

Effect of Human Urine on Soil pH in Ndele, South-South of Nigeria

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DOI: <https://doi.org/10.51584/IJRIAS.2026.11080102>

Received: 27 August 2026; Accepted: 01 September 2026; Published: 12 September 2026

ABSTRACT

The widespread challenges across the globe of producing sufficient food for the satisfaction of humans in this highly populated world needs exploring and expanding new approach of research in the agricultural sector of the economy. Our domesticated method of using chemical fertilizers to improve soil quality for food production can no longer be depended upon as a result its adverse effect on soil pH. Application of ammonium (NH_4^+) fertilizers to the soil react in the soil in a nitrification process to develop nitrate (NO_3^-) and through that process release H^+ to the soil whereby making the soil to be acidic in nature. Therefore, this research was carried out to investigate the effect of human urine on soil pH. The design for this experiment was arranged in a completely randomized block design with four treatments with control of (0gNha^{-1}) and 150gNha^{-1} of human urine. The treatments were replicated four times to give a total of twenty (20) pots filled with 10kg of soil each. The experimental results of the study showed the increase of the chemical properties of human urine in the treated pots suggests that human urine for the treatment of soil can be used to increase soil pH and also act as a fertilizer by improving soil nutrients. The result obtained show that there was significantly ($P < 0.05$) on the effect of urine on soil pH compared with the control. It is recommended that human urine that has been seen as a waste and nuisance to the environment could be trapped and used as fertilizer for soil treatment by the famers.

Keywords: Human Urine, Soil pH, Chemical Fertilizer

INTRODUCTION

The widespread challenges across the globe of producing sufficient food for the satisfaction of humans in this highly populated world needs exploring and expanding new approach of research in the agricultural sector of the economy. Our domesticated method of using chemical fertilizers to improve soil quality for food production (Adeoluwa and Sulaiman, 2012) can no longer be depended upon as a result its adverse effect on soil pH, (Bloom *et al.*, 2012). Application of ammonium (NH_4^+) fertilizers to the soil react in the soil in a process called nitrification to form nitrate (NO_3^-) and through that process release H^+ to the soil whereby making the soil to be acidic in nature, ((Bloom *et al.*, 2012).

Much soil in the high rain fall areas are acidic due to its slight acidic content (pH usually about 5.7) with the reaction of carbon dioxide. Also the burning of fossil fuels releases oxides of sulfur and nitrogen into the atmosphere. These react with water in the atmosphere to form sulfuric and nitric acid in rain, (Van *et al.*, 1984; Sparks and Donald 2003) while in some part of the globe, the soil is alkaline as a result of weathering of silicate, aluminosilicate and carbonated minerals that contains N^+ , K^- , Ca^{2+} , and Mg^{2-} (Bloom *et al.*, 2012).

There are varieties of stresses plants experience in acid soils including the toxicity of aluminium, hydrogen, and manganese with calcium and manganese deficiencies in the soil (Brandy and Welly, 2002). The most widespread problems in acid soil are the toxicity of aluminium. All soils contain aluminium but the one that is dissolved is toxic to plants (Kopittke *et al.*, 2016). Aluminium is not a plant nutrient, therefore, the intake of aluminium by plant is not noticeable but it goes to the plant roots inactively through the processes of osmosis and inhibits plant root growth (lateral roots and root tips become thickened and lacks fine branching)

It is very imperative to find sustainable soil pH for the health of the plants before cultivating the soil. A

suitable soil pH resolves the effective way plants absorbed nutrients. There are compounds that could be added to the soil to increase or decrease the soil pH level. In some developed countries, these compounds are not cheaply accessible to farmers and often times have negative impact on the soil. Human urine could be one of the alternatives to influence soil pH.

Human urine is domestically known as a waste in the human systems that are excreted out from the human body and its point of destination is on the ground in some rural areas or in the septic tanks where it is finally flushed-out either to the water treatment amenities or to the drainage, ponds, forest or rivers. Different societies in the world from ancient time to the present days used human urine for divers' purposes in the world. Studies have made human urine to gain more attention as a motivating suggestion in agricultural industries as a fertilizer to replace chemical fertilizers for crop productions. Recently, because of human urine has gained more concern as a result of its potential plant nutritional significance such as nitrogen (N), phosphorous (P) and potassium (K) also known as (NPK). The quality of human urine is directly proportional to the nutritional quality of food intake and quality health status of human beings. It is known as a safe, ideal, and cheap liquid fertilizer for producing crops by the agriculturist since the plants feed directly on the urine that are undiluted when it is applied to the soil as a liquid fertilizer instead of the chemical fertilizer.

Generally, Urine is observed as menace or irritation in the atmosphere specifically when under the weather conditions. This is as a result of lack technical know-how to transform urine for substantial agricultural use (Adeoluwa and Sulaiman, 2012).

In view of the foreseen adverse effect of chemical fertilizers on soil, food production and environmental effect in our society, the interest to determine and develop effective usage of urine cannot be over emphasized. If urine application to soil is made accurately at the appropriate time for food production, urine is absorbed constantly Nitrogen in urine has been known to be in similar agricultural value as nitrogen in the commercial chemical fertilizer, (Adeoluwa and Sulaiman, 2012).

Soil pH is the degree of acidity or basicity (that is alkalinity) of a given soil is an important factor for germinating crops. It is significant to the soil because it influences the available vital nutrients in the soil. pH is a scale that is defined as negative logarithm (base 10) of the hydronium ions ($H^+_3O^+_{ag}$) activities in a solution. The pH scale measures from 0 to 14. Any pH value below 7 is acidic and above 7 is alkaline.

The pH of soil is measured as a master variable in soils as a result of its effect on soil chemical processes, particularly by controlling the chemical forms of nutrients and chemical reactions that takes place in them (Queensland Department of Environment and Heritage, 2017). Specifically, microorganisms' activities depend on soil pH. Most a time they are more available in acid soils to plants than in a neutral to alkaline soils that are generally support the growth of plants (Loncaric *et al.*, 2008). According to Jiang *et al.*, (2017), the height of plant, lateral spread, size of flower and numbers, pollen production, biomass, etc are highly influenced by the soil pH.

Usually, the pH of a natural soil totally relied on the composition of the parent materials of the soil and the weathering processes the parent materials experience, (USDA-NRCS, 2017).

Human Urine as a Nutrient Resource

Human urine is increasingly investigated as a source-separated nutrient resource for circular agriculture because it contains substantial nitrogen and also contributes phosphorus, potassium and other nutrients. Its fertilizer value varies with diet, storage conditions, treatment and application strategy. Recent reviews indicate that urine-derived fertilizers can support nutrient recycling and may reduce reliance on some synthetic fertilizer inputs when appropriately managed (Martin *et al.*, 2022; Liu *et al.*, 2024; Saliu *et al.*, 2024).

Soil pH and Agronomic Performance

The original experiment reported an increase in soil pH from 4.60 in the control to 4.90 at the highest urine application rate, together with increases in measured calcium, organic carbon, phosphorus, nitrogen, sodium,

magnesium and potassium. Contemporary literature supports the potential of urine-derived fertilizers to improve nutrient availability and selected soil-fertility indicators, although the magnitude and direction of pH change depend on soil characteristics, crop, treatment and application rate (Kabir et al., 2024; Martin et al., 2022).

Safety, Contaminants and Treatment

Current evidence indicates that urine reuse should be treated as a managed agricultural input rather than an automatically safe waste-reuse practice. Potential concerns include pathogens, pharmaceutical residues, salts and other contaminants. Appropriate source separation, stabilization or treatment, storage, application management and compliance with relevant guidance are therefore important (Kabir et al., 2024; Saliu et al., 2024). The storage procedure used in the present experiment should be interpreted in the context of the study methods and should not be presented as a universal safety guarantee.

Circular Nutrient Management

Recent research places urine reuse within a broader circular nutrient-management framework in which nutrients recovered from sanitation streams are returned to agricultural production. The feasibility of this approach depends on treatment technology, nutrient-recovery efficiency, logistics, farmer acceptance, regulation and contaminant control (Liu et al., 2024; Kabir et al., 2024). Within this context, the present study provides locally relevant experimental evidence on the response of an acidic soil under Ndele ecological conditions to graded applications of stored human urine.

Soil pH Classifications

Table 1 shows the soil pH classifications by the United States Department of Natural Resources Conservation Services with their pH levels from <3.5 (extremely acidic) to >9.0 (very strong alkaline)

Denomination	pH range
Ultra acidic	<3.5
Extremely acidic	3.5-4.5
Very strong acidic	4.5-5.0
Strong acidic	5.1-5.5
Moderately acidic	5.6-6.0
Slightly acidic	6.1-6.5
Neutral	6.6-7.3
Slightly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strong alkaline	8.5-9.0
Very strong alkaline	>9.0

Figure 1: soil pH classification (USDA NRCS data base, 1993)

Plant Preferences on Soil pH

In general terms, various species of plants adapt to soils of different pH levels. It is fairly well known the suitability of soil pH level. The data base of USDA can be used to measure the suitable soil pH level of varieties of plants. Table 2 shows the suitable soil pH levels for some commonly cultivated crops cited in (USDA PLNTS data base, 2017)

Scientific name	Common name	pH (minimum)	pH (maximum)
<u>Vetiveria zizanioides</u>	Vetivergrass	3	8
<u>Pinus rigida</u>	pitch pine	3.5	5.1

<u>Rubus chamaemorus</u>	Cloudberry	4	5.2
<u>Ananas comosus</u>	Pineapple	4	6
<u>Coffea arabica</u>	Arabian coffee	4	7.5
<u>Rhododendron arborescens</u>	smooth azalea	4.2	5.7
<u>Pinus radiata</u>	Monterey pine	4.5	5.2
<u>Carya illinoensis</u>	Pecan	4.5	7.5
<u>Tamarindus indica</u>	Tamarind	4.5	8
<u>Vaccinium corymbosum</u>	highbush blueberry	4.7	7.5
<u>Manihot esculenta</u>	Cassava	5	5.5
<u>Morus alba</u>	white mulberry	5	7
<u>Malus</u>	Apple	5	7.5
<u>Pinus sylvestris</u>	Scots pine	5	7.5
<u>Carica papaya</u>	Papaya	5	8
<u>Cajanus cajan</u>	Pigeonpea	5	8.3
<u>Pyrus communis</u>	common pear	5.2	6.7
<u>Solanum lycopersicum</u>	garden tomato	5.5	7
<u>Psidium guajava</u>	Guava	5.5	7
<u>Nerium oleander</u>	Oleander	5.5	7.8
<u>Punica granatum</u>	Pomegranate	6	6.9
<u>Viola sororia</u>	common blue violet	6	7.8
<u>Caragana arborescens</u>	Siberian peashrub	6	9
<u>Cotoneaster integerrimus</u>	Cotoneaster	6.8	8.7
<u>Opuntia ficus-indica</u>	Barbary fig (pricklypear)	7	8.5

Figure 2: Optimum Soil pH Levels for Plants (USDA PLNTS data base, 2017)

However, some plant may not be tolerant of a particular soil pH as a result of a particular mechanism and that may not apply in other soil, (Sumner *et al.*, 2002). Different varieties of the same species often have different suitable soil pH.)

The objective of this research is to investigate the effect of human urine on soil pH under Ndele ecological environment

MATERIALS AND METHODS

Experimental Site

This research was conducted between April and September 2018 at the Crop Section of the Coaching and Exploration Farm, Ignatius Ajuru University of Education, Faculty of Agriculture, Ndele , Rivers State. (Latitude 40°581N and Longitude 60°481E)

Specimen

The Auger sampler was brought together to collect soil samples. The soil samples were at 0-20cm depth from site where loam soil used for the experimentation was collected. These samples were bulked and used for laboratory analysis. Samples were further collected from each pot for post - harvest physiochemical properties determination.

The dried samples ground and passed through 2 mm sieve and used to determine soil properties. Particle size spreading of the experimental soil was determined using the Bouyoucous scheme as outlined in Gee and Or

(2002) procedure. Soil pH determination was carried out in soil/water solution ratio of 1:2.5.

The pH values were declaimed off using pH meter with glass electrode (Peech, 1965). Exchangeable bases of calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) were extracted using ammonium acetate (NH₄OAC) extraction method. Potassium and sodium was dogged using flame photometer.

Urine Liquid Fertilizer

The urine used for the experiment was collected from household through a plastic container. To eliminate noticeable pathogens from urine that would be used for the treatment of soil, it was stored in an air-tight container. The container was kept airtight for forty days before application. The airtight storage is to reduce loss of nitrogen by volatilization, kill all the pathogens and ascaris infection, (Hoglund, 2001; Schonning and Stenstrom, 2004).

Experimental Design and Treatment

The experimental were five rates of urine; 0g, 150g, 300g, 450g, and 600g; equivalent to 0cl, 18.25cl, 36.5cl, 54.75cl and 73cl. The rates were replicated four times and arranged in a randomized complete block design

Soil samples were taken before planting and after harvesting of okra and taken to the laboratory for analysis of the following parameters:

1. Base saturation (%)
2. Sodium (cmolkg⁻¹)
3. Magnesium (cmolkg⁻¹)
4. Potassium (cmolkg⁻¹)
5. Available Phosphorus (mgkg⁻¹)
6. Calcium (cmolkg⁻¹)
7. Organic Carbon (%)
8. Total Nitrogen (%)
9. pH (kCL)
10. Sand (gkg⁻¹)
11. Silt (gkg⁻¹)
12. Textural class

Data Analysis

Data collected from the experiment subjected to analysis of variance table randomized complete block design and means separated by least significant difference (LSD) using SPSS software

Table 3: Analysis of urine before planting

Parameter	Human urine
pH	9.2
Chlorine (g/L)	0.25
Potassium (g/L)	0.05
Sodium (g/L)	0.3
Phosphorus (g/L)	0.04
Total Nitrogen (g/L)	4.55
Ammonia (g/L)	0.02
Urea (g/L)	0.45
Total Solids (g/L)	3

The initial soil characteristics of the study soil before planting and urine application is displayed in table 5. Like most tropical soils the amount of nitrogen, phosphorus and potassium contents are low. The value of nitrogen in the soil is lower than that in the urine. The pH value of 4.7 shows that the soil is acidic and the textural class is sandy loam.

Table 4: Soil properties before planting

Soil properties	Value
Base saturation (%)	85
Sodium (cmolk ⁻¹)	0.1
Magnesium (cmolk ⁻¹)	0.8
Potassium (cmolk ⁻¹)	0.2
Available Phosphorus (mgkg ⁻¹)	14.0
Calcium (cmolk ⁻¹)	1.6
Organic Carbon (%)	0.5
Total Nitrogen (%)	0.07
pH (kCL)	4.7
Sand (gkg ⁻¹)	759
Silt (gkg ⁻¹)	139
Textural class	Sandy loam

Table 5: Effect of urine on physiochemical properties of soil

URINE	pH	Ca	OC	P	N	Na	Mg	K
Control	4.60	1.60	0.50	14.00	0.07	0.10	0.80	0.20
18.25CL	4.71	4.50	0.80	28.20	0.16	0.20	1.70	0.30
36.50CL	4.80	4.53	0.83	28.40	0.17	0.22	2.00	0.37
54.75CL	4.83	4.70	0.91	28.60	0.19	0.31	2.04	0.39
73.00CL	4.90	4.90	1.00	28.90	0.20	0.44	2.90	0.40
SE	.052	.070	.056	.067	.065	.063	.058	.093
URINE	PH	Ca	OC	P	N	Na	Mg	K
Control	4.60 ^a	1.60 ^a	0.50 ^a	14.00 ^a	0.07 ^a	0.10 ^a	0.80 ^a	0.204 ^a
T _{average}	4.81 ^b	4.66 ^b	0.89 ^b	28.53 ^b	0.18 ^b	0.29 ^b	2.16 ^b	0.37 ^b

The soil analysis results after urine application is displayed in table 6. The results indicate that human urine application improved all soil chemical parameters and the effect improved with increasing application of urine

DISCUSSIONS

Effect of Human Urine on Soil pH

The physicochemical properties of soil before planting indicate that soil pH existence was 4.7 demonstrating that the topsoil was highly acidic (Landon, 1991) and has a low exchangeable calcium, potassium, magnesium and sodium are low (Asdu and Nweke, 1999), Total nitrogen and organic carbon were 0.07 and 0.5% are evaluated very low according to the base line by the Federal ministry of Agriculture and Water Resources (2002) for Nigerian soil. This base line clearly pointed out that soil used for this research was degraded in terms soil pH or fertility.

The effect of human urine on soil showed significant ($P < 0.05$) higher effect on pH when it is compared with the control, and also affect the available phosphorus, full nitrogen and the exchangeable magnesium and calcium organic carbon, sodium, potassium, after comparing with the control.

The significant increase shown in available phosphorus, total nitrogen and exchangeable magnesium and

calcium in the different urine handlings indicate that human urine could be good and useful as liquid sustenance for soil fertility treatment. Similarly, the increase of the chemical properties of human urine in the treated pots suggests that human urine for the treatment of soil can be act as a fertilizer by improving soil pH and nutrients. This is supported in the idea of Adeoluwa and Sulaiman (2012) that the management of urine improves the soil productivities.

CONCLUSION AND RECOMMENATION

The experimental results of the study showed the increase of the chemical properties of human urine in the treated pots suggests that human urine for the treatment of soil can be act as a fertilizer by improving soil pH, nutrients, organic carbon, total nitrogen, available phosphorus and cations of soil, Therefore, human urine can be used as an alternative replacement of chemical fertilizer

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