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A STUDY OF ECOLOGICAL SANITATION OF HUMAN URINE BY TUNNEL HARVEST AND RE-USE FOR PERI-URBAN VEGETABLE PRODUCTION IN KANO- A PILOT SCHEME

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ABSTRACT
This paper employs Ecological sanitation approach by constructing a urine diversion toilet with urine collection facility attached to harvest urine, sanitize the urine by storage of 4month and subsequent application for assessing the nutrient contained for the growth and yield of two vegetable species; Amaranthus caudatus and Lactuca sativa. The different urine and NPK fertilizer in solution concentration levels were prepared and the volume of urine were diluted in ratio per 100mls with water to make 100% volume. There were total of 9 treatments replicated 3 times in a completely randomized blocked design making 54 pots. The result indicated that for Amaranthus caudatus75% (1:3) water : urine level produced highest significant height (p<0.05) of 90.30cm±6.7 and highest yield of 14323Kg/ha, while in Lactuca sativa, 100% urine level produced most significant (p<0.05) number of 21.00±1.1leaves per plant and highest yield of 6957Kg/ha. The research might contribute to reduction of poverty and hunger of Millennium Development Goals (MDG) and attainment of Sustainable Development Goals (SDG) of the United Nations (2015) in areas such as the study area of urban Kano. It is therefore necessary to evolved better means of addressing environmental sanitation in urban Kano by assessing the practical value of a urine diversion toilets developed and tested elsewhere with modification to suit existing condition or situation in the area.
Keywords: Ecology, Urban, Fertilizer, Amaranthus, Lactuca, Urine

INTRODUCTION

Rapid population increase within urban cities of Nigeria including Kano metropolis, pose serious challenge to environmental sanitation. Open defecation and urination are common practices that are almost part of some cultures. These practice results to some effects among which are: poor environmental sanitation which leads to outbreak of diseases and leaching of Nitrate and other soluble salts that contaminate ground water. Several researches have indicated that urine contain readily available nutrients that promote plant growth through ecological sanitation that involves separately collecting urine and feces for agricultural purpose, and have long been use in so many countries including Sweden, China, South Africa and some part of America.

The United Nation in year 2000 launched a global initiative on key development issue popularly known as UN Millennium development goal (MDG) that sets out eight targets that concerns most nations in the world and are expected to be achieved by 2015(UNDP,2016). However, these targets were not achieved by most countries across the globe based on assessment and for various reasons. In Nigeria, the MDG programme was introduced but fraught with several challenges. Issues such as reducing extreme poverty and hunger by half, reducing child mortality, eliminating gender disparity and ensuring environmental sustainability were poorly implemented (Ajiye, 2014). Thus, there was no visible impact of most set targets in many parts of the country. The MDG was subsequently reviewed and changed to Sustainable Development Goals (SDG) in 2012. The success of this new programme depends on a number of factors; namely partnership of government, private sectors, civil societies, and Citizens. Out of the eight issues set-out to be covered by MDG, sanitation is perhaps one of most serious problem; poverty, lack of access to safe water, illiteracy and poor and inadequate housing have further worsen sanitation in almost every part of Nigeria including cities such as urban Kano where poor sanitation has compounded human health and health care, hence the population of Kano and Nigeria in general are ranked among the most populated places in the continent in particular and at the global level too. WHO/UNICEF (2003) estimated that about 2.4 billion including Nigeria lacked access to improved sanitation facility. The population of urban Kano presently put at about 3million, pose a serious challenge to public health.

Water supply is critical for most areas and effective sanitation depends entirely on adequate water supply. Public toilets in urban Kano are very rare and poorly maintained. It is very common to see people urinating openly along the streets, open spaces, drains, in water bodies, on buildings and in important places e.g. school premises. This widespread practice by people contributes greatly to the poor state of environmental hygiene in many parts of urban Kano. Any approach that enable the collection of urine separately and subsequently utilize in urban cultivation particularly vegetables would reduce the stench from urine, improve level of environmental sanitation, ensure adequate supply of vegetables for the population and income for the growers is necessary. Ecological sanitation (eco-san) is a new paradigm that permits the complete recovery of nutrients from faeces, urine and grey water for the benefits of agriculture and consequently minimizes water pollution (Ganrot, 2005). Eco-san has been employed in peri-urban cultivation with a number of benefits (Pasquini, 2006).

In this study, harvesting of urine by eco-san approach to assess nutrient under field experimentation for the growth and yield of two edible vegetable species namely; *Amaranthus caudatus* and *Lactuca sativa*, was carried out.

MATERIALS AND METHODS

Study Area

The study area is the Bayero University Kano old campus, located in Gwale local Government of Kano metropolis. Kano State lies approximately between latitudes 10˚ 33'N and 12˚ 23'N and longitudes 7˚ 45'E and 9˚ 29'E, with a population of 9,401,288 based on the 2006 National head count or census (NPC, 2010). It has an estimated land area of 21,276.872 km^2 out of which 1,754,200 hectares for agricultural and 75,000 hectares forest vegetation and grazing land (AIAE, 2007). The urban Kano has a number of peri-urban farms such as 'Kwakwaci, Dan'agundi, Sharada, Ja'en, Kwarin Gogau and Gama Kwari' to mention a few. The farmlands uses domestic wastewater for the cultivation of household vegetables including Spinach (*Amaranthus sp*), Lettuce (*Lactuca sp*), Cabbage (*Brassica sp*), cucumber (*Cucumis sp*) and many others.

Reason for Selecting the Type of Experimental Toilet Used:

A convenient and appropriate site was selected for the work. In selecting the type of urine diverting toilet constructed, special concern was given to cost, convenience and most common type of toilet use by mass in the experimental area.

Selection of Experimental site:

A convenient place was also selected for pot experiment, in selecting the site, consideration was given to space for preparation of seedling plots, water availability, sun light and protection against insects, rodents and disease attack.

The Improvised Urinal Facility for Urine Harvest and Collection

A square shaped land of two square meters was selected and raised by 9 inches height blocks. The selected space was cemented but sloped at one end and attached to a urinal. The urinal was made by cutting a 4 liter gallon vertically and one half was fixed with cement by the end of the sloped part of the space as a urinal. The mouth of the gallon was placed and adjusted as an outlet and attached with 1inch PVC pipe as channel of the urine to the outside. At the outside, 20ltrs jerry-can was selected and 1inch diameter circular space by the right at the top and 5cm away from the handle was perforated using sharp hot metal and 1inch PVC pipe of 10cm length then attached to befit the outlet made and fixed permanently by melting. The PVC pipe was again joined by the other end through an elbow to the union. It was the union that joined through a screw cap ring to the extension of the PVC pipe from the urinal to attach the urine collection facility to the urinal. The facility was placed fixed to the urinal by digging an underground hole of 60 inches deep and 30 by 30 inches by width and breadth and subsequently covered with flat aluminum sheet to avoid anything from tempering with the setting. Hence, five (5) 20ltrs capacity yellow jerry-cans were filled for storage.

Urine Collection and storage

The urine sample was collected from voluntary donors only hence, the urine collection facility was attached to the urinal for collection only during volunteer's utility. The sample collected was stored for maximum of 4 month in tightly capped 20 liters capacity Plastic Jerry-cans in the field as described by Hoglund (2001) and Heinonen Tanski *et al*(2007).

Experimental Design

The experiment consisted of two variety of edible vegetable crops: Lettuce (*Lactuca sativa*) and Spinach (*Amaranthus caudatus*), simultaneously tested in two (2) treatments (dilutions in ratio of water: urine and water: NPK per 100% volume capacity) of 4 levels concentrations. The treatment combinations were laid out in Randomized completely blocked design (RCBD) replicated 3 times each making a total of 54 pots.

Plant Growth Monitoring and Data collection

Data collection commenced three weeks after planting (WAP) and subsequently at 4,5,6,7 and 8 WAP. One plant was selected randomly and tagged in each pot to measure the growth parameters: Plant height was measured with measuring tape, Stem girth with micro screw gauge, leaf area with leaf area meter, Chlorophyll content with Chlorophyll meter and number of leaves by counting manually based on Igboro *et al* (2015).

Statistical Analysis

Statistical analysis was performed using Sigma stat software version 3.5. The result were analyzed by two-way analysis of variance (ANOVA) with least significant difference compared, at statistical significant difference $p<0.05$.

RESULTS

The mean plant height of *A. caudatus*(spinach) treated with urine and NPK is shown in Table 1. From the result, at 3WAP *A. caudatus* treated with urine recorded the highest plant height of 14.25cm. At 4th WAP also, *A. caudatus* treated with 75% level of urine recorded the highest value of 27.67cm. The trend is similar at 5th, 6th, 7th and 8th WAP that is 37.67, 46.33, 52.67 and 90.30cm respectively, while the control treatment recorded the least significant different throughout the weeks. The mean number of leaves for L. sativa ((lettuce)treated with varying concentrations of urine and NPK fertilizer in solution is shown in Table 2.From the result at 3WAP *A. caudatus*, the highest significant difference was observed with 25%, 50%, 75% and 100% urine treatment that is similar 5.00 number of leaves and also in 50%, 75% and 100% NPK fertilizer in solution treatment while the least significant difference was observed in 25% NPK fertilizer in solution and with control treatment that is 4.00 number of leaves. At 8th WAP *L. sativa*, highest significant difference was recorded with 75% and 100% urine treatment that is 20.00 and 21.00 number of leaves, while least significant difference was observed in the control treatment that is 10.00 number of leaves. The fresh weight of *A. caudatus (spinach)*treated with varying concentrations of urine and NPK fertilizer in solution is shown in Table 3. From the result, highest significant difference in both fresh weight and yield was observed with 75% level of urine treatment (42.97g/14323kg/ha)seconded by 100% level of NPK fertilizer in solution treatment (36.93g/12323kg/ha), while the control treatment produced (16.97g/5651kg/ha) the least effect. The fresh weight of *L. sativa* (lettuce) treated with varying concentrations of urine and NPK fertilizer in solution is presented in Table 4. From the result 75% and 100% levels that is (19.10g/6367kg/ha and 20.87g/6957kg/ha) of urine treatment produced highest significant difference while control treatment had produced least significant difference of 10.53g/3510kg/ha.

Table 1: Mean Plant Height of *Amaranthus caudatus* (Spinach) Treated with varying of Urine and NPK Fertilizer in Solution.

Treatments	Level (%)	3rd WAP	4th WAP	5th WAP	6th WAP	7th WAP	8th WAP	Mean
Urine	25	14.25ab±0.8	23.00bc±1.0	30.33ab±2.5	36.33c±2.5	41.67bc±5.0	61.30b±2.3	34.48
	50	13.33ab±0.6	22.33bc±1.5	31.50ab±8.1	33.67c±2.1	42.67b±4.0	58.30bc±4.7	33.63
	75	14.00ab±1.0	27.67a±0.6	37.67a±2.1	46.33a±0.6	52.67a±2.3	90.30a±6.7	44.77
	100	13.83a±0.3	25.33ab±0.6	32.00ab±1.0	40.33b±2.1	49.33a±3.2	56.00b±0.0	36.14
NPK	25	8.25c±1.3	16.00d±0.7	15.00bc±0.0	26.00d±0.0	35.00c±0.0	41.00c±0.0	23.54
	50	12.73b±0.6	18.17cd±0.3	25.00bc±2.7	31.33cd±1.5	39.67bc±0.6	45.50bc±0.0	28.73
	75	12.67b±0.6	21.25c±1.0	33.00ab±1.0	35.67c±0.6	46.00a±0.0	52.50bc±0.5	33.52
	100	16.00a±1.5	23.67bc±1.0	39.50a±3.5	35.67c±1.2	52.00a±1.0	65.00b±1.8	38.64
Control	0	7.23c±0.6	11.02e±0.0	14.93c±0.6	17.33e±1.5	22.67d±7.5	26.30d±5.5	17.41
Mean		12.48	20.94	28.77	33.63	42.41	55.13	
LSD (0.05)		3.297	3.402	10.255	5.852	7.150	19.261	

Means within each column followed by same letter or none at all are not significantly different at $P < 0.05$.

Table 2: Mean Number of Leaves for *Lactuca sativa* (Lettuce) Treated with Varying Concentrations of Urine and NPK Fertilizer in solution.

Treatments	Level (%)	3rd WAP	4th WAP	5th WAP	6th WAP	7th WAP	8th WAP	Mean
Urine	25	5.00a±0.1	7.00a±1.1	8.00a±0.9	11.00b±0.2	13.00b±0.2	18.00b±0.6	9.83
	50	5.00a±0.0	6.00b±1.2	7.00ab±0.8	11.00b±0.1	11.00bc±0.6	17.00bc±0.8	8.83
	75	5.00a±0.2	6.00b±0.0	7.00ab±0.2	14.00ab±0.9	14.00ab±0.1	20.00a±2.3	10.33
	100	5.00a±0.6	6.00b±0.0	8.00a±1.2	15.00a±2.1	16.00a±1.3	21.00a±1.1	11.50
NPK	25	4.00b±0.6	6.00b±0.1	7.00ab±0.3	12.00ab±0.2	13.00b±0.9	18.00b±0.0	9.67
	50	5.00a±0.9	7.00a±1.1	8.00a±0.0	11.00b±0.8	13.00b±0.2	17.00bc±0.9	10.16
	75	5.00a±0.6	6.00b±0.9	6.00b±2.1	9.00b±1.1	12.00b±0.7	16.00bc±0.1	8.83
	100	5.00a±1.1	6.00b±0.8	8.00a±0.9	9.00b±0.6	12.00b±0.0	15.00c±0.9	9.17
Control	0	4.00b±0.2	5.00c±3.2	7.00ab±0.9	8.00b±0.7	9.00c±1.6	10.00d±0.2	7.50
Mean		4.80	6.10	7.30	11.10	12.60	21.10	
LSD (0.05)		0.499	0.763	1.040	3.065	2.378	2.158	

Means within each column followed by same letter or none at all are not significantly different at $P < 0.05$.

Table 3: Fresh weight of *Amaranthus caudatus* (spinach) Treated with Varying Concentrations of Urine and NPK Fertilizer in Solution.

Treatment	Level (%)	Fresh Weight	Yield (kg/ha)
Urine	25	27.03c±1.8	9010
	50	27.20c±0.9	9067
	75	42.97a±5.5	14323
	100	33.88b±0.7	11293
NPK	25	21.17cd±0.0	7057
	50	23.70cd±0.0	7900
	75	33.40bc±0.9	11133
	100	36.93ab±9.26	12323
Control	0	16.97d±0.9	5657
Mean		29.25	9751
LSD (0.05)		8.41	

Means within each column followed by same letter or none at all are not significantly different at $P < 0.05$.

Table 4: Fresh weight of *Lactuca sativa* (Lettuce) Treated with Varying Concentrations of Urine and NPK Fertilizer in Solution.

Treatment	Level (%)	Fresh Weight	Yield (kg/ha)
Urine	25	13.30b±3.5	4433
	50	13.63b±1.1	4543
	75	19.10ab±0.3	6367
	100	20.87a±1.4	6957
NPK	25	13.16b±1.9	4387
	50	13.37b±0.9	4457
	75	15.93b±0.5	5310
	100	17.27b±0.9	5756
CONTROL	0	10.53c±1.9	3510
Mean		15.24	5080
LSD (0.05)		3.32	

Means within each column followed by same letter or none at all are not significantly different at $P < 0.05$.

DISCUSSION

The two tested vegetables; *Amaranthus caudatus* (Spinach) and *Lactuca sativa* (Lettuce) had indicated higher growth (plant height and number of leaves) with human urine treatment than with NPK fertilizer in solution treatments and at each level of concentration. The result has confer more evidence that human urine contains various chemical substances that are equal or even higher than those contained in Urea or Ammonium fertilizers and also confirmed that those chemicals are as effective as those contained in NPK fertilizer in solution or any other commercial fertilizer in enhancing plant growth as emphasized by Kirchmann and Pettersson (1995).The result is also in line with result reported by Morgan, (2003) for a trial on yield of vegetables treated with human urine in Zimbabwe. In addition, the result collaborates the work of Adeoluwa and Cofie (2012) on yield of *Amaranthus specie* in Ibadan, Nigeria where 100% urine gave 58.17 tone ha^{-1} compared to 34.34 tones ha^{-1} of *Amaranthus* under NPK 15:15:15.

CONCLUSION

The re-use of 75% concentrated human urine as plant nutrient was very effective in promoting both growth and yield of Spinach (*Amaranthus caudatus*) and Lettuce (*Lactuca sativa*). Lower concentration of urine were however (25% and 50%) fairly better than the control on growth and yield of these plants. The 75% concentration of urine showed better performance in terms of growth parameters measured compared to same concentration of NPK a standard fertilizer. Successful urine harvest through the eco-san approach on a broad scale in urban Kano would go a long way to improve urban environmental sanitation and subsequently contributes towards achieving the

Sustainable Development Goals in Kano, Nigeria.

Development of the urine harvesting system would have been the responsibility of government at all levels in collaboration with relevant agencies, Departments and institutions including NGO's.

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