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Bioremediation of Kaolinite Soil using Poultry Manure and its Effect on Growth of Okra (*Abelmoschus esculentus*)

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Abstract

Understanding the effect of poultry manure on kaolinite soil properties and the performance of Okra on the amended soil is important for the effective and efficient management of soils for optimum crop production and environmental conservation. The study was carried out to specifically evaluate the impact of poultry manure amendment on soil properties and the performance of okra. About 15kg of soil samples were collected and put in polythene bags. Poultry manure at the rate of 5, 10, 15, and 20 g was applied. There was no amendment application in the control. Poultry manure was thoroughly mixed and allowed to stay for two weeks before planting. Okra seeds were planted at three seeds per bag and later thinned down to two. They were replicated 8 times 4 thus summing up to a total of thirty-two samples. The experiment lasted for 3 months. The experiment was arranged in a Randomized Complete block design (RCBD). Soil samples were collected and analyzed using standard laboratory methods and data generated was subjected to analysis of variance (ANOVA). Significant means were separated with the least significant means at the 0.05 probability level. The growth parameters of okra using kaolinite soils with poultry manure gave a significant increase in germination percentage, mean plant height, the mean number of leaves, and mean several branches. This is a rapidly growing technology in environmental management.

Keywords: Bioremediation, Kaolinite soils, Poultry manure, Physicochemical properties, Okra

1 Introduction

Kaolinite soils refer to clay soils that have an abundance of ($Al_2Si_2O_5$) $(OH)_4$) called Kaolinite which is commonly found in forms of sediments, soils, and sedimentary rocks [1]. It is soil that forms by the gradual process of breaking down feldspars into smaller particles accompanied by leaching of other elements such as Calcium (Ca), Sodium (Na), and Potassium (K), to form rich Aliminium products in soils [2]. It has a characteristic pink-orange-red color caused by the presence of red Iron oxide giving it a distinct rust hue. Other colors exist in lighter concentrations of white or yellow or light orange colors [3]. Kaolinite belongs to a group of common clay Mineral of hydrous aluminum silicates which comprises the principal ingredient kaolin also called china clay [4]. This group includes rare forms of kaolinite such as dickite and nacrite, allophane, and halloysite and are chemically similar to amorphous kaolinite. Primarily Aluminium, Silicon, Oxygen, and Ferric ions including some hydroxyl compounds are the main components of this kaolin, other elements such as potassium, Calcium, Phosphorus, and Magnesium occur in smaller Proportions [5-6].

According to [7], Kaolin (S.I) contains smaller amounts of potassium which are present within mica layers attached to kaolin crystals, whereas potassium is not present within these kaolin structures [8]. Due to kaolin's chemical reactivity, kaolin helps to provide effective support to agriculture and other land users. Soils with abundant kaolin deposits are mostly found in the wet tropics as a high population of the world relies on this soil for food and fiber production, Kaolin present in the living part of the soil (solum) is different from kaolin in the underlying sediment of the soil [5]. Kaolin tropical soil has a large crystal size which is associated with low surface reactivity. This is likely the resultant low chemical fertility [9]. This soil would limit agricultural production and reduce the capacity of the soil to cleanse water [10]. Usually, fertilizer like lime and other organics such as poultry manure is commonly applied to these soils, and reactions of these additives with kaolin crystals enhance the fertility and structure of the soil for food production in agriculture [11]. Kaolinite is a dominant clay mineral of oxisols and ultisols [10]. These soils exhibit acidic reactions and clay mineralogy dominated by kaolinite [11] Oxisols and Ultisols are acidic soils with a pH of 5.5 or lower and are widely distributed in the Tropical and subtropical regions, constituting about 30% of the total area of the earth and 50% of Arable land in the earth as well as it provides about 25 and 80% of vegetable production in the world [12]. Acidification of soils can occur due to natural or anthropogenic processes or both at the same time. In most subtropic and tropical regions Acidification is a natural process that is characterized by a deficiency in Nutrients and Toxicity by metals such as Manganese (Mn), Iron (Fe), and Aluminium (Al) with aluminum being the major limiting factor for plant growth in acidic soils [13-15]. Microorganisms are everywhere in the natural environment. They play very important roles in metal Transformation. Bioremediation is a technique used in the removal of harmful contaminants from soil such as heavy

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metals and reducing them into other less toxic substances in the soil like CO_2 and H_2O, N_2, etc. [16]. By definition, Bioremediation is the use of living organisms primarily micro-organisms to detoxify environmental contaminants, into less toxic forms [17]. This technique makes good use of naturally occurring bacteria, fungi, and plants to degrade or detoxify substances that are hazardous to human health and the environment [18]. For bioremediation to be effective, Microorganisms must enzymatically attack the pollutants and convert them into harmless products [19].

This process can be applied to soil through In-situ and Ex-situ Techniques [20]. Although the use of bioremediation in the treatment of hazardous waste is a relatively new concept, it is a rapidly growing technology in environmental management, and there have been numerous reports on the application of bioremediation in contaminated sites. Examples of bioremediation include land farming, composting, bioreactors, bioventing, biofilters, bioaugmentation, biostimulation, intrinsic bioremediation, and pump and treat [1]. Some bioremediation strategies have been developed to treat contaminated wastes and sites [6]. *Abelmoschus esculentus* is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. It is among the most heat- and drought-tolerant vegetable species in the world and will tolerate soils with heavy clay and intermittent moisture, but frost can damage the pods. In cultivation, the seeds are soaked overnight before planting to a depth of 1–2 centimeters (0.39–0.79 in). It prefers a soil temperature of at least 20 °C (68 °F) for germination, which occurs between six days (soaked seeds) and three weeks. As a tropical plant, it also requires a lot of sunlight, and it should also be cultivated in soil that has a pH between 5.8 and 7, ideally on the acidic side [8]. Seedlings require ample water. The seed pods rapidly become fibrous and woody and, to be edible as a vegetable, must be harvested when immature, usually within a week after pollination. The first harvesting will typically be ready after about 2 months of the plantation, and it will be approximately 2-3 inches long [21-24].

2 Materials and methods

2.1 Study Area

The study was conducted at the Biological Research farm, Department of Biology, School of Biological Sciences, Federal University of Technology, Owerri Imo State, Southeastern Nigeria. The area lies between Latitude 5 21'N and 5 28'N and Longitude 7 11'E and 7 45'E. The area has an average annual rainfall of 2500 – 3000 mm and an annual temperature of 27-30 with an average relative humidity of 79%. Vegetation is a tropical rainforest that has been cultivated and deforested and has been replaced by secondary forest to a large extent. The major socio-economic activities include farming, trading, etc.

2.2 Collection of Soil

The kaolinite soil used was collected from Ife in Mbaise, Imo State and Transported to the Department of Biology Research Farm, Federal University of Technology Owerri.

2.3 Fieldwork on farm

A reconnaissance visit was made to the study area before the study was carried out. A total number of 4 samples were collected randomly from the study site, with the use of a trowel, polythene bag, masking tape, and a scale. Again different 15kg of the unsieved soil was bagged and properly labeled for the application of poultry manure.

2.4 Soil Preparation

The soil was collected and weighed. Sixteen (16) planting bags of 15kg were used. Other materials included poultry manure which was gotten from the School of Agriculture and Agricultural Technology (SAAT) farm, and a beaker for measurements. Different level of poultry manure was thoroughly mixed and allowed for 2 weeks before planting.

2.5 Experimental design and Treatment

The experiment involved treatments replicated into 8, in a Randomized Complete Block Design (RCBD), which consisted of (8) planting bags in each group containing kaolinite soil. It was categorized into Group A, B, C, and D: in which group A contained the control, and group B, C, and D, contained the soil treated with poultry manure before planting, It was left under normal conditions of temperature, sunlight, and water, in increasing amounts of poultry manure in the different bags as follows and was replicated 4 times:

Unamended soil

1st bag: 0 kg of poultry manure
2nd bag: 0 kg of poultry manure
3rd bag: 0 kg of poultry manure
4th bag: 0 kg of poultry manure

Amended soil

5th Bag: 5 kg of poultry manure
6th Bag: 10 kg of poultry manure
7th Bag: 15 kg of poultry manure
8th Bag: 20 kg of poultry manure

2.6 Planting of Test Crop

Improved varieties of okra seed were sourced from Agricultural Development Program (ADP) office in Owerri. Okra was planted 2 weeks after treatment application. 10 seeds per bag were planted and later thinned after emergence to 1 plant per stand to avoid competition and to allow the roots to diversify well for optimum yield.

2.7 Plant Parameters Studied

Growth parameters such as plant height, leaf area, and the number of leaves, were measured two weeks after planting. Leaf area was calculated: $L \times W \times 0.75$, where L= leaf length, W= leaf width. Yield (weight of Pod) was also measured.

2.8 Data Collection Procedure

Plant Height: Plant heights were measured weekly starting from the 2nd week after planting. For the collection of height data, the plants were tagged in each experiment until their heights were measured from ground level to the tip of the terminal bud, using a meter rule on the 2, 4, 6, 8, 10, and 12 weeks after planting. The data obtained from the measurement were computed and the height of the plant for each treatment was determined and recorded.

2.9 Weeding

Successful cultivation of okra depends largely on the efficacy of weed control. Weed control during the first 2 to 6 weeks after planting is crucial because weeds compete vigorously with the crop for nutrients and water during this period. This was done manually by handpicking.

2.10 Post Field Work

This was done after the harvest of okra. Soil samples were collected from each group using a hand trowel, and polythene bags and was properly bagged and labeled for post-analysis in the laboratory.

Table 1: Microbial and Fungi Population before and after Soil Remediation with Poultry Manure

Soils	Microbial count (x10^{6} CFUg^{-1})	
	Bacterial	**Fungi**
Before soil remediation		
K_1	1.01	0.02
K_2	1.00	0.04
K_3	1.02	0.09
K_4	1.01	0.08
After soil remediation		
K_1 + (5kg of PM)	1.01	0.02
K_2 + (10kg of PM)	1.74	0.16
K_3 + (15kg of PM)	2.67	0.22
K_4 + (20kg of PM)	3.05	0.81

CFU = Colony forming Unit, K= kaolinite soils
PM = Poultry Manure

Table 2: Growth Parameters on Kaolinite Solid not Remediated and Remediated with Poultry Manure

Soils	Germination %	Mean plant Height (cm)	Mean number of leaves	Mean number of branches
Before soil remediation				
K_1	43	13.3 ± 1.2	19.0 ± 2.5	3.4 ± 0.4
K_2	47	14.0 ± 1.7	17.5 ± 2.3	2.7 ± 0.3
K_3	49	13.5 ± 1.3	18.0 ± 2.4	3.0 ± 0.3
K_4	44	14.4 ± 1.8	19.4 ± 2.5	3.4 ± 0.4
LSD	NS	NS	NS	NS
After Soil Remediation				
K_1+ (5 kg of PM)	52^{d}	18.2^{d} ± 2.0	24.4^{d} ± 2.9	3.7^{c} ± 0.5
K_2 + (10kg of PM)	63^{c}	21.4^{c} ± 2.2	29.3^{c} ± 3.3	4.8^{b} ± 0.6
K_3 + (15 kg of PM)	80^{b}	27.7^{b} ± 2.5	33.6^{b} ± 3.7	5.2^{b} ± 0.9
K_4 + (20kg of PM)	91^{a}	32.3^{a} ± 3.1	41.8^{a} ± 4.2	6.5^{a} ± 1.0

Mean having different superscripts along the column differ significantly at P = 0.05. NS = not Significant.
K= kaolinite soils
PM = Poultry Manure

3 Results and discussion

3.1 Microbial Analysis before and after Kaolinite Soil Remediation

Table 1 shows the result of microbial analysis of kaolinite soils before and after soil remediation. The result revealed low bacteria and fungi populations in kaolinite soils that were not remediated, but an increase in microbial and fungi populations with the application of manure.

3.2 Growth of okra

The growth of parameters of the test crop (okra) was adversely affected on kaolinite soil that was not remediated with poultry manure. There was a reduction in germination percentage, plant height, number of leaves, and number of branches recorded. The result indicated a significant increase in growth parameters with the application of poultry manure (Table 2).

4 Conclusion

Application of poultry manure to the soil in the right quantities improves soil health. It has been known to have a positive effect on plant growth and improves the pH of acidic soils. The effect of poultry manure on the soil is determined by the amount of nutrients a particular plant needs to be healthy. Results of physicochemical analysis effectuated the amended soil samples from kaolinite soil and shows large differences when compared to the results from an unamended soil sample. The acidity of soil being high has an obviously adverse effect on plant growth. In conclusion, study has demonstrated that poultry manure has a significant effect on kaolinite soil and the performance of Okra plant.

5 Recommendations

- Based on the findings of this study, the following recommendations were made:
- Farming areas with acidic properties should not be avoided or abandoned but should be remediated to improve soil qualities and soil health.
- Farmers and Agriculturists should ensure regular and constant inspection and maintenance of soil and make use of less acidifying farm practices to minimize the soil acidification process.
- Organic manure mainly poultry manure should be added to the acidic soils to improve soil fertility.

References

1. Kanket, W., Suddhiprakarn A, Kheoruenromne I, and Gilkes RJ. Chemical and crystallographic properties of kaolin from Ultisols in Thailand. Clays and Clay Minerals 2005 , 53, 478-489.
2. Indarratne S.P. Soil mineralogy. In: Soils of Sri Lanka (ed. R.B. Mapa). 2020, Springer International, Switzerland.
3. Angaji M.T., Zinali A.Z. & Qazvini N.T. Study of physical, chemical and morphological alterations of smectite clay upon activation and functionalization via the acid treatment. World Journal of Nano Science and Engineering 2013, 03(4): 8.
4. Indraratne S.P. Occurrence of organo-mineral complexes in relation to clay mineralogy of some SriLankan soils. Journal of the National Science Foundation of Sri Lanka 2006, 34: 29–36.
5. Phillips IR, Sheehan KJ Importance of surface charge characteristics when selecting soils for wastewater re-use. Australian Journal of Soil Research 2005, 43, 915-927.
6. Roberts, J. &Nattaporn P. "How the unique properties of soil kaolin affects the fertility of tropical soil" Article in applied clay science. 2015.
7. Al-Ghazawi, Z., Saadoun, I. and Al-Shak'ah A. Selection of bacteria and plant seeds for potential use in the remediation of

diesel contaminated soils. Journal of Basic Microbiology, 2005, 45, pp. 251-256.
8. Osemwota, O.I. “Effect of abattoir effluent on the physical and chemical properties of soils”.*Environmental Monitoring and Assessment* 2010, 167(1-4):399-404.
9. Aichberger, H., Hasinger, M., Braun, R. and Loibner, A.P. Potential preliminary test methods to predict biodegradation performance of petroleum hydrocarbons in soil. Biodegradation, 2005, 16, pp. 115-125.
10. Army T. Kaolinite mineral Encyclopedia Britanica). . (.2009.
11. BakariA.,&Zauro T. D. “Geological and Geological characterization of kaolinite Deposits around Kaoje, Kebbi state Nigeria. *International journal of scientific & technology research* 2015, 4:2277-8618.
12. Bolan, N. Z.,Szogi, A. A., Chusavath, I.T., Seshadri, B.,Rothrock, M.J. &Panneer, S. “Uses and management of poultry litter”. *World's poultry science journal*6664: 2010, 673-698.
13. Roberts, J. & Nattaporn P. “How the unique properties of soil kaolin affects the fertility of tropical soil” Article in applied clay science. (2015).
14. Khwunta, K., Anchalees S., Kheoruenromne I.B, &Balwart, S. “Change properties of kaolinites in Acidic soils from Thailand; Faculty of Agriculture, food and natural resources , The university of Sydney NSW (2006), Australia.
15. Sade, H., Meriga, B., Surapu, V., Gadi, J., Sunita, M &Suravajhala, P. Toxicity and Tolerance of Aluminium in Plants: Tailoring plants to Suit to Acid Soil Bio-metals 2016, 29:187-210.
16. Kochain, L., Hoekenga, O. &Pineros, M. How do crop plants tolerate acid soils? Mechanisms of Aluminium Tolerance and Phosphorous Efficency”.*Annual. Rev. plant. Biol. 2004,* 55:459-493.
17. Gupta, N., Gaurav, S., & Kumar, A. Molecular Basis of Aluminium Toxicity in Plants; a review Am. *J plant sci.* . 2013, 4:21-37.
18. Bose, J., Babourina, Q., Ma, Y., Zhou, M., Shabak, S. &Rengel, Z. Specifically of ion uptake and homeostasis maintenance during acid and aluminium stress. In Aluminium Stress Adaptation in plants, Signaling Communication In Plants. 2015, 24: 229-251
19. Meena, K. &Sarita, S. “Bioremediation Option for Heavy Metal Pollution”; Department of Biotechnology, ManavRachna International Institute of Research and Studies, Faridabad, India.; Department of Chemistry, ManavRachna University, Feridabad, India). 2019.
20. Boopathy, R., Factors Limiting Bioremediation Technologies, Bioresources Technology, 2000, 74: 63-67.
21. Iwamoto, T. &Nasu, M. Current bioremediation practice and perspective”.*J. Biosci. Bioeng.,* 2001, 92:1-8.
22. Alaska Department of Environmental Conservation (ADEC), Environmental Monitoring & Assessment Program Implementation of Strategy Division of Water(www.dec.state.ak.us/water/wqamp/emap/implementation3_05.doc). 2005.
23. Doreddula, S. K., Bonam, S. R., Gaddam, D. P., Desu, B. S. R., Ramarao, N., Pandy, V. . "Phytochemical Analysis, Antioxidant, Antistress, and Nootropic Activities of Aqueous and Methanolic Seed Extracts of Ladies Finger (Abelmoschusesculentus L.)in Mice". The Scientific World Journal. 2014, 519848
24. Fujii, H., Iwase, M., Ohkuma, T., Ogata-Kaizu, S., Ide, H., Kikuchi, Y., Idewaki, Y., Joudai, T., Hirakawa, Y., Uchida, K. & Sasaki, S. "Impact of dietary fiber intake on glycemic control, cardiovascular risk factors and chronic kidney disease in Japanese patients with type 2 diabetes mellitus: the Fukuoka Diabetes Registry". Nutrition Journal. 2013, 12: 159.