Assessment Of NPK In Human Male And Female Urine For Its Fertilising Potential In Agriculture

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ABSTRACT: The study evaluated concentrations of Nitrogen, Phosphorus and Potassium in male and female urine stored over six months and its potential as a fertilizing agent in agriculture. Urinals were constructed to allow for easy collection of male and female urine and then stored in transparent bottles for six months in a greenhouse. Monthly triplicate analysis of male and female urine was done for nitrogen, phosphorus, potassium, temperature, pH and colour change. Bray P1 and Flame photometry methods were used in the determination of phosphorus and potassium contents and Kjedahl digestion and non-digestion (direct) methods for nitrogen content. Temperature, pH and colour were determined using mercury thermometer, temperature/pH meter and a colour chart. Results showed that nitrogen in female urine was significantly ($p<0.05$) higher than that in male urine after 2 to 5 months of storage. However, there were no significant differences ($p>0.05$) with respect to the direct method. Contrastingly, phosphorus in male urine was significantly ($p<0.05$) higher than that in female urine after 2 to 3 months of storage but there were no significant differences in potassium content for all male and female urine samples. Generally, NPK yields in both urine sources peaked four months after storage. There was a moderate positive correlation between the direct female urine Nitrogen, and storage time. The phosphorus levels also correlated positively with storage time and temperature but weakly negative with pH. Generally, urine nitrogen strongly correlated positively with potassium but moderately with temperature and pH. Colour of matured urine (after six months storage) was yellow for females and brown for males. NPK contents in both male (30.4(3.4*)-1-43.7) and female (34.4(6.5*)-1-62.8) urine were comparable to those of chemical fertilizers, such as 21% N ammonia. However, the nitrogen content of digested female urine was significantly higher than that of male urine. Phosphorus concentration was higher in male urine than in female urine during the 2nd and 3rd months of storage. Ecosan urinals (a designed urinal that seeks to separately collect urine to optimize its usefulness) should be designed to separately collect urine for specific NPK requirements for crop production. Results of this study suggest that concentration of NPK in human urine is comparable to commercial chemical fertilizers. Human urine in agriculture should progressively be promoted by governments and other agencies.

Keywords: female urine, male urine, nitrogen, NPK, phosphorus, potassium.

1 INTRODUCTION

Use of excreta on arable land secures valuable fertilisers for crop production and limits the negative impact on water bodies [29,13, 6]. The environmental impact of excreta disposal usage would always be less than that of the direct use of water bodies as the primary recipient of excreta and greywater [29]. To preserve its fertility, arable land needs to be compensated for the plant nutrients removed. Today, chemical fertilisers produced by fossil resources do mostly this. In the long-term perspective the world cannot securely rely on fossil resources, as the recycling of plant nutrients. Another way of compensating soil fertility is from human excreta's direct application to arable land [18]. Urine has been used as a valuable plant food for centuries in many parts of the world, particularly in the Far East. It is surprising, therefore, that nearly all the urine produced in the West and in Africa goes to waste and is lost to agriculture [16]. Urine is known to contribute the major proportion of the nutrients (N, P and K) in domestic wastewater as compared to faeces which even poses a greater health risk when used [9]. Thus, separating the urine which accounts for about 1% of the total wastewater flow, and using it as fertilizer makes it possible to utilize most of the nutrient content of wastewater [10]. Urine is usually collected in a source separating toilet [20], and nitrogen discharge into water is reduced by about 60% irrespective of the type of treatment [10]. Pure urine is sterile but there is the likelihood of cross-contamination with the use of urine separating (Ecosan) toilets [28]. According to Jönsson et al. (2000) separated urine contains a greater part of the total nutrients in normal sewage; 80% of N, 55% of P, and 60% of K in just 1.5% of the volume of the sewage. According to Rheiberger (1936), there are comparable levels of creatine, urea and ammonia nitrogens in urine among primates such as man, mangabeys, baboons and chimpanzees. However, he identified sex differences in creatinine nitrogen coefficients of the male mangabeys, baboons and chimpanzees to be higher than those in the female counterparts. In small cases there was reversal of the magnitude seen in the macaques species precluding an assumption as to the validity of the observation. In analysing sex differences in urine with respect to lysine and α - amino nitrogen, the mean excretion of α - amino nitrogen whether "total," "free," or "bound," was higher for females than for males [22]. Thus, it is possible that the higher rate of amino acid excretion observed in females might be correlated with the sexual cycle, although no evidence of this was observed in the case of the four amino acids studied by Thompson and Kirby (1949) when samples from the same subjects were taken at various stages of the menstrual cycle.

The influence of sex (gender) on the level of NPK in human urine has received no attention. Therefore, there is a need to study the effect from the Ecological Sanitation (ECOSAN) perspective, especially under local conditions. This is because gender ECOSAN urinals are going to spring up with the advent of industries and ECOSAN concepts, especially in the developing countries. The use of urine in agriculture has been studied in countries such as Sweden, Germany, Switzerland, South Africa, Burkina Faso and Nigeria. In all these studies, the fertilizing ability of human urine was established as being comparable to that of chemical fertilizers, such as 21% N ammonia. However, in Ghana little

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is known about the use of urine as a fertiliser in agriculture. The present study, thus, sought to determine the NPK content of human male and female urine, and some factors that influence its maturity for agricultural use.

2 MATERIALS AND MEHODS

2.1 Study Area

A urine harvesting system was designed and built at the Department of Theoretical and Applied Biology (TAB) of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. The subjects used in this study were students and non-teaching staff who patronised a local restaurant close to the Department.

2.2 Urine Harvesting System

The urine harvesting system (plate 1) was built with locally available materials (Bamboo sticks, wood, cement and sand). Substructure receptacles (plate 2 and 3) were built with cement blocks [21] for both sexes. Connected to the receptacles were PVC pipes, which collected urine into 8 litre plastic containers, situated behind the urinals (plate 4). The PVC pipes were connected steeply to the receptacles, behind, to allow easy flow of urine to the containers by gravity.

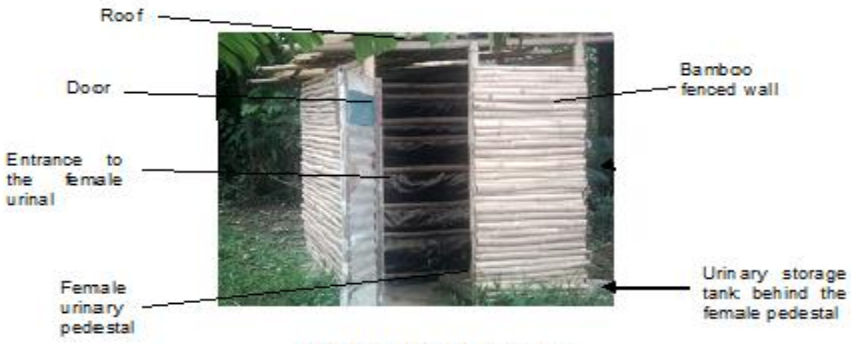

Plate 1. Front view of the ECOSAN urinal

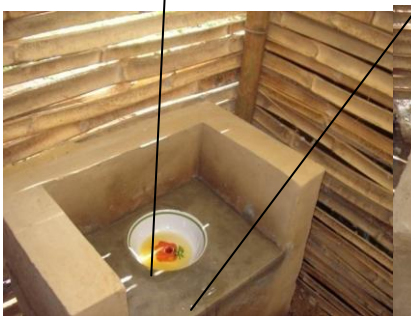

Plate 2. *Male urinal receptacle*

Plate 3*. Female urinal pedestal*

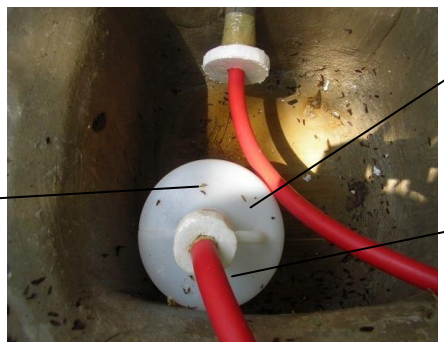

Plate 4.*PVC pipe draining urine into an 8 litre container*

2.3 SAMPLING AND ANALYSIS

2.3.1 Collection and Storage of Urine

Urine was collected in well- labeled 8 litre containers and stored in tightly capped transparent bottles [1], in Green-house at the Theoretical and Applied Biology Department. The collected urine was stored for periods of 1, 2, 3, 4, 5 and 6 months under normal atmospheric temperature conditions (25 ^{o}C and 33 ^{o}C) in the Green-house. The urine was labelled Male-1 and Female-1 for the first sample collected. A similar urine collection was made the following week and also stored. The second sample collected was labelled Male-2 and Female-2, respectively.

2.4 Method of Analysis

2.4.1 Physical parameters

Temperature, pH and colour of the freshly collected urine samples were determined for the male and female before storage. A control (composite urine) was also prepared by mixing equal volumes of male and female urine prior to analysis. Temperature (^{o}C) and pH were determined using the mercury –in- glass thermometer and Suntex pH/mV/Temp. meter. SP-701. Colour of the stored urines in the transparent bottles was read by matching with a colour chart [16] each time a sample was taken.

2.4.2 Chemical parameters

Freshly collected male and female urine samples were analysed separately in triplicate for Nitrogen (N), Phosphorus (P) and Potassium (K) and at month 1, 2, 3, 4, 5 and 6 months after storage. Total nitrogen was determined using the Kjeldahl method [4]. However, a direct distillation (non- digestion) method was also used, using the Kjeltec System, 1002 Distilling Unit. This was because the digestion of the urine prior to distillation, as required in the Kjeldhal method, led to a significant loss of nitrogen in the sampled urine. The two methods were thus employed for comparison.

2.4.3 Nitrogen determination:

Kjeltec method

To each of 10 ml triplicate urine samples, a 15 ml 40% NaOH solution was added, and shaken to mix thoroughly. Each mixture was distilled against 10 ml of 4% Boric acid in a Kjeltec distilling system for 4 minutes. The NaOH liberated the total nitrogen in the urine into the pink coloured Boric acid till green colour was produced. This green distillate was then titrated against 0.1M HCl until a pink colour was formed (that is the end point). The titre value was multiplied by a factor of 0.713 (plant/animal factor) to obtain %N. Some of the samples were digested with H2SO4 in a Kjeldhal chamber before distillation was carried out. The corresponding %N values were, however, relatively low. The method was as described by Bremner *et al*. (1982).

2.4.4 Phosphorus determination

The stored urine was well shaken before phosphorus analysis was carried out. The Bray P1 method [3] using Bray P1 reagent was employed in this analysis. A few drops (1ml) of a molybdate indicator were added to each 10 ml of triplicate male, female and composite urine samples. Distilled water was added to each mixture to a mark of 100 ml and allowed to stand for 15 minutes for colour development. The light intensity of the concentrated sample solution was measured as % transmittance using a Jenway Calorimeter /Spectrophotometer at a wavelength of 600 nm. The % transmittances (T) were then converted to absorbance (2-logT) and the corresponding concentration values read from the graph readings. The values of graph readings obtained were multiplied by a factor of 0.05 (plant/animal factor) to obtain percentages.

2.4.5 Potassium Determination

Potassium was determined using the Flame Photometry method described by Knudsen et al. (1982). A Jenway photometer machine was calibrated by using 5 different concentrations of Na-K standard solution. The values obtained were used to plot a standard graph, using a calibrated curve of flame emission and concentration of potassium. The machine readings of the urine samples were converted to parts per million (ppm) from the calibrated graph. One millilitre each of the triplicate urine samples of male and female urine was each diluted to 500 ml with distilled water. An oxyacetylene gas was turned on to burn to a fine blue flame after standardization. After stabilizing (i.e. aspirating the blank solution) the machine to 0.00 mark value, 10 ml each of the now 500 ml, triplicate samples was read from the instrument upon aspirating potassium ions (K^{+}) into the device for combustion. The instrument values were read on the said graph as parts per million (ppm). Each graph value was divided by a factor of 50 to convert them to percentages.

2.4.6 Statistical Analysis

The Statistical Package for Social Scientists (SPSS) software (version 15) was used in testing whether or not the means of dependent variables were significantly different among groups. The total % yield of nitrogen, phosphorus and potassium of the stored urine over the 6-month study period were analysed. This was indicative of when the urine could be used for crops that require proportionally high percentage of nitrogen, phosphorus or potassium. The significant difference in yield of NPK between male and female urines was also established for each month over the 6 months study period. If the overall ANOVA was significant and a factor had more than two levels, a post-hoc multiple comparisons follow up test was carried out using Least Significance Difference (LSD) or Duncan's Multiple Range Test (DMRT). In all cases, significance was determined at the 95% confidence level. One-way analysis of variance was performed to assess the differences among means, with a significance level of 5% ($p< 0.05$).

A Pearson correlation was used to establish either positive or negative relationship between maturation periods or the yields of N, P or K. An association between temperature or pH and the NPK was determined as well.

3.0 RESULTS AND DISCUSSION

Mean temperatures of male and female urine were strongly dependent on storage time ($r = 0.720$, $p< 0.01$), ($r = 0.789$, $p < 0.01$) respectively. Mean temperature of the composite urine also moderately correlated positively with storage time ($r = 0.397$, $p < 0.05$). This suggests that decomposition of urine or urea is associated with a change in temperature. It is likely that the environmental temperatures influenced the decomposition and maturation of the urine [1]. Chemical hydrolysis may produce internal heat change instead of the biological variance of N, P and pH [8], hence by extension associated parameters such as temperature. This was comparatively more observable in the female urine.

3.1 pH of stored human urine

Although the pH of the male urine fairly decreased from month 1 to 6 of the storage period, a significant decrease was observed only after month 4 (Table 1). This is in sharp contrast to work by Gethke *et al*. (2006) who reported that increased pH accompanied decreased concentration of phosphate phosphorus in stored urine. Maurer (2007) and Udert (2003) quoted a mean pH of 6.2 for undiluted fresh urine compared to 8.8 in this study. Aragundy (2005) showed that the initial pH of urine relates to the location and the environmental temperature of the place of storage. Fresh urine as used in Aragundy's study was not defined; however, fresh urine in the present study was 2 days old. The relatively high pH in this study may be due to high rate of decomposition within a short storage time. The decomposition of urea in the male urine. Contrary to what was observed in male urine, both the temperature and urea hydrolysing bacteria may have contributed to the decomposition of female urine. This may be because both the male and female urine were subjected to the same conditions, such as ambient temperature (25^{o}C). It is also possible that the hydrolysing bacteria were more abundant in the female urine than in the male urine as there were no significant changes in the male nitrogen levels, but in that of the female. This assumption is made because bacteria urease only speeds up the maturation time (the month of high yield) of urine, according to Aragundy (2005), is obtained when the pH is 9. This is a suitable pH for struvite precipitation [15], [8]. In one of Aragundy's set-ups this pH was achieved in the 4th month of storage, which is consistent with the current study at slightly lower pH of 8.78 in male urine. The mean pH of the female urine 7.59 increased from the first month to the third month (8.80), and then decreased gradually to a low value in month six (7.20). A similar pattern was also observed in the composite urine. The drop from month 3 to 4 was not significant (Table 1). The increase is consistent with increases in pH over storage period. It appears as though the maximum decomposition of urine, with pH indication, occurred at month four but slowed down later. However, the pH insignificantly correlated negatively to storage time($r= -0.299$, $p >0.05$). This further indicates that the inherent decomposition of the female urine can affect the pH irrespective of the storage time.

Table 1: *Mean physical properties of human urine over a 6 month storage period*

Storage time (month)	Male[b]			Female[b]			Composite[b]		
	T ^{o}C[a]	pH[a]	Colour	T ^{o}C[a]	pH[a]	Colour	T ^{o}C[a]	pH[a]	Colour
December	24.80[a]	8.795[c]	Light greenish brown	24.70[a]	7.59[a]	Light yellowish brown	27.80[b]	8.12[b]	Light greenish brown
January	24.45[a]	8.80[c]	Greenish brown	24.47[a]	8.78[b]	yellow	24.59[a]	8.82[c]	Light greenish brown
February	27.47[b]	8.75[c]	Dark greenish brown	27.03[b]	8.80[b]	Orange yellow	27.55[b]	8.67[c]	Light greenish brown
March	28.92[c]	8.78[c]	Greenish brown	29.18[d]	8.72[b]	Orange	29.12[c]	8.68[c]	Light greenish brown
April	28.22b[c]	7.45[b]	Greenish brown	27.97[c]	7.75[a]	Light brown	28.15b[c]	7.64[b]	Light brown
May	27.92[bc]	7.02[a]	Greenish brown	28.40[cd]	7.20[a]	Brown	27.97[b]	7.04[a]	Brown

[a]Average of six replications (N=108)
[b]Means in a column having a common letter are not significantly different at the 5% level of significance.

3.2 Colour of Human Urine

Changes in the colour of urine over the storage period varied from light greenish brown to greenish brown in males and light yellowish brown through yellowish orange to brown in females (Table 1). During the period of high decomposition the colour of the female urine was orange. According to Baer (2002), during storage of urine turbidity increases due to the growth of bacteria. This may affect the colour of stored urine. It thus appears that matured male and composite urine is

greenish-brown whilst that of the female urine is orange colour at urine maturation. The term mature urine in this study means stored urine with the highest decomposition to yield high NPK levels, and other associated parameters. The colour of urine is also dependent on the individual- a yellowish colour may depict feverish conditions, and in females the interpretation of urine colour appearance could be more complex because of hormonal and other feminine influences. It is important, however, to note that in this investigation, different females from different backgrounds were involved.

3.3 Male urine quality

Nitrogen level in male urine over the six month storage period increased from the 1st to the 4th month and decreased thereafter to the 6th month (Table 2). The increase was not significant. This may be ascribed to a slow rate of urea hydrolysis or decomposition over the six months storage period probably due to low level of hydrolysing bacteria. The results, however, showed that the phosphorus level in the male urine increased significantly during storage from month one to four and finally decreased by the sixth month (Table 2). The pH increase triggers the precipitation of struvite ($MgNH_4PO_4 \cdot 6H2O$) hydroxyapatite ($Ca_5(PO_4)_3(OH)$ and occasionally calcite ($CaCO_3$) [27],[27],[6]. However, Gethke *et a*l. (2006) indicated that increased pH accompanied decreased concentration of phosphate phosphorus in stored urine. The present work, however recorded decreasing pH from month 4 (8.78) to month 6 (7.02) – Table 1, and decreasing phosphorus from 4th month (1.7267) to the 6th month (1.0037)- Table 2, and thus agrees with that of [26],[27],[6]. This is an indication that the yield of phosphorus is affected by pH. The present study also indicates that the phosphorus yield in stored male urine is affected by storage time ($r = 0.582$, $p < 0.01$) and temperature ($r = 0.674$, $p < 0.01$). The relatively low percentages of phosphorus levels may have been due to the absence of highly concentrated early morning urine [24]. This is so as the local restaurant was opened for work at 9.30am everyday, over the study period. Individual's early morning's urine may not have been collected for this study. The potassium level in the male urine assumed a decreased - increased fashion from first month to the sixth month. None of the changes was significant. The male urine nitrogen, however, showed a strong positive correlation with the potassium level ($r = 0.831$, $p < 0.01$). This suggests that the prevailing factors could not effect any significant changes in the potassium levels.

Table 2: *NPK levels in male urine over a six -month storage period*

Storage period (months)	Digested Nitrogen (%)x	Direct Nitrogen (%)x	Phosphorus (%)x	Potassium (%)x
December	2.83a	23.597a	0.5652a	49.9000a
January	3.70a	32.68a	0.7138a	44.4167a
February	3.92a	34.36a	0.6380a	45.9467a
March	4.05a	38.00a	1.7267c	42.2500a
April	3.86a	34.42a	1.5443c	46.0617a
May	2.88a	25.02a	1.0037b	42.1833a

[x]Average of six replications (n= 36)
Means in a column having a common letter are not significantly different at the 5% level of significance.

3.4 Female urine quality

Nitrogen concentration in the stored female urine significantly increased from the first month to the fourth month and then decreased thereafter as observed in the digested urine (Table 3). However, in the direct method, significant changes occurred only between the first month and the rest of the storage months. The yield of nitrogen peaked during the 4th month of the six month storage period. The decrease may be due to the slowdown of urine hydrolysis. It may be that the high pH in the 4th month inhibited the bacterial decomposition of the urine or all the organic urea might have been utilized by hydrolysing bacteria, as reported by Udert et al., 2003c. It is also likely that chemical hydrolysis coupled with relatively high external temperature may have caused this slowdown process of nitrogen yield. The increase in yield of nitrogen was possibly due to the influence of the storage time ($r = 0.390$, $p < 0.05$) and pH

($r = 0.364$, $p < 0.05$) which may in turn affect the urine hydrolysis. The temperature, may equally contribute to the yield of the female urine nitrogen ($r = 0.363$, $p < 0.05$) as explained earlier. The urine nitrogen level correlated significantly with the potassium level ($r = 0.520$, $p < 0.01$). It is likely that similar factors caused the increase in yield of both nitrogen and potassium levels in the urine over the storage period. There was, however, no significant correlation between the nitrogen and the potassium levels in the digested female urine due probably to the method of nitrogen analysis. The choice of the two methods was to compare the relative yields of nitrogen.

Table 3: *NPK levels in female urine over a six -month storage period*

Storage period (months)	Digested Nitrogen (%)x	Direct Nitrogen (%)x	Phosphorus (%)x	Potassium (%)x
December	2.43a	12.56a	0.5540b	58.1333a
January	7.33bc	34.18b	0.2050a	50.0400a
February	7.34bc	34.33b	0.3822a	54.5833a
March	7.80c	36.32b	1.5557d	56.0000a
April	6.04b	33.29b	1.5540d	60.4667a
May	3.42a	30.93b	1.0300c	52.5333a

[x]Average of six replications (n= 36)
Means in a column having a common letter are not significantly different at the 5% level of significance.

The significant decrease in the phosphorus level from the 1st to the 2nd month of storage time might be due to the significant increase in pH over this period [8]. The increase in the phosphorus level from the 3rd to the 4th and 5th months of storage may be due to the relatively longer storage time ($r = 0.631$, $p < 0.01$) and temperature ($r = 0.741$, $p < 0.01$). This may be due to struvite precipitation [5]. As the decomposition process started slowing down from month five to six, it is possible that this was also accompanied by a proportional decrease in the phosphorus level in the female urine. The decreased- increased zigzag fashion of potassium level reached a peaked value in the 5th month of storage. All the changes were not significant, and suggestive of the fact that the exposed factors did not effect any significant changes in potassium levels during the 6- month storage period, though hydrolysis occurred.

3.5 Quality of composite urine

The nitrogen content of the composite urine increased from the first month to the fourth month and then decreased gradually to the sixth month. These changes were, however, not significant indicating that the urine hydrolysis was rather slow, if any. This might be attributed to little or no hydrolyzing bacteria to effect significant changes in the yield of urine nitrogen. It is possible that the hydrolyzing bacteria had no time to effect decomposition, as the analysis was carried out a few minutes after the mixture was made. This is because equal volumes of male and female urine were mixed together shortly before the analysis was carried out. On this assumption, it is possible that changes in nitrogen levels observed were insignificant due to temperature changes as observed in Table 1. It can also be ascribed to a brief chemical hydrolysis over a short period, of mixing male and female urines, before analysis was carried out. The nitrogen yield, nevertheless, might have influenced the yield of the composite urine potassium ($r = 0.749$, $p< 0.01$). The decrease in phosphorus level from the 1st to the 2nd month storage time may be due to the increase in pH over this period. It can be deduced from this assumption that the increase observed in the 3rd and 4th months' storage time was as a result of decreased pH ($r = -0.342$, $p<0.05$). It appears that after maturation (month four; the NPK levels were relatively high) the decreased pH did not correspond with the increased phosphorus level. The yield of phosphorus might have also been influenced by the storage time ($r = 0.705$, $p < 0.01$), and temperature ($r = 0.649$, $p < 0.01$), [5]. Potassium levels in the composite urine also assumed a decreased-increased zigzag fashion just as was observed in the male urine. However, the level increased steadily from the 4th to the 6th months' of storage. The non- significance of the changes observed might have, once again, been attributable to the slow rate of the process of decomposition. As observed earlier, the yield of potassium in the composite urine appears to be affected by the same factor(s) responsible for the nitrogen yield ($r = 0.749$, $p< 0.01$).

Table 4: *NPK levels in composite urine over a six -month storage period*

Storage period (months)	Digested Nitrogen(%)x	Direct Nitrogen (%)x	Phosphorus (%)x	Potassium (%)x
December	2.53a	20.34a	0.5770b	46.3333a
January	4.36b	34.25a	0.3028a	45.4333a
February	4.56b	36.15a	0.3872a	52.3000a
March	4.58b	36.01a	1.5734d	46.9333a
April	4.13b	32.38a	1.4607d	52.0000a
May	4.27b	31.65a	1.1790c	55.9667a

[x]Average of six replications (n= 36)
Means in a column having a common letter are not significantly different at the 5% level of significance

3.6 Gender yield significance

Results of the present study revealed no significant differences in NPK in male, female and composite samples although the male urine pH was significantly higher than that of the female in the first month's sample. This might be due to factors other than urine hydrolysis contributing to the increase in urine pH over the storage period. This is likely so since the urine nitrogen from the hydrolysis correlated significantly with the pH ($r = 0.631$, $p < 0.01$) as well as phosphorus ($r = - 0.776$, $p < 0.01$) and potassium levels ($r = 0.860$, $p < 0.01$) [8]. The significant differences in the female digested urine nitrogen from that of the male and the composite from the 2nd to 5th months of storage can be ascribed to the relatively high rate of hydrolysis of female urine. The rate of hydrolysis was monitored by determining the urine sample parameters, in every 14 days. It is also possible that the female physiology allows a relatively higher excretion of urinary nitrogen [22]. The direct urine nitrogen did not show any significant difference in all the urine sources. This is an indication that the method of analysing the urinary nitrogen influences the levels of nitrogen yields. On the other hand, the phosphorus level in the male urine was significantly higher than that of the female and the composite on the 2nd and 3rd months of storage. This might be due to the inherent male metabolic activity of phosphorus that permits relatively higher urinary excretion of phosphate phosphorus than in female. It may also be that the struvite precipitation, at this time, was better in the male urine than in the female or the composite urine. In the absence of significant differences in gender pH changes, phosphorus yield might have been influenced by storage time and/or temperature [5]. It appears that at equilibrium, pH has little or no influence on the urine phosphorus level. All the parameters appeared to have peaked in month 4, indicating higher activity period. There were no significant differences in all the decreased levels of the parameters studied in the urine from all the sources in month 6. This may signal the end of active decomposition or hydrolysis but not the end of the process itself. This is assumed, as observed by Aragundy (2005) that the process went on after even eight months storage in one of his set-ups. The pooled relative percentage of NPK level was higher in female urine (34.4(6.5*)-1-62.8), followed by the composite (34.8(4.5*)-1-54.4) and then in male urine (30.4(3.4*)-1-43.7) suggesting possible influence by gender physiology. These NPK levels were comparable to some chemical fertilisers, especially 21% N ammonia nitrogen in Kejetia market, Kumasi in 2010; and GHC 128.00 could be accrued from this ECOSAN urinal every month as revenue from its use. It is concluded that the female urine has higher NPK levels than the male urine, though the differences were not significant. Generally, both pH and temperature influenced the yield of NPK in human urine. The maturation time for urine was four months with associated colours of orange and greenish brown for female and male urine, respectively.

4.0 References

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