

Influence of Ammonium Sulphate from anaerobic pasteurization digester latrines (APDLs) effluent on soil pH

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Abstract

Improper disposal of human waste is one of the most serious health problems in developing countries due to pollution of the environment. The use of chemical fertilizers for agriculture increase the plant growth to meet the food security of the world, but also causes environmental problems including lowering of soil pH. On the other hand, anaerobic pasteurization digester systems enable the recovery of nutrients from human faces and urine for the benefit of agriculture, thus helping to preserve soil fertility. Therefore, the present work aims to assess the potential of using ammonium sulphate processed from anaerobic pasteurization digesters latrines (APDLs) effluent to stabilize soil pH. The experiment was laid out in a completely randomized design with four treatments replicated four times. The treatments were Ammonium sulphate, Compost manure, Di-ammonium Phosphate (DAP) and control. The results showed that soil pH increased significantly ($p < 0.05$) from 4.7 -4.9 before planting to 5.6 - 5.7 after planting. The organic and inorganic fertilizers as well as the interaction between the fertilizer and time did not have significant effect on soil pH ($p > 0.05$). The Ammonium sulphate recovered from APDLs final effluent could act as effective as a chemical fertilizer without significant reduction in the yield.

Keywords: Soil pH, Ammonium Sulphate, APDLs

1. Introduction

The poor human waste management is one of the developing world's most serious health problems. According to Rockström et al. (2005), the number of people lacking 'improved' sanitation in 2004 was estimated to be 2.6 billion, that is to say 42% of the world's population. They defecate in open fields, behind bushes, in buckets, or in latrines suspended over water sources or open pits. The recycling of human waste could bring major environmental benefits including plant growth. The feces and urine contain many valuable nutrients like nitrogen, phosphorus and potassium that can be hygienically extracted to produce organic manure applied to feed agricultural land. Muskolus (2008) reported that the recovery and use of human urine and feces could be practiced to enhance crop production without affecting environment.

Comparable to other fertilizer during the past three decades, agricultural intensification through the use of high yielding varieties, chemical or synthetic fertilizers has been responsible for significant increases in global crop yields especially in some developing countries (Smil, 2001; Beiying et al., 2010), but they also could cause soil hardening, compaction and soil degradation (Massah and Azadegan, 2016). Kochakinezhad et al., 2008 studied negative effects of chemical fertilizer on soil and environment bound its usage in sustainable agricultural systems, thus threatens future food security and raises production costs for often already poor farmers. Powlson et al., 2011 found that excessive use of chemical fertilizer in agriculture causes environmental problems including soil, physical destruction and nutrient imbalance. More so a large amount of inorganic fertilizer applied at the agricultural soils may result in the increase of heavy metals like Cd, Pb, and As (Atafar et al., 2010). However, most proportion of the chemical fertilizers due to rain and irrigation leached, consequently leading to environmental pollution including water pollution, soil pollution, and air pollution (Kaplan et al., 1999; Savci, 2012). Low use efficiencies of inorganic fertilizers coupled with their rising costs and the need for organically produced foods has directed the attention of farmers towards organic sources. Organic manures on the other hand increase soil fertility and thus the crop production potential possibly by changes in soils physical and chemical properties including nutrient bioavailability, soil structure, water holding capacity, cation exchange capacity, soil pH, microbial community & activity (Diacono and Montemurro, 2010). One major disadvantage of organic manure is its limited potentialities to afford higher crop production due to slow release of plant nutrients from organic matter.

Anaerobic pasteurization digester latrine (APDL) is a new a technology facility for human waste disposal that is very different from other facilities that have been used to dispose human waste. The effluent leaving the ADPL system is sterilized, making it safe for environmental discharge (Colón et al., 2012). The technology recognizes the need and benefit of protecting environmental health and promoting human well-being, recovering and recycling nutrients, and conserving and protecting natural resources. Nutrients and organic matter in human excreta are considered a resource, food for a healthy ecology of beneficial soil organisms that eventually produce food or other benefits for people (Esrey, 2000). Ammonium sulphate $(\text{NH}_4)_2\text{SO}_4$ is a granular or crystalline, in general white nitrogen fertilizer, containing 21% nitrogen and 24% Sulphur (Zapp et al., 2000). Because ammonium sulphate contains 100% ammonium nitrogen it guarantees a long-term and sustainable nitrogen supply. Furthermore, it prevents the nitrogen from being washed out of the soil. In addition, ammonium sulphate supports the availability of secondary nutrients like manganese, iron, and boron in the soil. It is against this background that this paper sought to assess the potential of using ammonium sulphate processed from anaerobic pasteurization digesters latrines (APDLS) effluent on soil pH.

2. Materials and method

2.1. Study area

The experiment was conducted at University of Eldoret farm, in Uasin Gishu District of Kenya. The university is located approximately 9 km from Eldoret town in western Kenya. Latitude 0.31° North, Longitude 35.17° East and at an Elevation of between 2110 m and 2140 m above sea level (Figure 3.1). The annual precipitation average 1103mm. The soils are of igneous origin, acidic (pH:4.5-5.0) and low in fertility and moisture storage. It is classified as rhodic ferralsol classification and oxisols classification (Osundwa et al., 2013).

2.2. Sample collection

Samples for the experiment consisted of compost collected from the farm, DAP, Peas (*Pisum sativum*) seeds purchased from Kenya Seed Company and ammonium sulphate extracted from effluent from ADPL.

2.3. Extraction of ammonia

Final effluent was collected from APDL in pre-cleaned-labeled 50.0 ml plastic containers and the sample was transported to the laboratory for treatment and extraction of ammonium

sulphate. Approximately 50.0 ml of the final effluent was accurately measured into a volumetric flask. Two hundred milliliters of distilled water were added and thoroughly shaken. 25.0 ml of aliquot of the solution was transferred into a 250.0 ml distillation flask and diluted with 100.0 ml of distilled water. 1.0 g of granulated zinc was added to the content in order to promote regular abolition in the subsequent distillation. Exactly 50.0 ml of standard 0.1M of acid (sulphuric) was placed in receiver and the flask was adjusted such that the end of the condenser just dipped into the acid while making sure that all the corks were tightly fitted.

Fifty milliliters of 10% sodium hydroxide was placed in the separating funnel and the sodium hydroxide run into the distillation flask by opening the tap. The tap was later closed as soon as the alkali had entered. The flask was heated so that the contents boiled gently and the distillation process continued for 60.0 minutes until half of the original volume remained. By this time all the total ammonium had passed over into the receiver contents.

2.4. Experimental design in the field

Planting of this experiment was done in March, 2015 using four treatments and one variety of green peas as the test crop under field conditions. The experiment was laid out in a completely randomized design with each treatment replicated four times with each plot measuring 2 m by 2 m at a spacing of 50cm between rows and within row spacing of 20 cm was used per plot. The treatments consisted of inorganic fertilizers (DAP), decomposed organic material (Compost), processed fertilizer from the digester (ammonium sulphate) and a control experiment (no fertilizer). The application of the treatment was done once and were applied at planting by spreading over the plot (ammonium sulphate was top-dressed in two applications, three weeks after planting and 2 months after planting following the farmers' top dressing regime.

2.5. Soil sampling and Statistical data analysis

Soils samples were taken from each block to a depth of 0.20cm just before the start of the experiment, the samples were bulked and mixed to obtain composite samples per block. Another soil sampling from each plot was done to the same depth soon after harvesting and the samples were bulked together. The soil was spread over a polythene sheet and mixed thoroughly by hand, after which a sub-sample was taken from each sample and placed in proper bags labeled with plot descriptions. The soils were spread on trays in a well ventilated room to

dry for 4 days after which they were gently crushed to break soil lumps and then sieved through a 2mm mesh and placed in labeled paper bags ready for chemical analysis.

During soil pH analysis, soil sample was collected in a plastic container and 25 ml distilled water was added to 20 g of soil. The mixture was stirred for 10 minutes and allowed to stand for 30 min and then stir again for 2 minutes. Before measuring the pH, the pH meter was calibrated using pH 4 and pH 7 buffer solutions.

After the data collection it was subjected to analysis of variance (ANOVA), using Genstat Software Version 14, to determine the differences in various Fertilizer application on soil pH. Significant differences were tested at 5% level of significance and means were separated using Tukey's test.

3. Results and Discussion

3.1. Effect of organic and inorganic fertilizers on soil pH

Soil pH before and after treatment of various fertilizers is summarized and presented in Table 1. pH increased significantly from 4.7 - 4.9 before planting to 5.6 - 5.7 after planting. Soil pH before and after was in the acidic range and application of the organic and inorganic fertilizers as well as the interaction between the fertilizer and time did not have significant effect on soil pH ($p > 0.05$). The increment of soil pH may be attributed to the addition of organic residues from the legumes in form of leaf litter drops and probably from the decay of roots and nodules legumes have the potential to improve soil fertility through the release of nitrogen from decomposing leaf residues, roots and nodules which results to increased sward productivity after nitrogen uptake by the companion grasses. (Guretzky et al., 2004; Cherr et al., 2006). F.Yan et al (1996) also reported Return of field bean *shoots* caused a significant soil pH increase from 5.64 to 6.29 .Therefore it may be urged the soil acidification it may be due to addition of plant residues by the legumes, the soil microbial activity increased.

Table 1: Effect of fertilizer type and time on soil pH

Fertilizer	Time	
	Planting	Harvesting
Ammonium sulphate	4.7 ^a	5.6 ^b

Compost	4.9 ^a	5.7 ^b
DAP	4.9 ^a	5.6 ^b
Control	4.8 ^a	5.7 ^b
Mean	4.8^a	5.6^b

Means followed by different superscript within a row are significantly different at $p < 0.05$

However, the pH increased in all plots irrespective of the fertilizer used and at the end of planting season, the average pH was 5.6. Additionally, time differences between planting and harvesting impacted significantly on pH ($p < 0.05$) despite the fact that fertilizers did not differ significantly in terms of their effect on soil pH. Fertilizer by time interaction reported insignificant effect on soil pH as indicated in Table 2.

The insignificant effect of fertilizers used on soil pH could imply that the nutrient compositions did not have much effect on the soil pH. Also, the lack of interaction effect between fertilizer and time and the significant effect of time may mean that both time and fertilizers acted independently without the additive effect of each factor.

Table 2: Effect of main factors (Fertilizer and Time) and their interaction on soil pH

	P-value	S.E	S.E.D	%C.V
Fertilizer	0.473	0.066	0.093	3.5
Time	0.001**	0.046	0.066	
Fertilizer×Time	0.093	0.093	0.131	

***Denotes significance at $p < 0.05$*

It is also possible that the increased pH could be due to the legume crop used rather than the fertilizers due to the ability of peas (legumes) to fix nitrogen through symbiotic relationship with the *Rhizobium* species, meaning they improve the nutrition of the soil they are in. Under such conditions, the availability of the base forming cations is limited since the soil solution is mostly occupied by aluminium and hydrogen ions (Mutegi, 2012).

4. Conclusion

Findings obtained in the present study showed insignificant difference in soil pH amongst ammonium sulphate, compost manure and DAP. Therefore, it is concluded that Ammonium sulphate recovered from APDLs final effluent can act as effective as a chemical fertilizer.

APDLs proved that there are sufficient nutrients for reuse for sustainable development in agriculture, for a sustainable society to be created, the nutrients from human waste and wastewater have to be recycled to agriculture.

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Conflict of interest

The authors declare no conflict of interest.

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