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DEMONSTRATION OF THE EFFECTIVENESS OF STRUVITE (URINE – BASED ORGANIC FERTILIZER) IN COMPARISON WITH NPK AND UREA (INORGANIC FERTILIZERS) ON CUCURBITA MAXIMA

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Abstract

This study compared the effects of struvite (a slow-release organic fertilizer) and inorganic fertilizers (NPK 20:10:10 and urea) on the growth of Cucurbita maxima (ugbogulu/anyu). It is targeted to prove that struvite, has positive effect on plants growth; then recommend it as fertilizer with an added advantage in relation to possibly being a great business venture. Here, struvite obtained from human urine was used for growing of the Cucurbita maxima which lasted for a period of four (4) months (December 2023, up to April, 2024). Four treatment groups employed included: control (no application), NPK 20:10:10, urea fertilizer and struvite group. Data on the following plant growth parameters were collected within 3 to 9 weeks after planting which was done third week of January, 2024. These data included: plant height, number of leaves, stem girth (circumference) and leaf area of the plants. Chlorophyll content, vitamin C content and mineral content were also determined according to the method of Arnon (1949), Klein and Perry (1982) and APHA (1995) respectively. The results showed that plants grown with struvite had a higher percentage change in plant height (91%) and the average plant height (cm) in 6-week harvest data was 23.78±1.08. The average number of the leaves in the struvite group was the highest (7.50±0.96), while the average number of the leaves in the urea group was the lowest (4.67±0.43). Struvite group had the highest average final stem girth (2.43±0.12) when compared with other groups (having 2.23±0.16 and 2.18±0.19 for NPK and Urea groups respectively). Also, plants treated with struvite fertilizer had the highest vitamin C content (440.50±10.21), highest average chlorophyll B content (2.21±0.79) and highest potassium content (5.43±2.08). Therefore, it is recommended to use struvite as an alternative to inorganic fertilizers for promoting plant growth, reducing negative environmental impact and making sanitation systems economically more attractive.

Keywords: Cucurbita maxima, Nutrients, Organic fertilizer, Struvite, Urine

INTRODUCTION

Fertilizers are used to introduce or replenish nutrients required for plants growth and development into soils. The use of fertilizers is indispensable if sustainable agriculture must be achieved. Fertilizers can be organic or inorganic. In recent years, the rapid increase in the population has led to large scale use of agricultural products from fertilizers; including synthetic fertilizers which has a lot of drawbacks. The use of inorganic fertilizers has negative consequences. Firstly, inorganic fertilizer products are very expensive and are not easily available in comparison with organic fertilizers. Most inorganic fertilizers are often produced or extracted from petroleum products and the process of production has a negative impact on the environment. Inorganic fertilizers do not increase the organic content of the soil and are easy to overuse, thereby damaging plants. Their use makes soil more acidic, thereby needing pH adjustment. When inorganic fertilizers are used, nutrients in the soil can easily be depleted. Some literature points out the presence of heavy metals in plants grown with inorganic fertilizers. The growing population requires more use of fertilizers leading to heavy reliance on inorganic fertilizer products to survive. Due to the problems listed above, it is necessary not only to embark on the use organic fertilizers but also to design a system which will make it possible to produce organic fertilizers in large scale / commercial quantity.

Struvite is a dry, stored mineral that can be produced from urine by adding magnesium (Mg); e.g. magnesium sulphate ($MgSO_4$), pre-treated magnesite ($MgCO_3$ converted to MgO) or bittern/ brine (liquid obtained from salt products from seawater). Magnesium ions combine with phosphate (PO_4^{3-}) and ammonium (NH_4^+) molecules to form solid precipitates that can be visually detected (Maurer *et al.,* 2006). This struvite is readily available and usable as a slow-release phosphate fertilizer. Compared to liquid urine, problems of storage, transportation, handling, and odour no longer exist; and the use of struvite from mixed-source urine seems to be socially acceptable (Gantenbein & Khadka, 2009).

The mechanism of struvite precipitation has been studied extensively in the United States, Canada, Europe, and Japan, where large municipal wastewater treatment plants use multipurpose systems to convert phosphorus to struvite (Ostara, 2010). Although this large-scale reactor relies on advanced technology to recover phosphorus, the challenge is to build a community-scale, low-cost struvite reactor that can be assembled from local materials and where magnesium products from appropriate activities may be effectively and easily used (Etter, 2009).

Struvite, used as fertilizer, can be easily produced by small businesses at a low cost. In other words, it is cheaper because they can be made from simple waste. They are generally safe and have low environmental impact. Generally speaking, plant or animal materials add organic substance, which retains moisture and supports a healthy soil microbiome. Additionally, the use of struvite fertilizers is less corrosive/ not likely to injure plants than inorganic fertilizers. Organic fertilizers may contain many micro-nutrients not found in inorganic fertilizers, and since they are released more slowly, they persist for a long time.

In this context, the recovery of nutrients, especially phosphorus and nitrogen, from human urine is important for its fertilizer value as well as for the conservation of natural resources, thus reducing water pollution and improving environmental sanitation systems in developing countries. Therefore, it is important to compare the plant growth benefits of struvite (recycled urine products) and commercial inorganic fertilizer products.

Statement of the Problem

The recovery of fertilizers from human urine; which is a waste product is very important because the use of poor quality/ inorganic fertilizer is known to cause negative consequences. Additionally, there is no control over the discharge of this waste (urine) into the aquatic environment and the surrounding, which can cause serious damage to the environment and is of great concern as it can damage water supply, and could be harmful to aquatic life or cause diseases if the water is used inappropriately; therefore needs to be channelled properly for optimal use.

Aim of the Study

This study aimed to recover struvite from human urine and compare its effects with inorganic fertilizers (NPK 20:10:10 and urea fertilizers) on *Cucurbita maxima* (ugbogulu/anyu) growth.

Objectives of the Research

i. To recover struvite (Magnesium Ammonium Phosphate Hexahydrate) from human urine, to be used as fertilizer.
ii. To analyze the nitrogen, phosphorus and potassium content of the recovered struvite, NPK 20:10:10 and urea fertilizer.
iii. To ascertain the comparative effect of struvite and inorganic fertilizers (NPK 20:10:10 and urea) on the growth rate of *Cucurbita maxima* (ugbogulu / anyu).
iv. To compare the effect of struvite, NPK and urea fertilizer on chlorophyll A, B and total chlorophyll content of the *Cucurbita maxima* (ugbogulu / anyu).
v. To compare the effect of struvite, NPK and urea fertilizer on vitamin C composition of the leaves, of the *Cucurbita maxima* (ugbogulu / anyu).
vi. To determine the comparative effect of struvite, NPK and urea fertilizer on mineral content (Mg, K, Fe, Zn, Ca) of the *Cucurbita maxima* (ugbogulu / anyu).

Significance of the Study

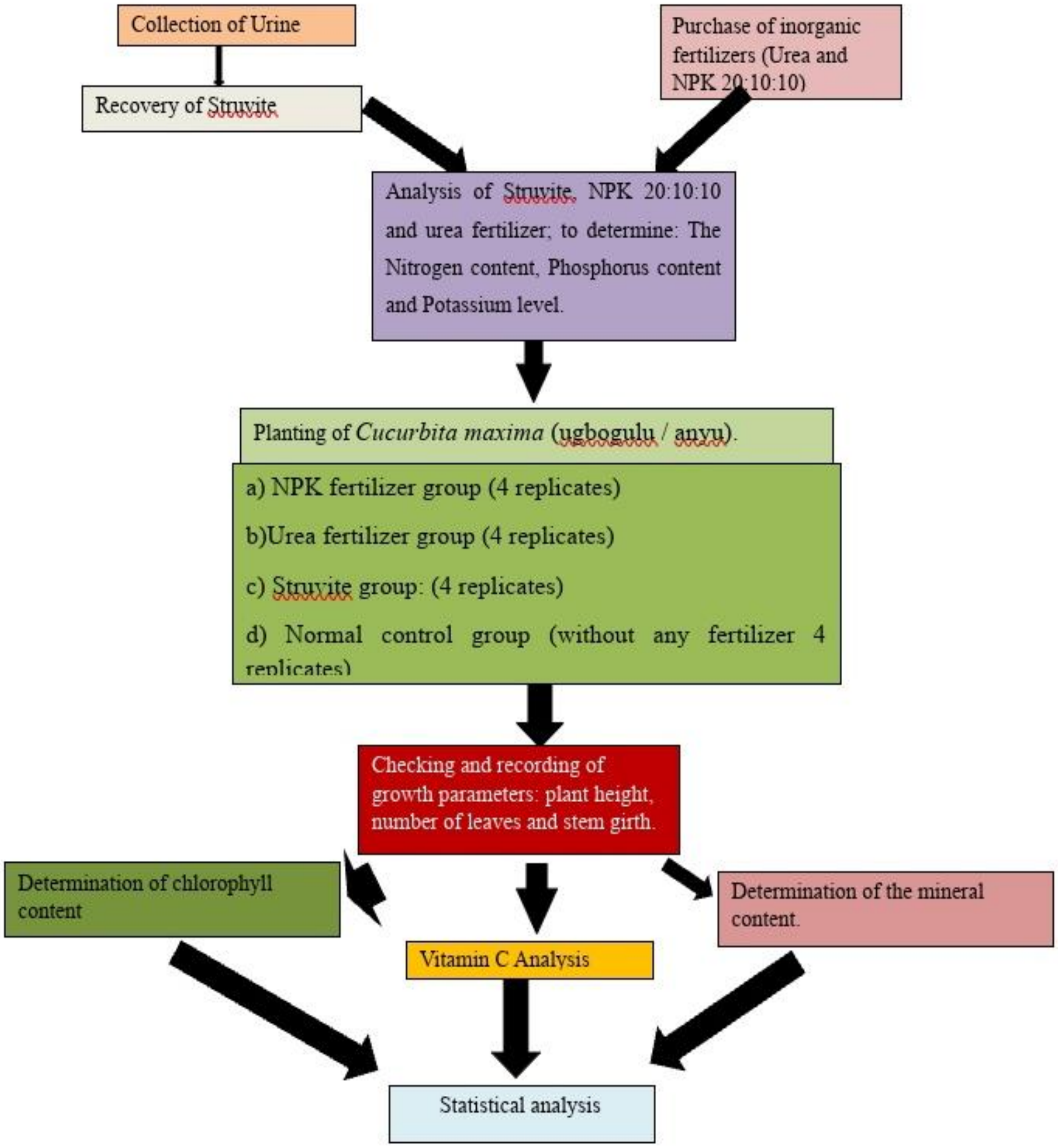
This study will help to determine if the use of struvite from human urine, will enhance growth parameters / improve crop yield in plants such as *Cucurbita maxima* and find out if it can influence the quality of the vegetables produced as regards to improvement in chlorophyll content, vitamin C content, some mineral content compared with inorganic fertilizers (NPK 20:10:10 and urea fertilizer). This work will also encourage the economic viability of introducing standard sewage disposal system in Nigeria.

Justification of the Study

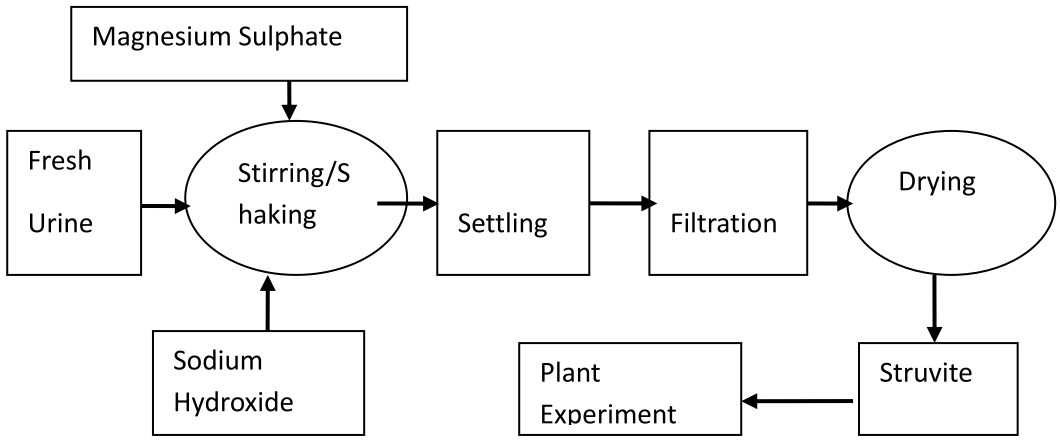
In this research work; urine, was converted to a more economical productive substance through a simple methodology of struvite recovery. The removal of nutrient compounds from aqueous waste (urine), as a means of controlling land and water pollution is currently a priority. Struvite formation is an attractive approach to precipitate a valuable multi-nutrients slow release fertilizer for vegetables and plants growth.

This study is of high interest as the entire methods, from struvite recovery to planting, vitamin C and mineral analysis stage was simple to carry out. Also, the raw materials involved are cheap and easily available.

WORK FLOW CHART



Experimental Design



Sixteen (16) sack bags of loamy soil was collected. The experiment was performed with four treatments groups which were replicated four times. The experimental treatments were: control (no application), NPK 20:10:10, urea fertilizer and struvite from human urine. The fertilizer application was done third week after planting using ring method. Manual weeding was carried out 6 weeks after planting by hand picking. There are three broad stages of this work.

Stage I: This phase comprises the collection of urine, struvite recovery and quantitative test on the Struvite, NPK and Urea fertilizer for Nitrogen, Phosphorus and Potassium.

Urine collection and Struvite Recovery (Method Described By Ayla *et al*., 2013)

Urine was collected and stored in jerry cans. To every litter of the collected urine 3.2grams of Magnesium sulphate was added.

Step by Step Procedure:

I. Collection of urine: Urine was collected in an airtight container from my house hold (a reliable source; free from any contaminant).

II. Mixing with Magnesium Source: 2.3grams of Magnesium Sulphate was mixed together with 1litre of the fresh urine (To every 10 litres, 23g of Magnesium Sulphate was added).

***III. Adjusting the pH**:* pH of the collected urine was measured using a pH test strip.{Its necessary to note that struvite formation is favourable at the pH range of 7-10. That is, to precipitate struvite; alkaline conditions are required. If the pH is too low, small amount of basic substance like sodium hydroxide (NaOH), will be added to raise the pH and if the pH is too high, small amount of acidic substance like Sulphuric acid (H_2SO_4) will be added to lower the pH}.

IV. Addition of Phosphate and shaking/ stirring the mixture: Drops of phosphoric acid was gradually added into the mixture; then poured into the vessel which was fixed unto the struvite reactor, for shaking/ stirring to agitate the reaction. This shaking lasted for 30 minutes.

V. Precipitation Reaction: The mixture was allowed to age for 48 hours. As the magnesium and phosphate ions came in contact, they react to form struvite crystals. This reaction can be stated as follows:

$Mg^{2+} + NH_4^+ + PO_4^{3-} + 6H_2O \rightarrow MgNH_4PO_4.6H_2O$

VI. Sieving and Drying: The crystal struvite formed; and the mixture then carefully poured through a filter bag to separate it from the liquid; then allowed to dry completely under room temperature.

Plate showing Struvite, recovered from human urine

Quantitative Test on the Struvite, NPK and Urea Fertilizer for Nitrogen, Phosphorus and Potassium

1. Nitrogen (N) Determination (AOAC, 1999)

The nitrogen content of the samples was determined using the micro kjeldahl method of AOAC (1999). The samples were dissolved with concentrated sulphuric acid, using copper sulphate and sodium sulphate as catalysts to convert organic nitrogen into ammonium ions. Alkali was added and the liberated ammonia was distilled into an excess boric acid. The distillate was titrated with hydrochloric acid and calculated as:

$$\text{Nitrogen}(\%) = \frac{1.4 x Titre Volume x total volume of digest}{1000 x weight of Sample x Aliquot distilled} \text{ x } 100$$

2. Determination of Phosphorus Content

Phosphorus content of the fertilizer sample was analyzed using spectrophotometry techniques, according to AOAC (2005) and was calculated as:

$$\text{Conc. of sample} = \frac{\text{Absorbance of sample x Concentration of standard (100mg/l)}}{\text{Absorbance of standard x 1}}$$

3. Potassium (K) Content Determination: Potassium concentration in urine based struvite fertilizer, NPK and urea fertilizer was determined using flame photometry according to Rehmat *et al.,* (2022).

Stage II: This phase involves the collection of *Cucurbita maxima* (ugbogulu / anyu) seeds and its identifying them, planting them and monitoring their growth.

Collection and Identification of Seeds

Cucurbita maxima (ugbogulu / anyu) seeds were collected from its fruit (anyu) and identified by a taxonomist. The seeds were dried and ready for planting.

Plate showing the *Cucurbita* maxima fruit used for this research

Plate showing the *Cucurbita maxima* seeds identified and used for this research

Planting of Seeds (Cucurbita maxima (ugbogulu / anyu) and Treatment Groups

Four (4) experimental groups were provided. They are:

a) NPK fertilizer group (4 replicates).
b) b)Urea fertilizer group (4 replicates).
c) Struvite group: (4 replicates).
d) Normal control group (without any fertilizer - 4 replicates).

4 seeds were planted per bag.

NPK group at four weeks

Struvite group at four weeks

Urea group at four weeks

Control group at four weeks

Plate showing the entire experimental groups after eight weeks

Determination of *Cucurbita maxima* Growth Parameters

Growth parameters including number of leaves, leaf area, plant height and stem girth was checked at intervals. Determination of number of leaves was done through physical counting. Plant height and stem girth was checked using rope and flexible measuring tape (cm). Leaf area (LA) was calculated as ½ W × L. As described by (Flávio and Marcos, 2003).

Where; W = leaf width

L = leaf length

Stage III- This includes determination of:

a) Chlorophyll content.
b) Vitamin C content.
c) Mineral analysis.

Determination of Chlorophyll content (Arnon, 1949).

Chlorophyll concentration was determined according to Arnon (1949) method.

The levels of chlorophyll 'a' and chlorophyll 'b' were determined using the equation given below:

Chlorophyll 'a' (μg/ml) = (12.7 x O.D. at 663 nm) – (2.69 x O.D. at 645 nm)

Chlorophyll 'b' (μg/ml) = (22.9 x O.D. at 645 nm) - (4.08 x O.D. at 663 nm)

and total chlorophyll (μg/ml) = (20.2 x O.D. at 645 nm) + (8.02 x O.D. at 663 nm).Chlorophyll content was expressed as mg chlorophyll per gram fresh weight of the leaf.

Ascorbic Acid (Vitamin C) content determination

Ascorbic acid content of the leaves sample was determined according to Klein and Perry (1982) and was calculated from the calibration curve of authentic L-ascorbic acid and the result expressed as mg ascorbic acid equivalent per gram (mgAE/g) of the sample.

Mineral Analysis: (Mg, K, Fe, Zn and Ca Content)

The mineral analysis of the sample was conducted using Varian AA240 Atomic Absorption Spectrophotometer based on the method of APHA 1995 (American Public Health Association)

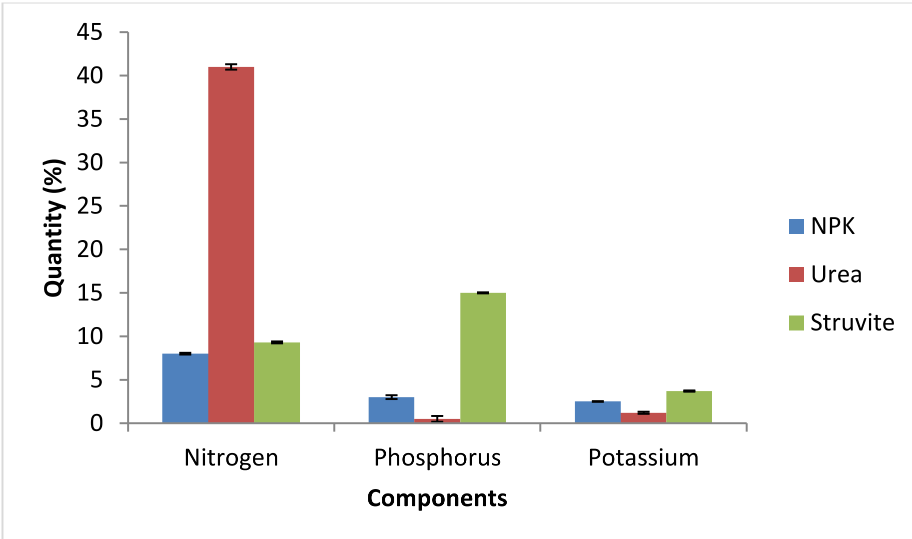
<u>Working principle</u>***:*** Atomic absorption spectrometer's working principle is based on the sample being aspirated into the flame and atomized when the AAS's light beam directed through the flame into the monochromator, and onto the detector that measures the amount of light taken up by the atomized element. Because metals have their own characteristic absorption wavelengths, using light from these materials causes no spectral or electrical interference. The energy absorbed in the flame at a characteristic wavelength is directly proportional to the concentration of elements in the sample.

Data Analysis:

Statistical analysis of the results was done using the Analysis tool pack of Microsoft excel. Tables and bar charts were employed to show the averages of each parameter. Charts were used to show the level/actual effect of struvite, and the purchased inorganic fertilizers on the plants growth. Data from mineral analyses (Mg, K, Fe, Zn and Ca) was subjected to Anova statistical analysis to compare all the parameters between and within the treatment / plant groups (level of significance $\alpha = 0.05$. That is, values were taken to be significant at $p<0.05$). Analyses of averages was performed to find out the effects of struvite fertilizer, NPK (20:10:10) and Urea fertilizer on the grown plants {*Cucurbita maxima* (ugbogulu /anyu)}.

RESULTS

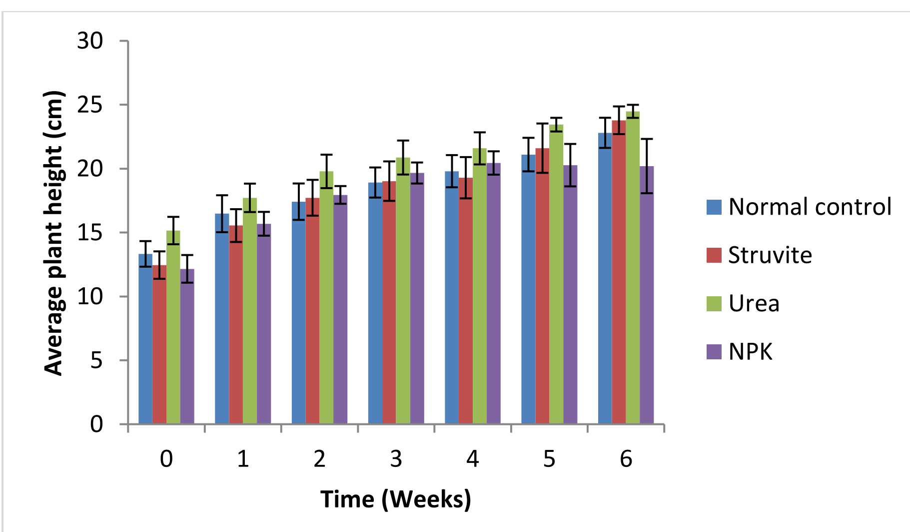
a. Nitrogen, Phosphorus and Potassium Concentration in Struvite, NPK and Urea



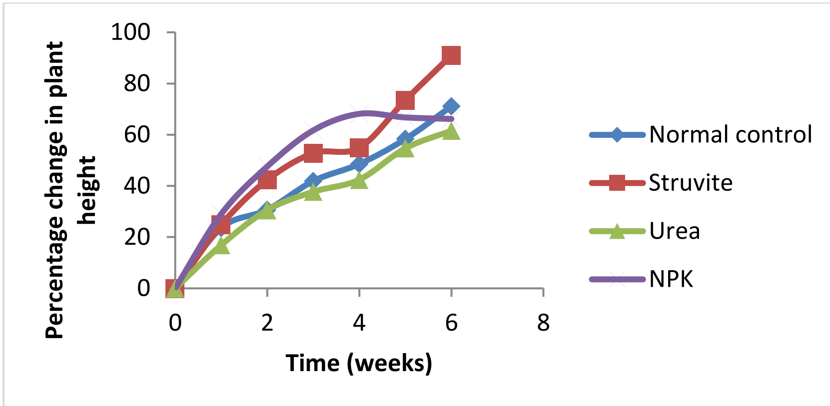
Bar chart Showing Nitrogen, Phosphorus and Potassium Concentration in Struvite, NPK and Urea

The comparison of nitrogen, potassium and phosphorus levels of the recovered struvite, urea and NPK fertilizer as shown above indicated that urea has the highest concentration of nitrogen with almost absence of phosphorus. Struvite has higher concentration of phosphorus compared with NPK fertilizer; but has the minimum concentration of potassium, which is termed more absorbable.

b. Effect of the Fertilizer Treatments on Plant Height



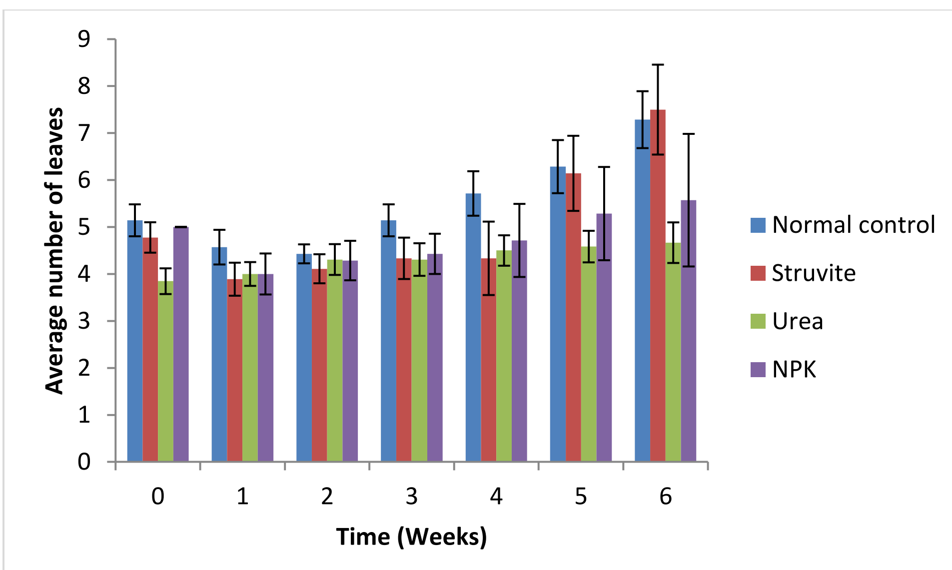
Bar chart showing average plant height (cm) during the experimental period



Scatter plot showing percentage change in plant height

From the results, there was a significant linear increase in plant height in all the groups ($p<0.05$). The struvite group had the highest percentage increase in plant height (91.00%) while the urea group had the least (61.57%); though there was no significant difference in initial and final plant heights when the groups were compared ($p>0.05$) The increase in plant height in the struvite group could be attributed to the high nitrogen and potassium content of the struvite since both nutrients promote plant growth and overall plant vigour.

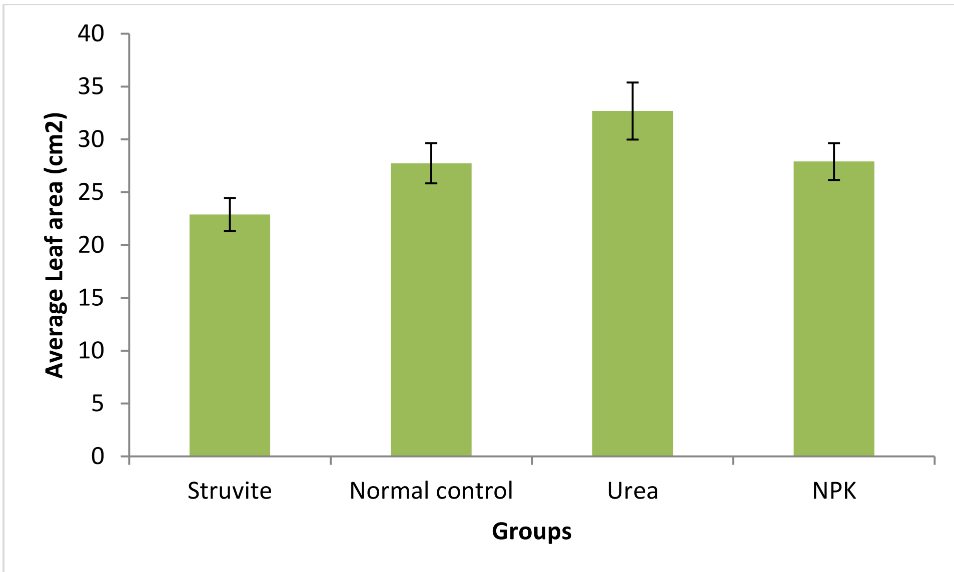
c. Effect of the Fertilizer Treatments on Number of leaves



Bar chart showing average number of leaves

From the results above, the struvite group had the highest percentage increase in number of leaves when compared with the rest of# the groups (56.98%). There was no significant increase in number of leaves in the urea and NPK groups. This increase in number of leaves means that the struvite encouraged more leaf formation more than the other fertilizer types.

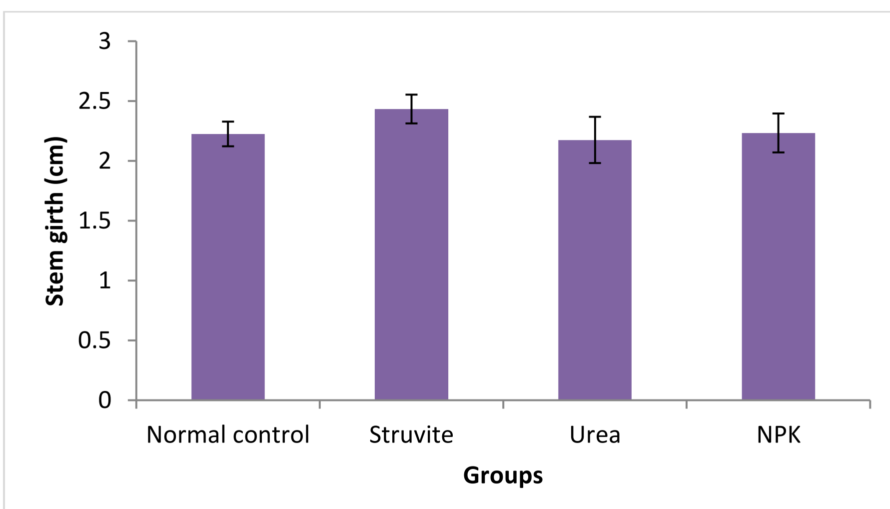
d. Effect of Fertilizer Treatments on Leaf Area



Bar chart showing average final leaf area of the various groups

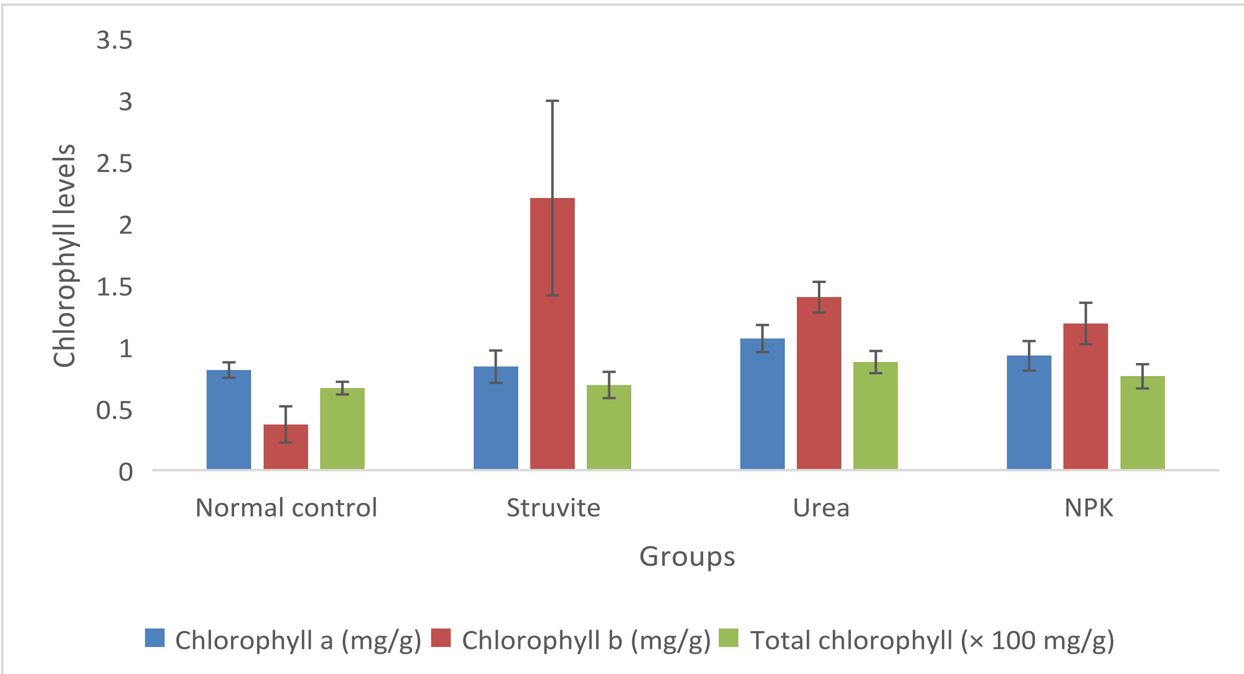
The struvite group had the least final leaf area while the urea group had the largest leaf area. Excessive/abundant nitrogen/nitrate is known to promote plant height but causes reduction in leaf area. This could be the case with the struvite group.

e. Effect of the Fertilizer Treatments on Stem Girth



From the results, the struvite group had the largest average stem girth when compared to the rest of the groups, though this wasn't significantly different from the rest of the groups (p>0.05). This could also be attributed to its nutrient composition that supports more of plant growth and leaf formation.

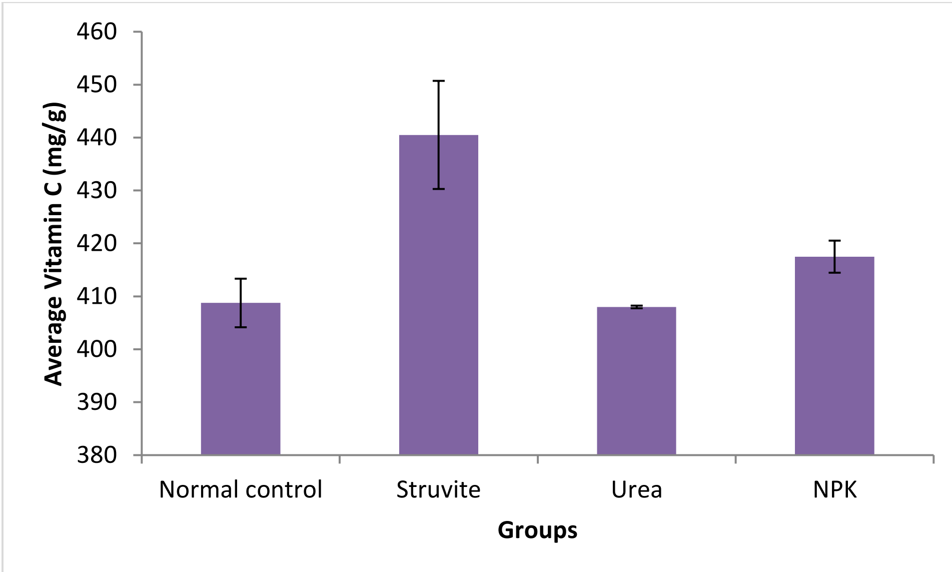
f. Effect of the Fertilizer Treatments on Chlorophyll Content



Bar chart showing average chlorophyll composition of the various treatment groups

The normal control group had the least chlorophyll A, B and total chlorophyll levels, thus the importance of additional nutrients to the soil to enhance light harvest. The struvite group had a higher chlorophyll B concentration. This means that the use of struvite manure can directly increase photosynthetic capacity since chlorophyll b is the major captor of light energy transferring it to chlorophyll a, the primary pigment involved in the conversion of light energy into chemical energy. The urea and NPK though had higher total chlorophyll levels; these weren't significantly different from that of the rest of the groups (p>0.05).

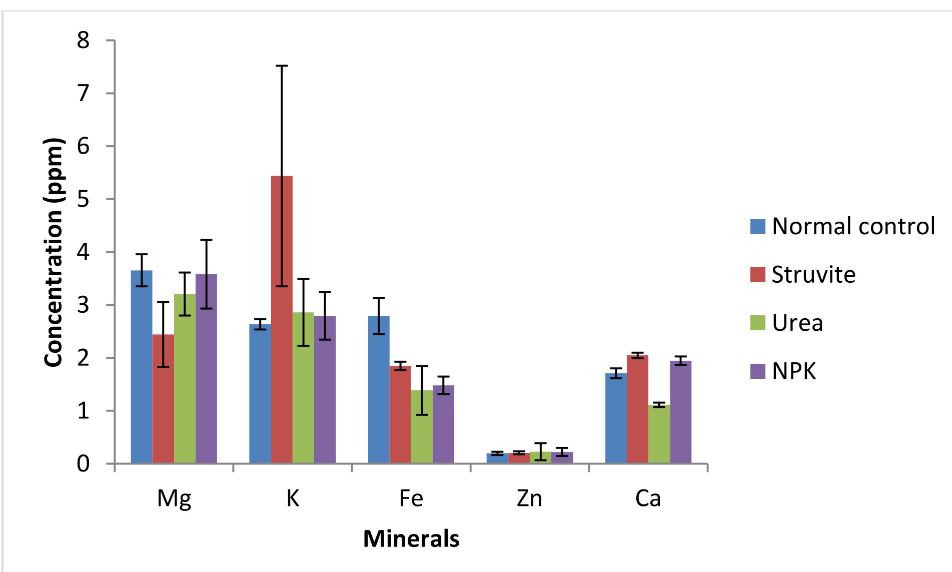
g. Effect of the Fertilizer Treatments on Vitamin C Concentration of the Leaves



Bar chart showing average vitamin C concentration

Based on the results, the struvite group had the highest vitamin C concentration while the urea group had the least. The difference in vitamin C was significant ($p<0.05$) when the struvite group was compared with most of the groups. Vitamin C concentration in plants is said to be affected by phosphorus and nitrogen content of the soil, thus the concentration in the struvite group. This also means that the nutrients in struvite are more absorbable.

h. Effect of the Fertilizer Treatment on Minerals Content



Bar chart showing mineral composition of the various plant samples

The above shows the mean results of mineral content of the various plant samples in each treatment group, there was a wide range of increase in potassium for those grown with struvite. The chart actually compared Mg, K, Fe, Zn and Ca concentration of the various plant samples. It showed there was greater concentration of potassium in plants grown with struvite. The variation of the parameters K, Mg and Zn in the fertilizer samples were not significant ($p>0.05$).

CONCLUSION

Urine is a unique waste, as it contains nutrients that are valuable in agriculture yet problematic in excess in aquatic environments. Nitrogen, phosphorus, and potassium as products of value can be recovered from human urine as struvite which are essential for plant growth. This study revealed that *Cucurbita maxima* plants responded well with the application of struvite manure. Thus, its application helps in reducing negative environmental impact and is adequate for maximum performance and growth of plants.

RECOMMENDATIONS

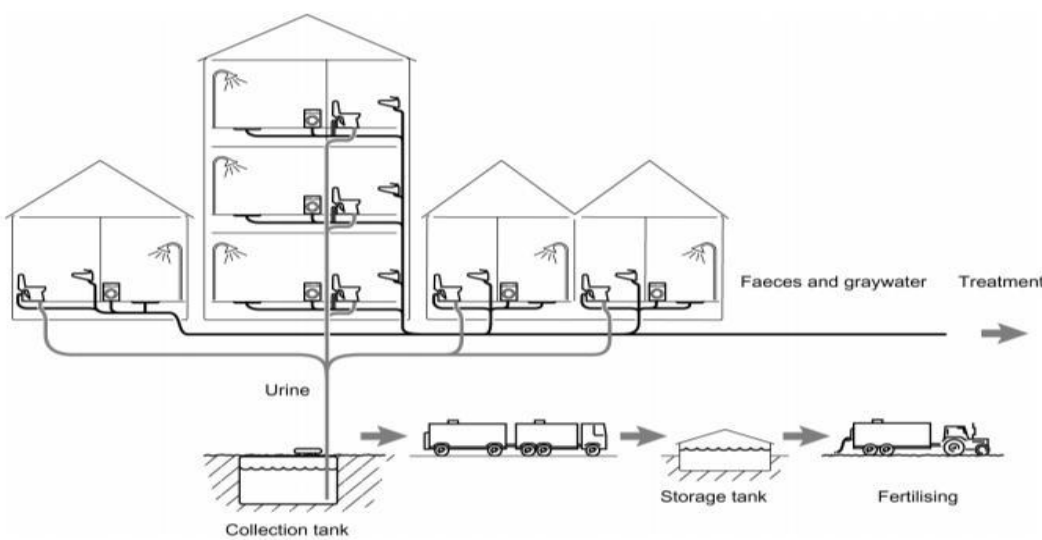
The following recommendations were made:

i. Struvite production should be done on a larger scale and used as organic fertilizer to improve plant yield.
ii. The research recommends that community sensitization should be undertaken to equip all households with knowledge and skills on the use of human urine as a fertilizer, to break ignorance, social norms and taboos by learning the usability of human urine fertilizer.
iii. The study also suggested that more experiment should be done on higher rates and lower rates of struvite fertilizer application on different crops and its applications should be provided according to the plant need, hence improving food security.
iv. It is also recommended that future studies must be conducted to understand more effect of struvite e.g on soil nutrient dynamics, so as to understand fully the potential, limitations and any possible drawbacks from using struvite.
v. Since urine separating systems are being implemented in Sweden, it is also recommended that such source separating toilet should be used here in Nigeria. However, regulatory guidelines may be employed as endorsement on how to use source separated urine in agriculture in order to minimize the risks for transmission of diseases and improvement in the sanitation systems of our country. Below are pictures showing source separating toilets:

Urine separating toilet models

Image source: Höglund, (2001)

vi. The government should endeavour to site these urine separating toilets at strategic positions, such as schools, markets and streets, aimed at collecting people's urine, keeping the environment clean and serving as source of employment.



A large-scale urine-separating wastewater system

REFERENCES

American Public Health Association (APHA) (1995). Standard methods for the examination of food, water and waste water (19th edition). Byrd press, Springfield, Washington.

Arnon, D. I. (1949). Copper Enzymes in Isolated Chloroplasts. Polyphenol oxidase in *Beta vulgaris. Plant Physiology,*24: 1-15.

Association of Official Analytical Chemist (AOAC). (1999). Association of Analytical Chemistry. Methods for Proximate Analysis. Pp 2318-2391.

Association of Official Analytical Chemist (AOAC). (2005). Official methods of analysis (18th edition), Washington D.C. *Journal of Nutrition*, 18: 1147-1161.

Ayla, U., Sinan, D., Emine, S., Figen, E. and Zeliha, K. (2013). Optimization of struvitefertilizer formation from baker's yeastwastewater: Growth and nutrition of maize and tomato plants. *Environmental Science and Pollution Research* **21**(5): 3264-3274 ISSN 0944-1344

Bhuiyan, M. I. H., Mavinic, D. S. and Koch, F. A. (2008). Phosphorus recovery from wastewater through struviteformation in fluidized bed reactors: A sustainable approach. *Water Sci Technol.,***57**(2):175-81. doi: 10.2166/wst.2008.002.

Etter, B. (2009). Process optimization of low-cost struviterecovery. M. Sc. thesis EPFL, Lausanne, Switzerland.http://www.eawag.ch/organisation/abteilungen/sandec/publikationen/stun (09/30/2009).

Flávio, F. B. and Marcos, V. F. (2003). A new method for estimating the leaf area index of cucumber and tomato plants.*HorticulturaBrasileira,***21**(4): 666-669.

Gantenbein, B. and Khadja, R. (2009). Struviterecovery from urine at community scale in Nepal (STUN) – Final project report phase 1, Kathmandu, Nepal. https://sswm.info/node/191

Henrique, R. R., Francielli, O., João, O. A. and Pedro, J. C. (2023). Broadcast nitrogen application can negatively affect maize leaf area index and grain yield components under weed competition. *Farming System,* **1**(3) ISSN 2949-9119,https://www.sciencedirect.com/science/article/pii/S2949911923000497

Höglund, C. (2001). Evaluation of microbial health risks associated with the reuse of Source-separated human urine, a doctoral thesis, Royal Institute of Technology (KTH) Department of Biotechnology and Applied Microbiology Swedish Institute for Infectious Disease Control (SMI), Department of Water and Environmental Microbiology, Stockholm.

Joanne, R. T., Martin, H. E., Kimberley, D. S., Francis Z. and Henry, F. W. (2021). Response of organic grain and forage crops to struvite application in an alkaline soil. *Agronomy Journal,* **114**(1), 795-810

Klein, B.P. and Perry, A.K. (1982). Ascorbic acid and Vitamin A activity in selected vegetables from different geographical areas of the United Sates. *Journal of Food Science*, **47**: 941-945.

Maurer, M., Pronk, W. and Larsen, T. A.(2006). Treatment processes for source-separated urine. *Water Research,* **40**(17): 3151–3166.

Orluchukwu, J. A. and Amadi, C. (2022). Effect of organic and inorganic fertilizers on the growth and yield of cucumber (*Cucumissativa L.)* In South-South Nigeria. International *Journal of Agricultural Policy and Research,***10**(2): 31-37.

Ostara Nutrient Recovery Technologies Inc. (2010): Creating Value from Waste. Ostara, Vancouver BC, Canada. http://www.ostara.com/commercial-installations (07/07/2010).

Rehmat, U., Zafar, A., Muhammad, B., Fareeha, H., Javed, I., Farhat, B., Sobia, N., Muhammad, A. Q., Abid, N., Khurram, S. B., Abdul, R., Lariab, F., Imran, A., Barkat, A. M., Ihsan, U., Abdulrahman, A., Mohamed, S. E., Shahbaz, A., and Hafiz, S. (2022). Method development and validation for the determination of potassium (K_2O) in fertilizer samples by flame photometry technique. *Journal of King Saud University – Science.* 34(5) ISSN 1018-3647,