

Effect of Urine Sources on Some Soil Health indicators, Maize yield and Its Heavy Metals Uptake in Abakaliki, Southeastern Nigeria

Abstract:

The need to find alternative to inorganic fertilizer which is costly and not easily affordable to local farmers necessitates research in rare areas. Thus, this experiment was carried out at the Plant and Screen house to study effect of urine sources on some soil health indicators, maize yield and its heavy metals uptake. Completely Randomized Design was used in laying the experiment. 20kg of sieved soil was treated with different urine sources replicated five times. The result indicates that soil pH, total N and organic matter were significantly ($P < 0.05$) higher in different urine sources than control. Human urine had significantly ($P < 0.05$) higher treatment effect on soil pH, percent total N and organic matter compared to other sources of urine. Similarly, human urine was 9-10%, 15-27%, 10-47% and 6-5% higher in number of leaves, plant height, grain yield and leaf area index when compared to those of cattle and goat urine sources. Significantly ($P < 0.05$) higher copper uptake by maize grains was obtained in control relative to those of urine sources. Copper and lead uptake by maize grains were respectively higher by 20, 80, 87% and 87, 47, 7% in control when compared to human, cattle and goat urine sources. Generally, heavy metals uptake by maize grains is below recommended safe limits for toxicity. Urine from adult animals is recommended as credible alternative for improvement of soil health status and sustainable productivity.

Key words: effect, heavy metals uptake, indicators, maize yield, soil health, urine sources.

INTRODUCTION

Traditional agriculture relies heavily on mineral fertilizer NPK for crop production in Nigeria and other developing countries (Nwite, 2015) and incidentally, use of fertilizer is confronted with problems of unavailability, high cost and increase in soil acidity. As a result, use of fertilizer is considered to be counterproductive and there is need for its alternative source. This alternative source is urine since it is easily affordable as it could be accessed from livestock and man. It has been reported by Adeoluwa and Sulaiman, (2002) that urine contains useful nutrients which if carefully harnessed could sustain soil health status and increase its

36 productivity. Well preserved urine has good quality and could have the same effect
37 as inorganic fertilizer in optimizing soil fertility status (Nwite, 2015). Research
38 shows that urine contains major nutrients including nitrogen, phosphorus,
39 potassium as well as calcium and magnesium which is dependent on age and feed
40 of the animals (Marino, 2008).

41 When there is no planned disposal of urine it naturally constitutes health hazard
42 due to its pungent odour which could be curtailed through its proper treatment and
43 conversion in treating soil for higher productivity (Nwite, 2015). This offensive
44 odour is attributed to freshly accumulated urine at pH of 6.7 (Hoglung, 2001).
45 Researchers (Heinonen Tanski and Van Wijk-Sibesma, 2005; Kichman and
46 Peterson, 1995; Steineck *et al.*, 1999; Richert *et al.*, 2002; Malkki and Heinonen-
47 Tanski, 1999) have shown that human urine source was successfully used as
48 fertilizer in crop production and raising flowers in Europe and other countries.
49 Confirmatory studies have been carried out using Barley and under crop and field
50 trials or even under home gardening (Richert *et al.*, 2002).

51 With the wide spread scarcity of inorganic fertilizer and its associated problems in
52 food production, there is need for alternative source. If appropriate quantity of
53 urine is applied to the soil at right time, its nitrogen contents could have the same
54 value as that of inorganic fertilizer (Adeoluwa and Sulaiman, 2012). For instance,
55 100kg N per hectare of urine improved Barley production between 90 – 110 days
56 of planting in Sweden (Richert *et al.*, 2002).

57 Naturally, human being could not easily accept food crops produced with urine due
58 to suspicion of its health hazard status and safe for consumption. This, however,
59 could be overcome by treating urine for quality assurance and safe from health
60 hazards (Nwite, 2015). In Nigeria food crops that grow around urinals or where
61 urine is disposed are normally eaten by human beings and animals without any
62 complaints of health problems. The objective of this experiment was to study effect

63 of urine sources on some soil health indicators, maize yield and its heavy metals
64 uptake under Abakaliki agroecological environment.

65

66

MATERIALS AND METHODS

67 **Experimental site**

68 The research was conducted in 2014 at Plant and Screen House of Teaching
69 and Research Farm, Faculty of Agriculture and Natural Resources
70 Management, Ebonyi State University, Abakaliki. The area is located **between**
71 **latitude (06° 4'N and 08° 65'E) in the South-Eastern** zone of Nigeria. The area
72 experiences bimodal pattern of rainfall which is spread from April-July and
73 September-November of each year. There is a break in August normally referred
74 by residents as “August break”. At the beginning of rainfall, it is torrential
75 and violent and is characterized by thunderstorm and **lightning**. The
76 minimum and maximum rainfalls are 1700 and 2000 mm with a mean of 1800
77 mm (ODNRI, 1989). The temperature during rainy season is usually low (27°C)
78 but increases to 31 °C in dry season. Relative humidity is 80% in rainy season
79 which declines to 60% during the cold Harmattan periods and dry season of
80 the year (ODNRI, 1989) being characteristics of tropical climate.

81 The soil is derived from sedimentary deposits from cretaceous and tertiary
82 periods. According to Federal Department of Agricultural Land Resources
83 (FDALR, 1985), Abakaliki agricultural zone lies within “Asu River” and is
84 associated with Olive brown shale, fine grained sandstones and mudstone. It is
85 unconsolidated within 1 m depth (Shale residuum) and belongs to the order
86 ultisol classified as *typic haplustult*. The area was grown of short vegetation
87 and medium to tall trees. There is also growth of native grasses, herbs and shrubs
88 with patches of ground.

89

90 **Experimental Design and Treatment Application**

91 The experimental design used in this study was Completely
92 Randomized Design (CRD). Human urine of male adult was collected from
93 **prison inmates** while cattle and goat urine was sourced from **Cattle and**
94 **Goats' market located at Gariki and Hossana, Abakaliki** respectively. **This**
95 **was to reduce the time needed to collect enough quantity of urine for the**
96 **study. Plastic containers of 5litres each were provided to both prison and**
97 **Animal attendance for the purpose of collection of urine.** The animals used
98 were of matured age. **The choice of these animals was based on ease of**
99 **accessibility since every farming family in the locality can afford to keep them.**
100 **These animals too are omnivorous and have common feeding habit at adult age.**
101 The urine was stored in air-tight plastic containers for 6 months before
102 application **to ensure sanitation process.** **The urine treatments were based on**
103 **hectare equivalence of 20kg soil.**

104 **Human urine = 50,000 mg ha^{-1} equivalent to 100 mg kg^{-1} soil**

105 **Cattle urine = 50000 mg ha^{-1} equivalent to 100 mg kg^{-1} soil**

106 **Goat urine = 50000 mg ha^{-1} equivalent to 100 mg kg^{-1} soil**

107 **Control = 0 mg ha^{-1} equivalent to 0 mg kg^{-1} soil**

108 The urine rates were applied to **20kg** of soil weighed into **perforated**
109 **polybags** two weeks after germination of maize seeds. These treatments were
110 replicated six times to give a total of twenty four experimental **polybags** in the
111 experiment. The **polybags** were watered to field capacity as often as moisture is
112 required. The **polybags** were separated by 0.5m spaces while replicates were set
113 1m apart.

114 **Planting of maize**

115 Maize variety (Oba super II hybrid) (*Zea mays* L.) collected from
116 Ebonyi State Agricultural Development Programme (EBADEP), Onu Ebonyi

117 Izzi, Abakaliki was used as a test crop. The maize seeds were planted at two
118 seeds per hole and at 5 cm depth in each pot. Two weeks after germination
119 (WAG), thinning was carried out to allow one plant per stand. Weeds were
120 removed by handpicking at regular intervals till harvest.

121 **Agronomic parameters**

122 A total of ten maize plants were randomly selected and tagged for
123 study. When the husks were dried, the cobs were harvested, dehusked,
124 shelled and grain yield adjusted to 14% moisture content. Plant height was
125 measured with metric ruler from the base of plant to tallest plant leaf at
126 tasseling.

127 **Soil Sampling**

128 Auger sampler was used to collect soil samples at 0-20 cm depth from
129 site where soil used for experiment was collected. The samples were bulked, air
130 dried and passed through 2mm sieve and used for routine laboratory analysis.
131 Samples were further collected from each polybag for some post-harvest
132 chemical properties determination.

133

134 **Laboratory methods**

135 Particle size distribution of the experimental soil was determined using
136 the Bouyoucous method as outlined in Gee and Or (2002) procedure. Soil pH
137 determination was carried out in soil/water solution ratio of 1:2.5. The pH values
138 were read off using pH meter with glass electrode (Peech, 1965). Total
139 nitrogen was determined using Micro-kjeldahl procedure (Bremner, 1996).
140 Available phosphorus determination was done using Bray-2 method as outlined
141 in Page *et al.* (1982). Organic matter was determined by Walkley and Black
142 (1934) digestion method. Exchangeable bases of calcium (Ca), Magnesium
143 (Mg), Potassium (K), and Sodium (Na) were extracted using ammonium acetate

144 (NH₄OAC) extraction method. Potassium and sodium were determined using
145 flame photometer. The compositions of urine were determined by Atomic
146 Absorption spectrophotometer as well as crop uptake copper (Cu) lead (Pb)
147 using Dewis and Freitas (1976) procedure.

148

149 **Data analysis**

150 Data collected from the experiment were subjected to Analysis of
151 Variance (ANOVA). Means were separated using Fishers' Least Significant
152 Difference (FLSD) as outlined in Steel and Torrie (1980). Significance was
153 reported at 5% probability level.

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RESULTS AND DISCUSSION

Composition of Urine

Table 1 shows some major nutrients and heavy metals composition of urine source. There were variations in values of nutrients and heavy metals in urine source. Nevertheless, human urine have highest values of nutrients when compared to livestock sources although, comparable. Cattle and goat urine contained 0.10 mgkg^{-1} each of copper (Cu) and lead (Pb) but was not found in human urine. The comparable composition of elemental concentrations in animal urine could be attributed to their adult age, omnivorous nature as well as similarity in their dietary needs.

Table 1. Compositions of some major nutrients and heavy metals in urine sources

Parameter	Human urine	Cattle urine	Goat urine
pH H_2O	9.1	9.0	8.9
Ammonia mgkg^{-1}	0.01	0.01	0.01
Nitrogen %	4.54	4.52	4.51
Phosphorus mgkg^{-1}	0.04	0.03	0.02
Potassium cmol/kg^{-1}	0.05	0.03	0.03
Sodium cmol/kg^{-1}	0.29	0.28	0.28
Copper mgkg^{-1}	-	0.10	-
Lead mgkg^{-1}	-	-	0.10

179 **Properties of Soil before initiation of study**

180 Table 2 shows physicochemical properties of soil before initiation of study.
181 Sand fraction was dominant in the particle size distribution. The textural
182 class was sandy loam. The pH was 5.0 which indicates strongly acidic soil
183 (Landon, 1991). Nitrogen was 0.13% and according to Enwezor *et al.* (1981)
184 is very low and organic matter which had 2.2% value was moderate using
185 Benchmark of FMAWRD (2002) for Tropical soils. Phosphorus (20.40
186 mgkg⁻¹) was high (Enwezor *et al.*, 1989). Exchangeable calcium was of
187 medium value but magnesium, potassium and sodium were very low (Asadu
188 and Nweke (1999). Cation exchange capacity recorded very low values
189 (Asadu and Nweke, 1999). It implies that the soil was of low fertility status
190 as obtained in Abakaliki areas for soils used for maize production as well as
191 other crops.

192 **Table 2.** Properties of soil before initiation of study

193 Soil properties	193 Values
194 Sand gkg ⁻¹	750
195 Silt gkg ⁻¹	140
196 Clay gkg ⁻¹	110
197 Texture class	Sandy Loam
198 pH H ₂ O	5.0
199 Total Nitrogen %	0.13
200 Organic matter %	2.2
201 Available phosphorus mgkg ⁻¹	20.40
202 Calcium cmol kg ⁻¹	3.10
203 Magnesium cmol kg ⁻¹	0.92
204 Potassium cmol kg ⁻¹	0.17
205 Sodium cmol kg ⁻¹	0.10
206 Cation exchange capacity cmol kg ⁻¹	7.50

207 **Effect of Urine Sources on Some Soil Health Indicators**

208 Effect of urine sources on some soil health indicators is shown in Table 3. **Soil**
209 **health indicators are used in this study to indicate parameters that are**
210 **determinant of soil fertility status.** Urine sources had significantly ($P < 0.05$)
211 higher treatment effect on pH when compared with the control. Human source
212 of urine had significantly ($P < 0.05$) higher pH than those of cattle and goat urine
213 sources, respectively. On the other hand, human urine was 5 and 6% higher in
214 pH than the urine from cattle and goat. Similarly, significantly ($P < 0.05$) higher
215 treatment effect was obtained in percent total nitrogen in human and cattle
216 sources of urine relative to control. Furthermore, human urine showed
217 significantly ($P < 0.05$) higher treatment effect on percent total nitrogen
218 compared to those of cattle and goat sources of urine. Available phosphorus
219 obtained in different urine sources slightly varied from that of the control. The
220 available phosphorus of human source of urine was 14% higher than control and
221 generally marginally higher than those of cattle and goat sources of urine. There
222 was significantly ($P < 0.05$) higher treatment effect of urine sources on percent
223 organic matter relative to control. Urine obtained from human and goat was
224 significantly ($P < 0.05$) higher in percent organic matter than the one from cattle.
225 This represents 21 and 14% increments in percent organic matter in human and
226 goat sources of urine compared to that of cattle source.

227 The significant increments of pH, percent nitrogen, organic matter and
228 improvement of available phosphorus show that these soil health indicators
229 were released into the soil by urine sources. This finding indicates that urine
230 could substitute mineral inorganic fertilizer as it could be used as fertilizer to
231 supply essential and major nutrients to soil on one land and on the other
232 improve soil health status. These findings are in line with the report of
233 Adeoluwa and Sulaiman (2012) that urine used as fertilizer improved soil health

234 status. Several researchers (Gutser *et al.*, 2005; Schonning, 2001; Adeoluwa and
 235 Cofie, 2012) reported positive impact of urine on nitrogen which increased and
 236 sustained soil fertility. Higher significant positive effect of human urine source
 237 on soil health indicators suggests that it could be more superior to other urine
 238 sources in improving soil health indicators (Nwite, 2015). This finding had
 239 earlier been reported by Benge, (2006) and Adeoluwa and Sulaiman (2012).
 240 This implies that urine sources especially human urine could serve as useful
 241 alternative fertilizer for crop production.

242 The positive impacts of the urine fertilizer on soil health indicators indicate an
 243 improvement on the soil health status. The human urine source improved the
 244 soil pH keeping it within a safe range of 5.6-6.0, nitrogen and organic matter at
 245 significant levels than other sources. Peverly and Gates (1973) stated that
 246 organic fertilizers perform better with some crops. This is further supported by
 247 Adeoluwa and Cofie (2012) findings that urine fertilizer improved some health
 248 indicators.

249

250 **Table 3.** Effect of urine sources on some soil health indicators

Treatment	pH H ₂ O	Total N %	P mgkg ⁻¹	OM %
Control	5.1d	0.10b	25.60	1.05d
Human urine	6.0a	0.14a	29.65	1.76a
Cattle urine	5.7b	0.12b	28.24	1.40a
Goat urine	5.6c	0.11b	28.30	1.62b
FLSD(0.05)	0.1	0.02	NS	0.05

257 P – Available phosphorus, OM % – Percent organic matter, N % -Percent Total
 258 nitrogen. Treatment means with different letters indicate significant differences
 259 (P<0.05).

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261

262 **Effect of Urine Sources on Agronomic Yield of Maize**

263 Table 4 shows effect of urine sources on agronomic yield of maize. Urine
264 sources had higher number of leaves, plant height **and** taller maize plants when
265 compared with the control, respectively. Human urine source was 9-10%, 15%-
266 27%, **and** 10-47% higher in these maize agronomic **yields** than those of cattle
267 and goat urine sources. The effect of urine sources not having any significant
268 effect on agronomic parameters of maize could be linked to inherent capability
269 of the maize plant (Benge, 2006). Results in Table 1 did not show much
270 variations on nutrients compositions and this could have influenced maize
271 agronomic parameters. The generally higher agronomic yield of maize in urine
272 sources relative to control could be attributed to improved soil health status by
273 urine treatment. This by implication underscores the usefulness of urine as
274 credible of alternative to inorganic fertilizer for sustenance of soil fertility status
275 and in increased maize production that is safe for human consumption. Human
276 urine increased agronomic yield of maize due to its high nutrients (Table 1) and
277 its ability to release same into the soil. Benge (2006) and Adeoluwa and
278 Sulaiman (2012) pointed out that human urine increased soil fertility and
279 *Jathropha* production.

280 **Table 4.** Effect of urine sources on agronomic yield of maize

281 Treatment	No of leaf	Plant height (cm)	Grain yield (g/pot)
282 Control	11.2	58.12	2.0
283 Human urine	13.4	85.08	4.2
284 Cattle urine	12.2	72.14	3.8
285 Goat urine	12.0	61.98	2.2
286 FLSD (0.05)	NS	NS	NS

287 LAI – Leaf area index.

288
289
290

291 **Effect of Urine Sources on Heavy Metals Uptake by Maize Grains**

292 Effect of urine sources on heavy metals uptake by maize grains is shown
293 in Table 5. The result showed significantly ($P<0.05$) higher effect of copper
294 uptake by maize grains in control compared to urine sources of human, cattle
295 and goat. This accounted for 20, 80 and 37% increments of copper uptake in
296 maize grains in control respectively when compared to human, cattle and goat
297 sources of urine. Lead uptake by maize grains was 87, 47 and 7% higher in
298 control relative to human, cattle and goat sources of urine.

299 The significantly higher copper uptake by maize grains grown in control plot
300 compared to those grown in urine sources treated plots could be attributed to
301 inputs from soil rather than urine fertilizer. Analysis of urine sources indicated
302 very low presence of copper and lead (Table 1). The same trend of higher Cu
303 uptake by maize grains was shown by control in Pb uptake by maize grains
304 compared to those obtained under urine sources treatment. These findings show
305 that urine could be used as fertilizer for crop production without placing man at
306 a risk of ecotoxicity of heavy metals. This finding could be attributed to
307 improved health status of soil (Table 3) and low presence of heavy metals in
308 urine sources. The likelihood of heavy metals to build up in soil amended with
309 urine fertilizer appears to be higher in soils treated with goat and cattle urine
310 than human urine. Adewole *et al.* (2008) reported heavy metal uptake by crops
311 in their work and noted that these heavy metals were stored in crop parts.
312 Anikwe and Nwobodo (2002) and corroborated by Asadu *et al.* (2008) in their
313 findings observed that human beings were at risk of heavy metals toxicity if
314 they could utilize crops grown around areas contaminated with heavy metals
315 due to eco-toxicity. This could be possible through recycling of heavy metals
316 through food chain. Heavy metal of lead has the capacity to cause brain, renal or
317 reproductive disorders in human beings. The heavy metals of copper and lead

318 are below 0.0-2.0 and 0.01 rated as medium to low (LASEPA, 2005) values and
 319 far below 0.0-5.0 (WHO, 1996) or 2-1500 and 2-300 recommended as normal
 320 by Alloway (1990). However, the interesting result is that heavy metal uptake
 321 by maize grains could not be linked to urine treatment of soil.

322
 323

324 **Table 5.** Effect of urine sources on heavy metals uptake by maize grains

Treatment	→ mgkg ⁻¹ ←	Pb
	Cu	
Control	0.30a	0.30
Human urine	0.04a	0.04
Cattle urine	0.24b	0.16
Goat urine	0.06c	0.28
FLSD (0.05)	0.05	NS

332 Cu – Copper, Pb – Lead, Treatment means with different letters indicate
 333 significant differences from each other (P<0.05).

334 **Conclusion**

335 This study has shown that urine sources could improve soil health status
 336 and serve as useful alternative fertilizer for maize crop production. Urine
 337 sources significantly improved soil health indicators. Agronomic parameters
 338 responded positively to improved soil health status and performed better in
 339 urine sources than control. Perhaps, the greatest beneficial aspect of use of urine
 340 as fertilizer is low input of heavy metals which keep them below safe limits and
 341 without any danger of eco-toxicity. In view of its superior performance over
 342 other urine sources, human urine could be harvested for treatment of soil for
 343 higher productivity rather than be allowed to be wasted through improper
 344 disposal.

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