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Evaluation of Organic Amendments Using Poultry Manure for the Improvement of Physical and Physico-chemical Properties of Theri Soil

E. Indira[1*] and B. Annadurai[2]

[1]Research Scholar, Manonmaniam Sundaranar University, Tirunelveli-627 012, Tamilnadu, India.
[2]Department of Physics, Aditanar College of Arts and Science, Tiruchendur-628216, Tamilnadu, India.

Authors' contributions

This work was carried out in collaboration between both authors. Author EI designed the study, wrote the protocol and wrote the first draft of the manuscript. Author BA managed the literature searches and analyses of the study performed the spectroscopy analysis. Author EI managed the experimental process. Author BA identified the species of plant. Both authors read and approved the final manuscript.

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ABSTRACT

To evaluate the effect of different Organic amendments including Poultry and their different proportions on various physico-chemical and physical properties on theri soil. Investigations were carried out on the surface (15 cm depth) of soil samples were collected from the village of Punnai Nagar (Kachanavillai) in Tuticorin district, Tiruchendur Taluk, Tamilnadu. The experiment s were carried out during 2014(Oct) to 2015(Jan) was laid out in Pot culture with 10 treatments and 3 replications. All the amendments were applied and wetting with water regularly for 90 days without allowing them to get dried. After 90 days measurements were made. The result revealed that the use of organic amendment will increases NPK, Water holding capacity, Pore space, EC, Organic Carbon and decreased pH, bulk density, Particle density, Hydraulic conductivity. These changes in soil environment improved the soil fertility without affecting soil health.

**Corresponding author: Email: indiraesaki76@gmail.com;*

Keywords: Organic amendment; organic carbon; physical properties; poultry manure; theri soil; Thermal- conductivity.

ABBREVIATIONS

PO	:	*Poultry Manure;*
W.H.C	:	*Water holding capacity;*
Bulk. Den, B.D	:	*Bulk Density;*
Par. Density, P.D	:	*Particle Density;*
Vol. Exp	:	*Volume Expansion;*
Th	:	*Theri soil;*
Hyd. Cond	:	*Hydraulic Conductivity;*
OC	:	*Organic Carbon;*
EC	:	*Electrical Conductivity;*
pH	:	*Potential of Hydrogen*

1. INTRODUCTION

Surface crusting and surface droughtiness are the major problems that are associated with theri soils because of the low organic matter content, low exchangeable bases and the sandy texture of theri soils. Theri soil coming under the sub-group of typic ustip saments [1]. Theri area is covered by fine to medium sized sand soil that contains heavy minerals Viz., monazite, illuminate, zircon and garnet. The top red sand column extend up to a depth of 10 meters and is under laid by recent formation of calcareous sand stone and clay. In the western part of the area and in north western part, the thickness of sedimentary formations become thin and is followed by archon rock. The humidity variation is 67-70%. The annual average rainfall was less than 650mm and nearly 60-65% of the rainfall is received during north east monsoon. Soil erosion, water logging, salinity and alkalinity, sand dunes, floods and other manmade factors bring about degradation of land resources. Indiscriminate exploitation of land resources without adequate conservation measures have resulted in soil degradation. Now it is not suitable for agriculture and it is consider as a waste land. Application of organic manures like poultry manures along with Goat manure or bio fertilizers can also achieve the yield target and a good return under better management practices. Organic sources are considered to be the source of complete planned food as they provide almost all the essential major and minor nutrients. The addition of various organics will provide dual benefit of improving soil by releasing nutrients more slowly as it decomposes slowly and improving physical properties of theri soil. Measurement of soil organic carbon, in conjunction with other soil physical and chemical properties and processes can be a valuable tool for developing a complete profile for soil fertility and may be used to increase the efficiency of fertilizer recommendations. The breakdown of added animal residues and organic carbon is affected by their physical and chemical characteristics as well as by temperature, moisture, nutrition and other factors that affect biological activity directly. Investigation about soil Organic Carbon (OC) by researchers and this review indicates the positive effects of soil OC on soil structure, soil porous, soil moisture, electrical conductivity (EC), thermal conductivity, soil pH, soil water holding capacity, NPK rate. Thermal properties of soil are dependent on material composition, fabric or packing arrangement, water content, and temperature. For a porous material at a given dry density, thermal conductivity increases with increasing moisture content. The composition of porous material also has an effect on the magnitude of the thermal conductivity. Thermal conductivity increases with increasing temperature. Reasons for this include an increase in the thermal conductivity of the individual components of the porous material, an increase in moisture migration, and improvement of particle contact bonds with increasing temperature [2]. High concentration of metal ions like sodium, Potassium, Phosphorus etc. in soil causes dispersion of particles which imparts poor soil structure and reduced infiltration rate [3]. Organic sources are considered to be the source of complete planned food as they provide almost all the essential major and minor nutrients. The findings of the study will be useful to the farmer's, policymakers and agencies involved in waste land development to evolve appropriate strategies for sustainable development of wastelands through organic amendments.

2. MATERIALS AND METHODS

A pot culture study was conducted during 2014(Oct) to 2015 (Jan) in Theri soil. Research field is in Punnai nagar (Kachanavilai), Tuticorin district, Tiruchendur Taluk, Tamil Nadu, India. This place lies between Long: 78°11E, Lat: 8°30° N. Soil samples(TH) were collected at this location at 19 km west from Tiruchendur 5km from Nazareth. Soil sample was collected in the experimental site by making 'V' shaped cut at a depth of 15 cm air dried ground, mixed and pass to sieved and attain the size 2 mm. Sieved soils were analyzed for their physico-chemical and

physical properties. The experiment was laid out in a pot culture with ten treatments replicated thrice. The pots were arranged under the screen house. In this study, 1 liter (1000 c.c=1.650 Kg) of theri soil was thoroughly mixed with different percentage of Poultry manure (PO) mixture. Ten different combinations, namely theri soil (TH) +10% of PO, TH + 20% of PO, TH+30% of PO, TH +40% of PO, TH+ 50% of PO, TH+60% of PO, TH+ 70% of PO, TH + 80% of PO, TH+ 90% of PO, TH +100% of PO. These different combinations were thoroughly ameliorated mechanically before use. For example TH+10% of PO mean 39 g (100 cc) of Poultry manure was mixed with 1.650 Kg (1000 cc) of theri soil. The volume of the soil is fixed. It was found that 100 cc of PO is equal to 39 g. It was also found that 100 cc of therisoil is equal to 165 g. These mixtures were allowed to settle for a period of 90 days by wetting with water regularly and without allowing them to get dried. After 90 days measurements were made on the physical and physico-chemical properties, such as pH, EC, NPK, particle density, bulk density, porosity, water holding capacity, volume expansion, organic carbon content, hydraulic conductivity and thermal conductivity.

2.1 Methods Used for Analysis

The soil samples were characterized for important physical, physico-chemical properties using standard procedures. Bulk density, particle density, water holding capacity, porosity, volume expansion were measured using Keen Raczkowski (KR) Box model [4]. Soil pH and EC was determined in 1:2.5 soils, water suspensions with help of glass electrode pH meter with a digital display and with a null balance conductivity meter correspondingly [5]. Organic Carbon determined Chromic acid wet oxidation method [6]. Available “N” alkaline permanganate method [7]. The available “P” was estimated by Flame photometer [8]. And available “K” determined by Ammonium acetate method [9]. Thermal conductivity of the soil determine by Lees disc method Ouseph et al. [10].

3. RESULTS AND DISCUSSION

3.1 Soil Characteristics

The soil was sandy clay loam in texture, neutral in reaction having pH range of 7.63 and low in Organic Carbon 0.19%.Theri soil has low available N=78Kg/ha, medium P= 5 kg/ha, K=104 kg/ha while Fe, Mn ,Zn ,Cu values takes a value of 0.369 ppm, 0.985 ppm, 4.861 ppm and 1.996 ppm respectively. Theri soil faces higher level of soil erosion with low nutrients and minerals. The permeability of water in theri soil is high. The soils were non saline and EC was found to be below 1.0 dSm^{-1}. Application of poultry manure had positive impact on all the soil properties shown in Table 1. [11] Found that composted Poultry manure could improve the soil physical properties. [12] Also observed that application of poultry manure with recommended rates produced taller plants than control.

3.1.1 Thermal conductivity

When OC increases in organic amended soil, soil moisture increases thus it will enhance the thermal as well as electrical conductivity (Fig. 1). Thermal conductivity ranged between 0.209266 w/m/k to 0.340973 w/m/k. Thermal conductivity positively correlated with WHC and OC and EC (Table 3). Moisture content is the most important factor influencing the thermal characteristics of soils [13].

3.1.2 Bulk density

After different dosage of organic amendment the bulk density (B.D) decreased (Table 1). On decrease of B.D soil became more porous and effective for root respiration and water permeability. It took a max 1.74 g/cm^3 and min 1.33 g/cm^3 (Table 1). Lower bulk density values of surface soil might be due to loose and porous nature and organic matter content [14]. It was observed that OC has Strong Negative correlation (r =-0.9487423) with Bulk density and Regression value (R^2 = 0.900).

3.1.3 Particle density

Particle density(P.D) had min value as 2.10 g/cm^3 in Th+100% PO (Table 1.) with the dosage of 5t/ha. It was 26.49% less than control which had the value 2.875 g/cm^3. For the normal soil the P.D is 2.65 g/cm^3. Particle density Negatively correlated with OC (r = -0.95983156). Similar results were obtained by Dilip kumar das [15].

3.1.4 Water holding capacity

W.H.C and Porosity had increased than the control soil due to organic amendments. The treatment (Th+100%PO) had attained a maximum W.H.C as 36.48% (Table 1). It was 31.14% more than control. It will enhance the

Plant growth. WHC is an important indicator of soil physical fertility is the capacity of soil to store and supply water and air for plant growth [16]. Our results showed a positive correlation of W.H.C was observed with OC content (r = 0.907171245) and (R^2=0.823).

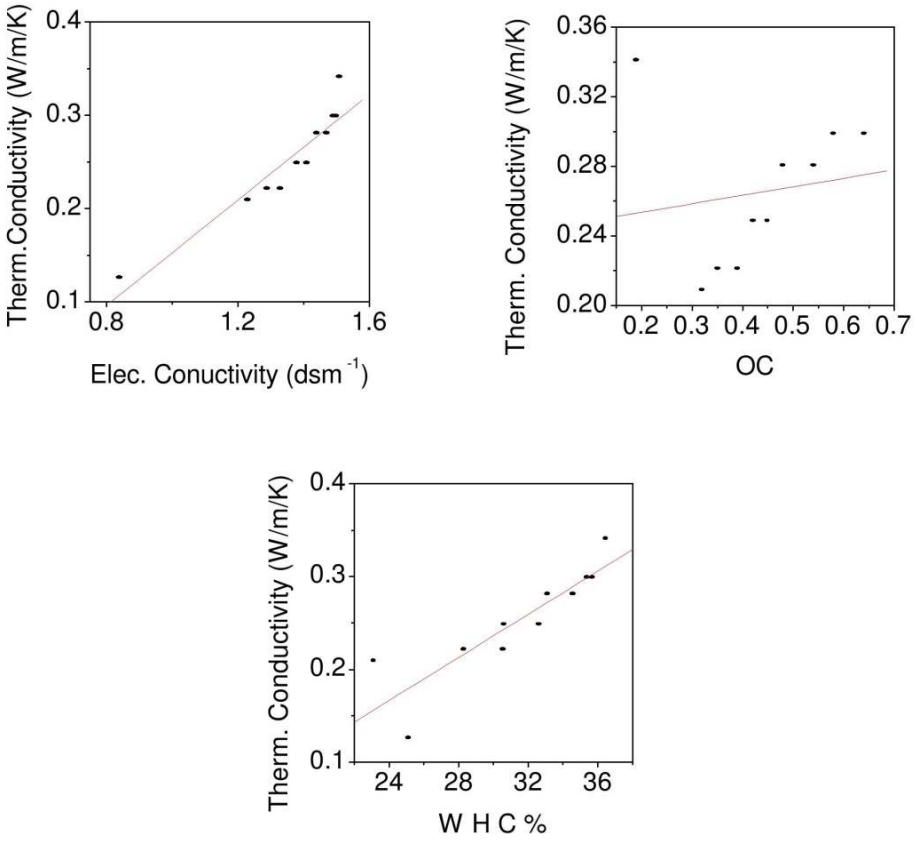

Fig. 1. Relationship between thermal conductivity and physical properties of theri soil

Table 1. Effect of various mixtures of poultry manure on physical properties of theri soil

Treatment	Bulk density g/cm^3	Particle density g/cm^3	porosity %	W.H.C %	Vol.exp %	Thermal conductivity w/m/k	Hyd.cond. mm/hr
Th+10%PO	1.74	3.07	43.48	23.13	6.24	0.209266	198.54
Th+20%PO	1.70	2.96	42.55	28.29	6.25	0.221407	194.97
Th+30%PO	1.67	2.86	41.67	30.54	6.73	0.221408	187.55
Th+40%PO	1.54	2.58	40.38	30.60	7.48	0.248778	181.51
Th+50%PO	1.48	2.50	40.02	32.60	7.98	0.248778	175.19
Th+60%PO	1.45	2.42	40	33.12	8.60	0.280846	167.92
Th+70%PO	1.43	2.40	39.28	34.57	9.69	0.280846	162.43
Th+80%PO	1.40	2.35	38.60	35.39	10.61	0.299066	149.94
Th+90%PO	1.38	2.22	37.93	35.71	12.01	0.299066	138.39
Th+100%PO	1.33	2.10	36.66	36.48	12.67	0.340973	118.76
Control	1.73	2.857	39.13	25.12	3.9	0.125813	210.00

1. TH- Their soil; 2. PO- Poultry Manure; 3. W.H.C- Water holding capacity; 4.Vol.exp- Volume expansion; 5. Hyd.Cond. - Hydraulic conductivity

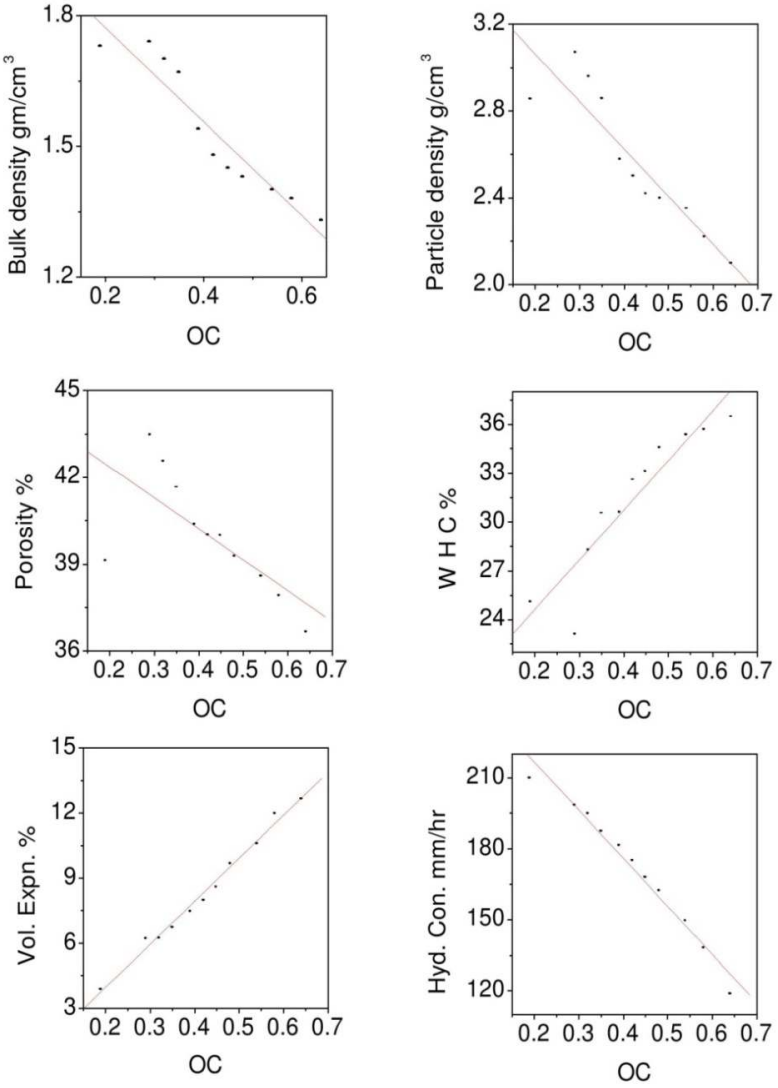

Fig. 2. Relationship between organic carbon and physical properties of therisoil

3.1.5 Porosity

Pore space decreased as the water holding capacity increased (Table 1). Max.pore space 43.48% and it gives a min.36.66%.Coarse textured soils have larger pore because of loose arrangement of larger particle with one another. Fine textured soils have more porosity than coarse textured soil. It has been reported by Aggelides and Loandra [17] that the organic compost application considerably improved soil physical properties by increasing soil pore sizes in loamy and clay textured soils. We also found strong negative correlation (r = -0.98288609) between porosity and OC content of soil samples.

3.1.6 Organic Carbon

The content of soil organic carbon is universal soil quality indicator with significant influence on soil properties. OC was max. As 0.64 % (Table 2) in poultry amended soil which was 70% higher than control. The present study suggest that soil organic carbon is an important index of soil quality and how effectively functions as medium in influencing soil physical, physico-chemical and thermal conducting properties (Fig. 1). Reduced tillage and incorporation of crop residues / organic inputs is one of the most effective management strategies for sequestering carbon [18]. The scientific analysis indicated soil organic carbon is a leading variable for increasing the

water holding capacity same trend was observed in the present study (Fig. 1) [19]. Also observed reduction in soil loss from Potato field as a result of application of Poultry manure. Use of fertilizers from both organic and inorganic origin not only elevate the nutrient status of soil but also bring about changes in physical, chemical and biological properties of the soil [20]. It was observed that OC has positive significant correlation (r =0.991150909) with Vol.exp and strong negative correlation (r = -0.99388932) with Hyd.Cond of soils.

3.2 Physico-chemical Characteristics

3.2.1 PH

Soil pH refers to a soil's acidity or alkalinity and is the measure of hydrogen ($H^{+)}$ ions in the soil. A higher concentration of H^+(low pH) will neutralize the negative charge on colloids, thereby decreasing CEC and increasing AEC [21]. Control takes a maximum pH Value of 7.63 this will be reduced to 6.87 under Organic treatment. This is possible due to microbial decomposition of Organic manure. This is favorable for a good crop production according to Okwuagwu. [1] Decreasing trends in pH were observed (Table 2).

3.2.2 EC

The soils were non saline and the EC values ranged from 1.23 dSm^{-1} to 1.51 dSm^{-1}.The values of NPK, pH, EC of treated soils were shown in Table 2. EC of control is 0.84 dSm^{-1}. Chemical properties indicated a decrease in soil pH and increase in EC when a soil OC, NPK increases.

3.3 Chemical Properties

3.3.1 Nitrogen (N)

Nitrogen values range between 78 Kg/ha to 116 Kg/ha. Nitrogen content was 32.75% more than control after treated with Organic amendment (Table 2). The breakdown of organic residues by microbes is dependent upon the Carbon to Nitrogen ratio. [22] For good composting C: N ratio less than 20 allows the organic materials to decompose quickly.

3.3.2 Phosphorus (P)

Phosphorus values ranged between 11.8 Kg/ha to 64.8Kg/ha (Table 2). Application of poultry minimizes the 'P' fixation and there by aiding in higher availability of phosphorous in soil [23]. This is due to the complexation and Chelation process and solubilization of "P" through organic acids released by organics [24].

3.3.3 Potassium (K)

The value of Potassium was high as 489 Kg/ha each at Potassium content increases as the dosage of Organic manure increases [25]. Confirmed the availability of "K" increases due to the addition of organics like press mud, composted coir pith, FYM each at 12.5t/ha compared to non application of organics. Intensive tillage, cause a faster decomposition of soil organic matter which resulting in degradation of soil health resulting in varying level of crop production at Potassium takes values from 386 Kg/ha to 474 Kg/ha (Table 2). As per the studies of srivastava [26]. There was an increase

Table 2. Effect of various mixtures of poultry manure on chemical properties of theri soil

Treatment	PH	EC DSm^{-1}	OC %	N Kg/ ha	P Kg/ ha	K Kg/ ha
TH+10%PO	7.06	1.23	0.29	84	30.9	412
TH+20%PO	7.02	1.29	0.32	89	34.5	424
TH+30%PO	6.98	1.33	0.35	92	38.6	431
TH+40%PO	6.96	1.38	0.39	96	41.2	445
TH+50%PO	6.92	1.41	0.42	99	45.5	456
TH+60%PO	6.91	1.44	0.45	102	48.9	462
TH+70%PO	6.9	1.47	0.48	104	54.2	468
TH+80%PO	6.89	1.49	0.54	107	59.2	472
TH+90%PO	6.88	1.50	0.58	112	64.2	478
TH+100%PO	6.87	1.51	0.64	116	71.7	489
CONTROL	7.63	0.84	0.19	78	10.8	315

1. TH-Their soil; 2. PO-Poultry manure

Table 3. Correlation coefficients (r) and regression equations between physical properties of poultry treated theri soil

Soil parameters	Correlation Coeff. (r)	Levelf significance	Regression equations
TC & EC	0.934502	High degree positive	Y=2.124X + 0.841 R^2=0.873
TC & OC	0.980896136	High degree positive	y = 0.360x + 0.104 R^2 = 0.962
TC & WHC	0.88556277	High degree positive	y = 0.009x - 0.028 R^2 = 0.784
B.D & OC	-0.9487423	Strong negative	y = -1.192x + 2.043 R^2 = 0.900
P.D & OC	-0.95983156	Strong negative	y = -2.683x + 3.742 R^2 = 0.921
Porosity& OC	-0.98288609	Strong negative	y = -17.90x + 48.04 R^2 = 0.966
WHC & OC	0.907171245	High degree positive	y = 32.23x + 17.66 R^2 = 0.823
Vol.exp & OC	0.991150909	High degree positive	y = 20.15x - 0.162 R^2 = 0.982
Hyd.Cond. & OC	-0.99388932	Strong negative	y = -222.0x + 266.5 R^2 = 0.987

1. B.D-Bulk density; 2.TC-Thermal Conductivity; 3.OC-Organic Carbon; 4.P.D –Particle density

in soil available nutrients with the application of poultry manure. He also indicated that performance of poultry was better than Fym.

4. CONCLUSION

Overall results of the study reveal that Poultry manure with 5.0t/ha (according to Appavu et al. [27]) dosage was most effective in the treatment of Th+50%PO and Th+60%. It shows a maximum water retention value of 36.48%. The desired increase of water holding capacity will improve the ability to supply the nutrients to the soil. The effect of application of Poultry manure with Theri soil increases Porosity than control but decreases bulkdensity by 16.18% Of the selected 10 independent variables, the organic carbon and the bulk density to be the important variable deciding the water holding capacity. The desired increase of water holding capacity will improve the ability to supply the nutrients to the soil. Organic carbon, micro, macro nutrients, WHC, electrical conductivity and thermal conductivity. Simultaneously it decreases pH, Hydraulic conductivity, Bulk density, Particle density. These changes readily respond to alterations in plant vegetations or land used without affecting its health as well as improving the crop yields.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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