mL of 50% BaCl2. Using an acid burette, the solution was titrated slowly with 0.2N HCl until the pink color disappeared. The amount of acid used to neutralize the base was recorded. Likewise, 30mL of fresh sample of 0.3N NaOH was titrated.

The amount of carbon dioxide evolved expressed as milligram carbon dioxide produced per 100 grams soil was calculated using the formula from the titration data of the amount of CO2 evolved:

$$\text{mg of CO2} = (B\text{-}V) \times 22 \times N \times 2$$

where: V = Volume (mL) of acid used to titrate the alkali in the CO_2 trap to the end point
B = Volume (mL) of acid used to titrate the fresh sample of alkali to the end point
N = Normality of the acid
22 = weight of 1 meq CO_2 in mg

Determination of Soil Chemical Properties

The procedures of PCARR (1980) were employed in determining the chemical properties of soil.

Soil pH. This was determined potentiometrically in 0.01M calcium chloride using 1:2 soil-solution ratio.

Soil organic matter. This analysis was made following the Walkley-Black method. This involved wet combustion of the organic matter with a mixture of potassium dichromate and sulfuric acid. The residual dichromate was titrated against ferrous sulfate.

Total nitrogen. This was determined following the Kjeldahl method where organic matter in the soil samples was digested with concentrated sulfuric acid in the presence of salt mixture. The ammonium-N liberated by digestion was determined by distillation making use of boric acid as the receiver and was titrated with standard sulfuric acid.

Available phosphorus. Available P was analyzed using the Bray No. 2 method where phosphorus in soil was extracted with a combination of HCl and NH_4F. Phosphate in the extract was determined colorimetrically with the development of blue phosphomolybdate complex with stannous chloride as the reducing agent. Percent absorbance was read using a spectrophotometer.

Exchangeable potassium. This was analyzed following the quick method using ammonium acetate extraction. The concentration of potassium in the dilution was read directly in a flame photometer.

Data Analysis

Data on the microbial respiration rate and chemical properties of soil from different land use applied with farmyard manure were analyzed using the analysis of variance (ANOVA) for factorial in CRD and the results were interpreted at 5% level of significance. Least Significant Difference (LSD) test was used to determine significant differences among treatment means. Duncan's Multiple Range Test (DMRT) was used to determine significant interaction effect.

Results and Discussion

General Description of the Sampling Sites

Disturbed Grassland. The disturbed grassland sampling site is situated in Capiz State University, Burias Campus, Barangay Burias, Mambusao Capiz with coordinates 11^0 26' 50" N latitude, 122^0 32' 33" E longitude. The present vegetation is dominated by grasses with few shrubs and its topography was slightly hilly. An interview of the nearby household revealed that the area had been devoted to disturbed grassland for more than 10 years. It was open for grazing of carabaos and cattles.

Rice Paddy. The rice field sampling site is located in Sitio Aliwas, Barangay Burias, Mambusao Capiz with coordinates of 11^0 26' 53" N latitude, 122^0 32' 33" E longitude. Present vegetation in the area was rice. The topography was flat, and human influence included land preparation, planting, application of synthetic fertilizers and other farm practices. Upon the approval of permission letter, the land owner was asked and it was known that the area had been a ricefield for 4 ½ years.

Artificial Forest Area. Artificial forest site is found in Capiz State University, Burias Campus, Barangay Burias, Mambusao Capiz with coordinates of 11^0 26' 56" N latitude, 122^0 32' 41" E longitude. The present vegetation in the artificial forest included different species of trees, shrubs and vines. The topography was flat. Signs of human influence included burning of woods for charcoal and different kinds of household wastes. An interview of the local revealed that the area had been devoted to forestry for more than 30 years.

Cornfield. Cornfield sampling site is situated in Sitio Aliwas, Barangay Burias, Mambusao Capiz with coordinates of 11^0 26' 58" N latitude, 122^0 32' 37" E longitude. Present vegetation in the area was corn. The topography was very hilly, and human influence included land preparation, planting, application of synthetic fertilizers, spraying of glyphosate and other farm practices. Upon the approval of permission letter, the land owner was asked and he said that the area had been a cornfield for 5 years.

All the sampling areas belong to the Alimodian clay loam soil type. According to Carating et al. (2014), Alimodian soil series is taxonomically known as Typic Hapludalfs. This soil series was first described in the municipality of Alimodian, province of Iloilo, Philippines. This soil series originated from weathered shale and sandstone, with shale predominating. The surface soil is brown to reddish brown clay loam with good medium granular structure that is slightly friable when wet but brittle when dry. The subsoil is light brown clay loam with weak medium columnar structure that is slightly brittle and slightly compact.

Microbial Respiration Rate as Affected by Farmyard Manure Application and Land Use

In Table 1.0, the results on the microbial respiration rate of soils as affected by farmyard manure application after one week of incubation significant differed ($p<0.01$), implying that the application of farmyard manure highly influenced the microbial respiration rate of soil samples. Least Significant Difference (LSD) test further revealed that soil samples amended with farmyard manure had higher microbial respiration rate as compared to unamended samples. Graham et al. (2012) similarly reported that adding organic amendments such as manure results in increased microbial biomass and higher microbial activity. The carbon and other nutrients in manure can increase microbial biomass and soil respiration rates by two to three times. Much of the increase in microbial activity is due to increases in bacterial populations.

Likewise, it was revealed that the result in terms of land use was highly significant. This means that microbial respiration rate differed significantly with land use. LSD test revealed that soils in the paddy and artificial forest comparably recorded the highest microbial respiration rate of 47.08 mg CO_2 and 43.71 mg CO_2, respectively. These were found higher than that of the microbial respiration rate of soil from the grassland area. Soil in the cornfield recorded the lowest microbial respiration rate of 19.95 mg CO_2.

In the case of rice paddy, this result could be attributed to the fact that rice farmers were returning back the residues to the field. Also, farmers utilized carabao in cultivating the field and the carabao's manure released during field operation are left in the field. These conditions provided enough organic materials in rice paddy which served as food for microorganisms. On the other hand, artificial forest floor had a lot of organic litters such as fallen branches and leaves. These likewise served as food source of the microorganisms. For disturbed grassland, less organic materials had been accumulated since the grasses are continually grazed by farm animals. In cornfield, plants were cut during harvest and so less organic materials are returned back to the soil. The lower microbial population in cornfield could also be due to the application of glyphosate which destroy the soil microbiota.

On the other hand, analysis of variance revealed that there is no significant interaction between the two factors. This means that the effect of farmyard manure application and land use on the microbial respiration rate is independent of each other.

Table 1.0. Microbial respiration rate (mg CO_2) of soils under different land use as affected by farmyard manure application.

Land Use	Manure Application		Total	Mean
	Without Application	With Application		
Disturbed grassland	16.72	35.48	52.20	26.10 b
Paddy	35.20	58.96	94.16	47.08 a
Artificial forest	36.96	50.45	87.41	43.71 a
Cornfield	11.44	28.45	39.89	19.95 c
Total	100.32	173.35	273.67	
Mean	25.08 b	43.34 a		34.21

LSD (a) =6.0919; LSD (b) =4.3076; Means followed by the same letter are not significantly different from each other.

Soil Chemical Properties as Affected by Farmyard Manure Application and Land Use

Soil pH

The pH of soils under different land use was highly influenced by farmyard manure application (Table 2.0). It was further revealed that soil samples amended with farmyard manure had higher pH than unamended samples. Similarly, the result in terms of land use was highly significant, denoting that the soil pH varied significantly depending on the land use. LSD test showed that soils in the paddy had the highest pH while soil pH in the cornfield was the lowest.

Also, it was manifested that there is a significant interaction between the two variables. This means that the effects of farmyard manure application and land use on soil pH are interrelated. It was found out that application of farmyard manure in paddy soil resulted to the highest pH. On the other hand, unamended soil from the cornfield resulted to the lowest pH.

Land use intensification from more pristine grasslands to intensive agricultural systems generally tends to increase the soil pH and typically leads to decreased soil carbon concentration, reduced water retention and poorer soil structure (Malik et al., 2018). Furthermore, manure can also contain components with potential liming effects on the soil. This particular contribution can help keep soil pH in normal levels, maximizing nutrients availability for crops (Olivo, 2019).

Table 2.0 Soil pH under different land use as affected by farmyard manure application.

Land Use	Manure Application		TOTAL	MEAN
	Without Application	With Application		
Disturbed grassland	5.09 e	5.49 c	10.58	5.29 c
Paddy	5.64 b	5.91 a	11.55	5.78 a
Artificial forest	5.22 d	5.66 b	10.89	5.44 b
Cornfield	4.44 g	4.68 f	9.12	4.56 d
TOTAL	20.40	21.74	42.14	

MEAN	5.10 b	5.43 a		5.27

LSD (a x b) = 0.0998; Means followed by the same letter are not significantly different from each other.

Soil Organic Matter (SOM)

The organic matter content (%) of soils was highly affected by farmyard manure application (Table 3.0). It was revealed that soil samples amended with farmyard manure had higher SOM than the unamended samples. Olivo (2019) forwarded the idea that over the long term, when manure with high carbon content is applied, such as beef manure, soil organic matter increases. As organic matter increases, more nutrients come available due to a larger pool of nutrients. The benefits from increased soil organic matter are exhibited by an improvement in other physical and biological properties as well.

Similarly, it was revealed that the result in terms of land use was highly significant, implying that the organic matter content of soils differed significantly depending on the land use. LSD test revealed that soils in the artificial forest had the highest organic matter content. Soils in the cornfield and disturbed grassland comparably recorded the lowest organic matter content. This is consistent with Malanguis et al. (2017) that the mean organic matter content was lowest (2.18% ± 0.89) in grassland while the highest (3.44% ± 0.89) was observed in the reforestation site.

There is likewise, a significant interaction between the two variables, indicating that the effects of farmyard manure and land use on soil organic matter content are interdependent with each other. DMRT revealed that farmyard manure application in paddy and artificial forest soil resulted to the highest organic matter content. Meanwhile, unamended disturbed grassland and cornfield soil had the lowest organic matter content.

Table 3.0. Organic matter content (%) of soils under different land use as affected by farmyard manure application.

Land Use	**Manure Application**		TOTAL	MEAN
	Without Application	With Application		
Disturbed grassland	1.98 ef	2.38 de	4.36	2.18 c
Paddy	2.89 c	4.19 a	7.08	3.54 b
Artificial forest	3.67 b	4.56 a	8.23	4.11 a
Cornfield	1.56 f	2.52 cd	4.08	2.04 c
TOTAL	10.10	13.65	23.74	
MEAN	2.52 b	3.41 a		2.97

LSD (a x b) =0.4187; Means followed by the same letter are not significantly different from each other.

Total Nitrogen (N)

After one week of incubation, the total N content of soils under different land use was highly affected by farmyard manure application. This connotes that the application of farmyard manure had a significant impact on the total N content of soil samples. When compared to unamended samples, LSD test revealed that soil samples amended with farmyard manure had higher total N content. Han et al. (2016) reported the result of their experiment that soil nitrogen content increased by 17% after the organic manure treatment, while soil nitrogen content after NPK fertilizer treatment was similar to that of the control group.

Likewise, it was manifested that the result in terms of land use was highly significant, implying that the total N varied significantly with land use. LSD test showed that soils in the artificial forest recorded the highest total N content, while soil in the cornfield posted the lowest total N content. Andrade et al. (2020) supported the idea that land-use and land management practices have a significant impact on soil quality. The carbon and nitrogen content decreased with increasing depth. This similarity in the pattern is explained by nitrogen and carbon being components of the structure of organic matter. The low accumulation of organic matter can be due to the limited production of plant biomass and rapid mineralization during the rainy season, which results in low levels of nitrogen.

On the other hand, it was manifested that there is no significant interaction between the two factors. This means that the effect of farmyard manure and land use on the total N content of soil is independent of each other.

Table 4.0. Total nitrogen content (%) of soils under different land use as affected by farmyard manure application.

Land Use	**Manure Application**		TOTAL	MEAN
	Without Application	With Application		
Disturbed grassland	0.22	0.28	0.50	0.25 b
Paddy	0.19	0.36	0.54	0.27 b
Artificial forest	0.30	0.38	0.68	0.34 a
Cornfield	0.11	0.22	0.33	0.16 c
TOTAL	0.82	1.24	2.06	
MEAN	0.20 b	0.31 a		0.26

LSD (a) =0.0390; LSD (b) = 0.0552; Means followed by the same letter are not significantly different from each other.

Available Phosphorus (P)

The results on the available P content (ppm) of soils under different land use as affected by farmyard manure application one week after incubation was highly significant. This means that farmyard manure application had a significant effect on the available P content of the soil. LSD test further revealed that unamended samples had higher available P content than soils amended with farmyard manure. There was an increased microbial activity in farmyard manure amended soil which have immobilized most of the available P as this element is being tied-up in the tissues of microorganisms.

It was also revealed that the available P content of soils varied significantly depending on land use. LSD test manifested that soils in the paddy and cornfield comparably recorded higher available P content. Soils in the disturbed grassland and artificial forest comparably posted lower available P content. The fertilizers applied in paddy and cornfield may have led to the accumulation of P and other fertilizer elements in the soil.

Likewise, a significant interaction effect was established between the two variables. It was revealed that unamended paddy soil resulted to the highest available P. However, farmyard manure application in paddy soil resulted to the lowest available P which was comparable to the available P recorded in disturbed grassland and artificial forest soil regardless of farmyard manure application.

Table 5.0. Available phosphorus content (ppm) of soils under different land use as affected by farmyard manure application.

Land Use	**Manure Application**		TOTAL	MEAN
	Without Application	With Application		
Disturbed grassland	245.61 cd	211.69 d	457.31	228.65 b
Paddy	774.27 a	201.17 d	975.44	487.72 a
Artificial forest	264.33 cd	309.94 cd	574.27	287.13 b
Cornfield	359.18 c	573.10 b	932.28	466.14 a
TOTAL	1643.39	1295.90	2939.29	
MEAN	410.85 a	323.98 b		367.41

LSD (a x b) =107.9872; Means followed by the same letter are not significantly different from each other.

Exchangeable Potassium (K)

It was manifested in Table 6.0 that farmyard manure application highly influenced the exchangeable K of soils. LSD test manifested that soils amended with farmyard manure had higher exchangeable K content than unamended soil samples.

Likewise, it was manifested that the exchangeable K of soils varied significantly depending on land use. LSD test showed that soils in the cornfield recorded the highest exchangeable K content, while soils in the disturbed grassland recorded the lowest exchangeable K content. It was noted that the land owner of the cornfield admitted that he is heavily applying commercial inorganic fertilizer such as urea and complete fertilizer to achieve higher yield. As also observed, the farmer-owner was collecting corn cobs and allowed them to decompose in the site.

There is also a significant interaction between the two variables, manifesting that the effects of farmyard manure and land use on soil exchangeable K are interrelated. DMRT revealed that farmyard manure application in cornfield resulted to the highest exchangeable K content. Meanwhile, both amended and unamended disturbed grassland soil had the lowest exchangeable K content.

Table 6.0. Exchangeable potassium content (ppm) of soils under different land use as affected by farmyard manure application.

Land Use	**Manure Application**		TOTAL	MEAN
	Without Application	With Application		
Disturbed grassland	4.00 e	5.00 e	9.00	4.50 c
Paddy	9.67 cd	10.67 c	20.33	10.17 b
Artificial forest	8.50 d	10.83 c	19.33	9.67 b
Cornfield	14.17 b	19.67 a	33.83	16.92 a
TOTAL	36.33	46.17	82.50	
MEAN	9.08 b	11.54 a		10.31

LSD (a x b) =1.2111; Means followed by the same letter are not significantly different from each other.

Conclusions

Based on the findings of the study, it is apparent that farmyard manure application improved the microbial respiration rate, soil pH, organic matter content, total nitrogen and exchangeable potassium of soil. However, application of farmyard manure in soil can cause a decline in soil P within one week after incorporation. Microbial respiration rate and all chemical properties of soil varied with different land use. There is a relationship between farmyard manure application and land use on soil pH, SOM, available P and exchangeable K of soil.

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