Human Urine an Alternative to Chemical Fertilizers in Crop Production

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Abstract: Characterization of human urine-from persons of less than 20, 20-40 and more than 40 years age group from vegetarian and non vegetarian diet category. Experiments were conducted at the university farm on 12 test crops in succession for 3 years in the same field was done with 10 treatment combinations and in a farmers field with 14 different treatments to assess the fertilizer value of human urine also green house and fertigation experiments were conducted. The constituents of human urine collected from persons of different age group of non-vegetarian diet was slightly higher compared to urine from persons of vegetarian diet. In the field experiment at the university farm, yield of all the crops was significantly highest in treatment receiving human urine + FYM followed by human urine alone. In the fertigation experiment, highest fruit yield of tomato was recorded in treatment receiving recommended dose of N through jeevamrutha through drips followed by treatment receiving recommended dose of N through human urine. At farmers field, ash gourd, french bean, pole bean and pumpkin yield was significantly higher due to application of recommended dose of N through human urine plus gypsum in three split doses, lowest yield of was with FYM alone.

Keywords: Cattle urine, Fertilizers, Human urine, Jeevamrutha

Introduction

Urbanization is essential for social development but considered as a curse, when the wastes it generates is considered. One of the huge waste generated by high density population of urban centers is anthropogenic waste from clossetes through internal drainage system. It consists of human urine, kitchen wastes, faecal matter and large quantity of water. Scientifically the municipal wastes are classified as sewage and sludge. Most urban /civic bodies have the onerous task of their disposal. As the population density increases, this task would be more voluminous and challenging.

But, due to high level of nutrients contained in these wastes, the best disposal mechanism is to use them productively for agricultural purposes. Such an attempt fulfils the twin objectives of their disposal and reduce the reliance on scarce/costly fertilizers used in crop production. It has number of other benefits like improvement in soil fertility, reduction of pollution, besides offering eco-friendly and organic solutions to ever increasing problems of food contamination. India has been estimated to produce 17.9 million cubic meters of sewage and 4 million tons of sludge each year with a combined nutrient contribution of 2.4 lakh tons of N, 1.3 lakh tons of P_2O_5 and 1.2 lakh tons of K_2O besides 12 lakh tons of organic carbon most of which are being wasted leading pollution of soil and water bodies.

However, the use of anthropogenic wastes in agriculture is not possible with the present system of sewage disposal mechanisms. The toilets and urinals in urban centers will have to be redesigned to collect the faecal matter and urine separately. In this direction an eco-friendly design of toilet called 'ECOSAN' needs to be popularized which help in source separation of human urine and faecal matter in a hygienic way. To exploit the huge potentiality of anthropogenic wastes as a supplement to fertilizers, many changes in policies and practice of civic bodies are needed besides a thorough research on use of anthropogenic wastes in agriculture. An attempt has been made to study the benefits/bad effects of using anthropogenic wastes in crop production.

In order to assess the fertilizer value of human urine and to study its impact on soil properties growth and yield of crops this research project entitled **"Utilization of Anthropogenic liquid waste for agricultural purposes"** was initiated with financial support from Arghyam, a NGO, Stockholm Environmental institute (SEI) Sweeden and UNICEF New Delhi from 2008 to 2012.

The objectives were:

- Characterization of human urine for its nutrients potential, its effect on yield and quality of crops.
- To study the short and long-term impact of human urine on soil properties and to work out cost economics for use in crop production.

Methods

The research work consisted of laboratory, green house and field experiments both on farm and in farmers field as detailed below:

Characterisation of human urine: Representative human urine samples from 10 persons each in the age group of less than 20, 20-40 and more than 40 years from vegetarian and non vegetarian diet category was collected and analysed for nutrient composition and other quality parameters by following standard procedures.

On farm field experiments: Six on farm field experiments were conducted at GKVK farm with 9 treatment combinations tried on **French bean, finger millet, field bean, tomato, brinjal and bhendi** as test crops during first year (2009-10) to assess the fertilizer value of human urine. Cattle urine was also used for comparison.

During second year (2010-11), the experiments were continued in the same experimental plots with **aerobic rice, finger millet, maize, cow pea, soybean and field bean** as test crops to study the impact of repeated application of human urine on soil properties, growth and yield of crops.
The quantity of human urine, cattle urine FYM and gypsum to be applied to different crops and for different treatments was worked out based on the N requirement of crops. The balance of P and K was applied through single super phosphate and muriate of potash respectively.

The experiments were conducted during 2011-12, with marigold and cluster beans as test crops in two plots where experiments were conducted with finger millet and aerobic rice as test crop during 2010-2011and 11-12, to assess the impact of human and cattle urine on yield of crops and properties of soil.

The treatments during 2009-10 tried were Absolute control 40% of rec. N through human urine as basal +60% N in 3 splits with and without gypsum, 40% rec. N through FYM as basal + 60% N

through human urine/cow urine. During 2010-11 in addition to these treatments, recommended dose of fertilizer was tried as treatment for comparison.

Experiments on farmers fields: Experiment was conducted in a farmers field at Nagasandra village near Bangalore, with 14 different treatments. **Ashgourd, French bean, pole bean and pumpkin** were grown as test crops in the same plot without disturbing the treatments. The quantity of human urine, cattle urine, FYM, gypsum etc. used in the experiment for different crops were worked out and applied as per treatments.

In both the on farm and farmers field experimental plots, the changes in properties of soil due to application of human urine and cattle urine with and without farm yard manure, fertilizers and gypsum was assessed. Also the effect of different treatment combinations on growth and yield of crops was recorded.

Green house experiment: Pot experiment was conducted under green house conditions at GKVK using red, laterite and black soil with tomato as test crop and nine treatment combinations to study the effect of human urine/cattle urine on soil properties, yield and quality of tomato.

Fertigation studies in Tomato: The performance of human urine (HU), cattle urine (CU) and jeevamrutha (J) applied through drip fertigation on tomato was evaluated. The treatments tried were entire N through HU/CU/J + balance P and K through fertilizers in 7 equal splits, 75 % N through HU/CU/J + balance N, P and K through fertilizers in 7 equal splits and 50 % N through HU/CU/J + balance N, P and K through fertilizers in 7 equal splits. Recommended dose of N, P and K applied to soil was considered as standard check. The fruit yield of tomato was recorded treatment wise.

Statistical analysis: The data on nutrient composition of urine, yield of crops as affected by treatments and changes in soil properties were subjected to statistical analysis as per standard procedure.

Results and Discussion

The results obtained from these experiments are discussed in the following pages.

Characterization of human urine: Slight variation in the pH and EC values of urine collected from persons of vegetarian diet and of different age group was observed (Table-1). The human urine was found to be slightly acidic to neutral in reaction. The pH ranged from 4.97 to 6.51, 4.79 to 6.65 and 4.26 to 6. The electrical conductivity ranged from 5.64 to 6.97, 6.85 to 8.17 and 6.81 to 7.89 dS m^{-1} for samples of < 20, 20 to 40 and >40 years age group respectively indicating that it has appreciable amount of salts.

The human urine has appreciably higher concentration of all the nutrients elements required by crops. The concentration of nitrogen varied from 0.21 to 0.41, 0.25 to 0.43 and 0.26 to 0.43 per cent, phosphorus concentration varied from 0.17 to 0.22, 0.11 to 0.26 and 0.13 to 0.24 per cent and the potassium content varied from 0.12 to 0.23, 0.14 to 0.20 and 0.17 to 0.22 per cent for samples of < 20, 20 to 40 and >40 years age group respectively. In addition, the urine has substantial quantities of calcium, magnesium, sulphur and micronutrient elements. The sodium concentration varied from 0.22 to 0.31, 0.13 to 0.23 and 0.14 to 0.22 per cent for samples of < 20, 20 to 40 and >40 years age group respectively.

The chemical composition of human urine collected from persons of different age group of non-vegetarian diet was slightly higher compared to urine from persons of vegetarian diet (Table 1).

On station field experiments: Significant difference in the yield of crops was recorded due to application of HU and CU with and without FYM and gypsum. The yield of all the six crops was significantly highest in treatment receiving human urine+ FYM followed by human urine alone and cattle urine alone. The yield of French bean crop was lowest in control (1.1qt./ha) while human urine + FYM treatment recorded highest yield (4.87t/ha) followed by human urine alone (Table 2). Human urine alone recorded significantly higher yield of crops compared to cattle urine alone thus indicating its superiority over cattle urine.

Table 1: Chemical composition of human urine samples from persons of vegetarian and non-vegetarian diet and of different age group.

Sl. No	Parameters	Vegetarian diet			Non-vegetarian diet		
		<20 years	20- 40 years	> 40 years	<20 years	20- 40 years	> 40 years
1.	pH	4.97-6.51	4.79-6.65	4.26-6.23	4.96-6.81	5.29-6.29	4.93-6.19
2.	EC (dS/m)	5.64-6.97	6.85-8.17	6.81-7.89	6.68-7.97	7.41-8.75	7.06-8.32
3.	N (%)	0.21-0.41	0.25-0.43	0.26-0.42	0.31-0.50	0.33-0.55	0.36-0.45
4.	P_2O_5 (%)	0.17-0.22	0.11-0.26	0.13-0.24	0.13-0.30	0.13-0.23	0.12-0.25
5.	K_2O (%)	0.12-0.23	0.14-0.20	0.17-0.22	0.15-0.22	0.12-0.25	0.17-0.24
6.	Na (%)	0.22-0.31	0.13-0.23	0.14-0.22	0.24-0.34	0.12-0.30	0.15-0.23
7.	Ca (meq/l)	8.00-16.00	6.00-18.00	10.00-24.00	8.00-20.00	14.00-22.00	14.00-26.00
8.	Mg (meq/l)	15.80-33.58	21.73-43.46	31.60-41.48	21.73-37.53	27.65-39.51	31.60-39.51
9.	S (%)	0.10-0.17	0.09-0.21	0.07-0.20	0.11-0.22	0.10-0.18	0.09-0.15
10.	HCO^-_3 (meq/l)	5.12-11.52	7.68-14.08	6.40-14.08	5.12-14.08	7.68-16.64	6.40-16.64
11.	Cl^- (meq//l)	22.72-32.08	28.07-36.54	26.29-36.09	23.61-37.87	26.29-38.76	28.07-37.87
12.	Zn (mg/l)	16.20-19.80	17.00-22.40	17.00-23.40	16.40-20.40	23.00-18.60	17.40-23.80
13.	Fe (mg/l)	98.60-139.40	114.20-131.80	118.80-143.00	116.60-164.80	119.40-134.80	119.40-134.80
14.	Mn (mg/l)	17.80-27.00	17.80-27.00	18.20-27.00	22.20-27.00	17.80-27.00	17.80-26.40
15.	Cu (mg/l)	41.82-47.84	41.82-48.04	43.82-48.04	45.96-48.78	41.82-48.44	41.82-48.44

Table 2: Effect of human urine (HU), cow urine (CU) and FYM+ human urine on yield of crops during 2009-2010

Crop	RDF (Kg ha^{-1})	Quantity of human urine/cow urine applied to supply recommended dose of nitrogen		Fresh vegetable Yield(t ha^{-1})			
		HU (l ha^{-1})	CU (l ha^{-1})	Control	HU	CU	FYM+ HU
French beans	63:100:75	33333	50000	1.19	3.99	2.41	4.87
Field bean	25:50:25	8333	12500	1.73	4.61	4.04	4.61
Tomato	250:250:250	83333	125000	16.6	28.3	27.6	29.6
Brinjal	125:100:50	41667	62500	9.2	32.5	29.8	33.6
Bhendi	125:750:63	41667	62500	7.0	13.2	12.3	13.7
Grain yield (t ha^{-1})							
Finger millet	100:50:50	33333	50000	2.11	3.78	3.22	6.17

During second year (2010-11) and third year, the cumulative effect human urine and cattle urine with and without FYM & gypsum was evaluated and compared with treatment receiving fertilizer alone. During both the years, a similar trend of results was obtained. Treatment receiving human urine + FYM recorded the highest yield of all the six crops grown during 2010-11 and two crops grown during 2011-12. Human urine alone recorded slightly higher yield in all the crops compared to treatments receiving fertilizers. Yield of all the crops was appreciably higher due to human urine application compared to fertilizers, thus clearly indicating the fertilizer value of human urine (Table 3). This increase in yield might be due to ready supply of nitrogen and other nutrients which had a positive impact on overall improvement in crop growth.

Table 3: Effect of human urine, cow urine and FYM+ human urine on yield of crops during 2010-2011 and 2011-12

Crop	RDF (Kgha^{-1})	Quantity of human urine/cow urine applied to supply recommended dose of nitrogen		Grain/seed yield (t ha^{-1})				
		Human urine (l ha^{-1})	Cattle urine (l ha^{-1})	Control	RDF	Human urine	Cattle urine	FYM+ HU
2010-11								
Aerobic rice	100:50:50	33,333	50,000	1.12	2.58	2.63	1.92	2.74
Finger millet	100:50:50	13,333	20,000	1.47	2.54	3.22	2.59	3.31
Maize	150:75:40	50,000	75,000	3.89	6.69	6.82	6.55	6.89
Cow pea	25:50:75	8,333	12500	0.74	1.00	1.02	0.98	1.03
Soybean	30:80:38	10,000	15,000	0.56	1.23	1.25	1.16	1.52
Field bean	25:50:25	8,333	12,500	0.63	1.21	1.42	1.25	1.44
2011-12								
Cluster bean	25:75:60	8,333	12,500	5.64	6.65	6.74	6.54	6.88
Marigold *	225:60:60	75,000	1,12,500	5.67	6.68	6.67	6.35	6.70

* Flower yield

Effect on soil properties: There was positive impact of human/cattle urine application on soil properties. During 2009-10 and 2010-11, the pH and salt content of the soils after harvest of crops was found to be within the permissible limits (Table 4).

Table 4: Effect of human urine, cattle urine FYM+HU on pH, and EC of soil at harvest stage of crop during (2009-10 and 2010-2011)

Treatments	pH (1:2.5)			EC dSm^{-1}		
	2010	**2011**	**Mean**	**2010**	**2011**	**Mean**
Fingermillet (2010) – Aerobic rice(2011)						
Control	6.70	6.72	6.71	0.15	0.15	0.15
CU	6.31	6.35	6.33	0.20	0.20	0.20
HU	6.38	6.40	6.39	0.29	0.29	0.29
FYM+HU	7.02	7.06	7.04	0.19	0.19	0.19
SEm ±	**0.05**	**0.06**		**0.15**		
CD(P=0.05)	**0.16**	**0.18**		**0.46**		
Field bean (2010)-Finger millet (2011)						
Control	5.60	5.77	5.69	0.17	0.17	0.17
CU	6.43	6.62	6.53	0.21	0.21	0.21
HU	6.26	6.45	6.36	0.32	0.33	0.33
FYM+HU	6.43	6.62	6.53	0.25	0.24	0.25
SEm ±	**0.14**	**0.01**		**0.05**	**0.02**	
CD(P=0.05)	**0.42**	**0.04**		**0.16**	**0.06**	
French beans (2010)-Maize (2011)						
Control	6.03	6.05	6.04	0.14	0.09	0.12
CU	6.12	6.12	6.12	0.18	0.17	0.18
HU	5.73	6.18	5.96	0.40	0.39	0.40
FYM+HU	6.15	6.25	6.20	0.16	0.13	0.15
SEm ±	0.16	0.14		0.12	0.10	
CD(P=0.05)	0.49	0.47		0.35	0.35	
Tomato (2010)-Cowpea (2011)						
Control	5.89	5.92	5.91	0.94	0.95	0.95
CU	6.00	6.03	6.02	1.25	1.26	1.26
HU	6.21	6.28	6.25	1.35	1.36	1.36
FYM+HU	6.54	6.58	6.56	1.12	1.13	1.13
SEm ±	**0.14**	**0.01**		**0.05**	**0.01**	
CD(P=0.05)	**0.42**	**0.04**		**0.16**	**0.03**	
Brinjal (2010) –Soybean (2011)						
Control	5.91	5.98	5.95	0.97	0.98	0.98
CU	6.10	6.13	6.12	1.25	1.27	1.26
HU	6.33	6.38	6.36	1.30	1.32	1.31
FYM+HU	6.64	6.73	6.69	1.16	1.17	1.17
SEm ±	**0.15**	**0.16**	**0.05**	**0.06**	**0.07**	
CD(P=0.05)	**0.44**	**0.47**	**0.16**	**0.18**	**0.20**	
Bhendi (2010) – Field bean (2011)						
Control	5.98	6.09	6.04	0.93	0.94	0.94
CU	6.08	6.19	6.14	1.20	1.21	1.21

HU	6.40	6.44	6.42	1.25	1.26	1.26
FYM+HU	6.64	6.69	6.67	1.18	1.20	1.19
SEm ±	**0.15**	**0.03**		**0.06**	**0.01**	
CD(P=0.05)	**0.46**	**0.06**		**0.17**	**0.03**	

The available N, P and K content of soils was found to increase appreciably in treatments receiving human urine + FYM and human urine alone compared to treatment receiving cattle urine and control during both the years (Table 5).

Table 5: Effect of human urine, cattle urine FYM+HU on available Nitrogen, phosphorus and potassium content of soil (Kg/ha) at harvest stage of crop during (2009-10 and 2010-2011)

Treatments	**Available nitrogen**			**Available phosphorus**			**Available potassium**		
	2010	**2011**	**Mean**	**2010**	**2011**	**Mean**	**2010**	**2011**	**Mean**
Fingermillet (2010) – Aerobic rice(2011)									
Control	233.1	233.1	233.1	27.8	27.8	27.8	246.4	247.8	247.1
CU	398.6	400.1	399.4	34.6	34.6	34.6	436.7	446.3	441.5
HU	415.3	420.0	417.7	33.9	54.2	44.1	488.1	481.7	484.9
FYM+HU	520.6	500.1	510.4	56.4	56.0	56.2	616.4	485.0	550.7
SEm ±	**16.12**	**1.30**		**3.27**	**0.31**		**17.36**	**0.90**	
CD(P=0.05)	**48.36**	**3.93**		**9.82**	**0.94**		**52.04**	**2.80**	
Field bean (2010)-Finger millet (2011)									
Control	289.8	294.3	292.1	28.7	29.3	29.0	239.0	247.4	243.2
CU	423.6	423.4	423.5	56.7	57.8	57.2	390.4	4009	395.6
HU	473.6	467.9	470.8	61.2	62.1	61.6	436.5	448.2	442.4
FYM+HU	597.9	498.4	548.2	61.3	62.4	61.9	448.1	460.1	454.1
SEm ±	**14.02**	**2.63**		**0.19**	**0.89**		**11.54**	**1.17**	
CD(P=0.05)	**42.08**	**7.92**		**0.58**	**2.68**		**34.69**	**3.54**	
French beans (2010)-Maize (2011)									
Control	236.5	241.4	239.0	27.3	27.5	27.4	226.1	227.8	226.9
CU	423.6	422.3	422.9	56.7	34.2	45.4	390.4	405.3	397.8
HU	473.6	472.1	472.8	61.2	53.0	57.1	436.5	410.4	423.5
FYM+HU	597.9	502.6	550.2	61.3	55.7	58.5	448.1	506.3	477.2
SEm±	**17.36**	**1.48**		**2.47**	**0.57**		**14.10**	**1.44**	
CD(P=0.05)	**52.04**	**4.45**		**7.41**	**1.71**		**42.31**	**4.33**	
Tomato (2010)-Cowpea (2011)									
Control	258.93	265.0	262.0	21.8	24.0	22.9	204.0	210.3	207.1
CU	368.61	3773	372.9	46.7	47.8	47.3	276.4	282.9	279.7
HU	398.55	407.9	403.2	63.6	65.1	64.3	342.2	350.2	346.2
FYM+HU	403.46	412.9	408.2	67.8	69.4	68.6	356.9	365.3	361.1
SEm±	**0.42**	**1.48**	**0.18**	**5.03**			**0.69**	**1.43**	
CD(P=0.05)	**1.25**	**4.43**	**0.56**	**15.08**			**2.28**	**4.28**	
Brinjal (2010) –Soybean (2011)									
Control	258.5	262.8	260.7	26.9	27.3	27.1	199.6	202.9	201.3
CU	368.0	374.2	371.1	33.5	34.1	33.8	270.5	275.0	272.8

HU	397.9	404.6	401.2	41.2	41.9	41.5	334.8	306.0	320.4
FYM+HU	402.8	409.6	406.2	49.5	50.0	49.8	349.2	306.0	327.6
SEm+	**0.39**	**1.40**		**0.27**	**0.08**		**0.67**	**0.09**	
CD(P=0.05)	**1.16**	**1.88**		**0.82**	**0.28**		**2.00**	**1.30**	
Bhendi (2010) - Field bean (2011)									
Control	253.9	254.7	254.3	22.1	22.4	22.3	200.0	208.1	204.1
CU	361.4	362.9	362.2	47.2	48.0	47.6	271.0	281.5	276.3
HU	390.7	392.5	391.6	64.2	65.1	64.7	335.5	330.1	332.8
FYM+HU	395.6	396.0	395.8	68.5	69.6	69.1	349.9	362.5	356.2
SEm+	**0.41**	**0.4**		**5.08**	**0.2**		**0.68**	**1.30**	
CD(P=0.05)	**1.23**	**1.2**		**15.23**	**0.5**		**2.24**	**4.20**	

Table 6: Effect of human urine, cattle urine FYM+HU on nutrient content of soil at harvest stage of crop during (2011-12)

Treatments	pH (1:2.5)	EC dSm^{-1}	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
Cluster bean					
Control	6.84	0.16	230.77	27.44	346.79
CU	6.80	0.20	396.10	34.15	446.29
HU	6.85	0.32	415.80	53.46	481.69
FYM+HU	7.14	0.24	495.10	55.30	484.99
SEm +	0.12	0.01	1.09	0.22	0.30
CD(P=0.05)	0.40	0.04	3.19	0.45	1.85
Marigold					
Control	5.77	0.17	292.47	29.14	440.88
CU	6.62	0.21	420.87	57.67	457.17
HU	6.45	0.33	464.95	61.66	397.34
FYM+HU	6.62	0.25	497.97	62.00	401.58
SEm +	0.01	0.02	2.56	0.46	1.06
CD(P=0.05)	0.04	0.06	7.92	1.38	3.18

There was positive impact of human/cattle urine application on soil properties during 2011-12, the pH and salt content of the soils after harvest of crops was found to be within the permissible limits. The treatment receiving 40% recommended dose of nitrogen through FYM as basal+ 60% through Human urine (T_5) recorded higher available nitrogen, available phosphorus and potassium when compared other treatments (Table 6).

Fertigation Experiment: In the fertigation experiment, significant difference in the fruit yield of tomato was recorded due to treatments. Highest fresh fruit yield (27.21 t ha^{-1}) was recorded in treatment receiving rec. dose of N through jeevamrutha through drips followed by treatment receiving rec. dose of N through human urine (26.75 t ha^{-1}) and cattle urine (26.02 t ha-1). Reduction in the fruit yield of tomato was observed in treatments receiving 75% and 50% N through jeevamrutha, human urine and cattle urine supply of N through jeevamrutha resulted in higher yield of tomato at all the three levels of N compared to human urine and cattle urine at the respective N levels (Table 7).

Table 7: Effects of human urine, cattle urine jeevamurtha and fertilizer on yield attributes and yield of tomato crop

Treatments		Yield (t/ha)
T_1	NPK alone	15.26
T_2	Entire N through human urine + Balance P and K through fertilizers in 7 splits	26.75
T_3	Entire N through cattle urine + Balance P ad K through fertilizers in 7 splits	26.02
T_4	Entire N through jeevamurtha + Balance P ad K through fertilizers in 7 splits	27.21
T_5	75 % N through human urine + Balance P and K through fertilizers in 7 splits	23.9
T_6	75 % N through cattle urine + Balance P ad K through fertilizers in 7 splits	23.35
T_7	75 % N through jeevamurtha + Balance P ad K through fertilizers in 7 splits	25.37
T_8	50 % N through HU+ Balance P and K through fertilizers in 7 splits	20.41
T_9	50 % N through HU+ Balance P and K through fertilizers in 7 splits	18.6
T_{10}	50 % N through HU+ Balance P and K through fertilizers in 7 splits	22.71
SEm ±		**0.07**
CD =P(0.05)		**0.23**

Experiments in farmers field: In the experiment in farmers field, fruit yield of ashgourd was significantly higher due to application of recommended dose of N through human urine in three split plus gypsum (T_8: 36.26 t ha^{-1}) and it was on par with recommended dose of N through cattle urine plus gypsum in three split (T_{14}), recommended dose of fertilizers (T_2). Application of farm yard manure alone (T_1) recorded significantly lower yield (19.62 t ha^{-1}). Similar trend was also observed in case of French bean, pole bean and pumpkin crops (Table 8).

Table 8: Effect of application of human urine and cattle urine on fruit/pod yield (t/ha) of different vegetable crops grown in farmers field

Treatment details			Ashgourd (t/ha)	French bean (t/ha)	Pole bean (t/ha)	Pumpkin (t/ha)
T_1	:	FYM (Farmyard Manure) alone	19.7	8.7	9.2	19.5
T_2	:	Recommended dose of fertilizer + FYM	36.7	13.7	15.8	36.8
T_3	:	RDN through human urine in single dose	22.2	9.3	10.2	21.9
T_4	:	RDN through human urine in single dose + gypsum	23.6	9.9	11.1	23.3
T_5	:	RDN through cattle urine in single dose	21.1	8.9	9.8	20.8
T_6	:	RDN through cattle urine in single dose+ gypsum	23.5	9.6	10.7	23.3
T_7	:	RDN through human urine in two split doses	29.0	10.3	11.9	28.6
T_8	:	RDN through human urine in two split doses+ gypsum	31.8	11.3	13.9	31.4
T_9	:	RDN through cattle urine in two split doses	27.8	10.1	11.5	27.5
T_{10}	:	RDN through cattle urine in two split doses+ gypsum	30.2	10.7	12.8	29.9
T_{11}	:	RDN through human urine in three split doses	36.5	13.5	15.5	36.0
T_{12}	:	RDN through human urine in three split doses+ gypsum	**39.2**	**14.2**	**17.4**	**38.7**
T_{13}	:	RDN through cattle urine in three split doses	35.4	13.5	15.1	35.0
T_{14}	:	RDN through cattle urine in three split doses+ gypsum	38.0	14.1	16.6	37.5
S.Em ±			**2.01**	**0.4**	**0.76**	**2.02**
C.D.(P=0.05)			**5.8**	**1.3**	**2.22**	**5.9**

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively **; Source of nutrients**: human urine, cattle urine, chemical fertilizer and FYM	**Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **Where- RDN**: Recommended Dose of Nitrogen

Significant changes in soil properties due to application of human urine/ cattle urine with or without gypsum (Table 9 and 10). The available nitrogen content of soil varied significantly due to human urine and cattle urine and was highest (290.9 kg ha^{-1}) in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum applied to soil (T_{12}). Available phosphorus and potassium content of soil after harvest of ashgourd crop was significantly higher in treatment receiving recommended dose of nitrogen through human urine plus gypsum in three split doses (T_{12}: 31.4 kg ha^{-1}) the lowest N, P and K content of soil was recorded in treatment receiving FYM alone (Table 9).

Application of human urine/cattle urine in split doses with and without FYM/gypsum applied to soils resulted in significant differences in the pH and EC of soils. There was slight increase in pH and EC of soils due to human urine/ cattle urine application compared to FYM alone and Fertilizer + FYM treatments.

The available N, P & K content of soil differed significantly due to application of human urine/ cattle urine in split doses with or without FYM/gypsum. Highest available N, P & K content of soil was recorded in treatment (T_{12}) which received RDN through human urine in 3 split doses + gypsum. The lowest available N, P & K content was recorded in FYM alone treatment (Table 10).

Green house experiment:
Significant difference in the available. N,P&K content of red, laterite and black soil was observed due to human urine/ cattle urine applied at different doses compared to fertilizer alone treatment. In all the soils highest available N, P &K values were recorded in treatment receiving 2 times the rec. N through human urine/ cattle urine. The lowest values were recorded in treatment receiving fertilizers (Table 11).

The fruit yield of tomato was significantly influenced by the application of human urine/ cattle urine at different doses. Application of 2 times the rec. N through human urine recorded highest fruit yield of tomato in red and laterite soils followed by treatment receiving 2 times rec. N through fertilizer, where as in black soil reverse trend was observed (Table 12).

Table 9: Effect of human urine and cattle urine application on pH and electrical conductivity (dS m^{-1}) of soils after harvest of vegetable crops in farmers' field

Treatments	Ashgourd		French bean		Pole bean		Pumpkin	
	pH	EC	pH	EC	pH	EC	pH	EC
T_1	6.78	0.21	7.02	0.23	6.78	0.32	7.13	0.39
T_2	6.83	0.21	7.08	0.24	6.86	0.33	7.14	0.39
T_3	7.19	0.25	7.44	0.33	7.54	0.40	7.57	0.45
T_4	6.87	0.22	7.11	0.26	7.04	0.35	7.23	0.41
T_5	7.19	0.24	7.44	0.32	7.46	0.39	7.57	0.44
T_6	6.84	0.22	7.08	0.25	6.95	0.34	7.20	0.40
T_7	7.35	0.26	7.61	0.34	7.72	0.42	7.73	0.46
T_8	7.03	0.23	7.28	0.29	7.27	0.37	7.40	0.42
T_9	7.24	0.25	7.50	0.34	7.63	0.41	7.62	0.46
T_{10}	6.92	0.23	7.17	0.28	7.12	0.36	7.29	0.41
T_{11}	7.55	0.27	7.81	0.35	8.04	0.44	7.94	0.48
T_{12}	7.13	0.24	7.38	0.31	7.37	0.39	7.50	0.44
T_{13}	7.47	0.26	7.74	0.34	8.06	0.43	7.87	0.47
T_{14}	7.06	0.24	7.31	0.30	7.29	0.38	7.43	0.43
S.Em ±	**0.15**	**0.01**	**0.15**	**0.01**	**0.17**	**0.01**	**0.15**	**0.01**
C.D.(P=0.05)	**0.43**	**0.02**	**0.45**	**0.04**	**0.49**	**0.04**	**0.45**	**0.03**

Table 10: Effect of human urine and cattle urine application on available nitrogen, phosphorus and potassium (kg ha^{-1}) content of soil after harvest of vegetable crops in farmers' field

Treatments	Ashgourd			French bean			Pole bean			Pumpkin		
	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O
T_1	269.6	25.3	274.0	266.5	24.45	265.9	256.2	23.3	259.0	261.0	22.9	257.2
T_2	288.0	30.1	316.2	285.5	30.62	314.5	289.9	30.0	314.3	292.5	30.0	317.9
T_3	272.7	26.7	277.4	270.6	26.24	283.4	264.1	25.2	278.0	265.6	24.9	274.9
T_4	273.4	27.4	284.3	270.6	27.19	293.1	267.5	26.3	288.6	269.3	26.0	286.2
T_5	271.8	26.3	275.7	267.8	25.78	279.0	259.7	24.8	273.2	264.4	24.4	269.8
T_6	273.2	27.1	280.6	275.4	26.71	288.2	265.2	25.8	283.3	266.6	25.5	280.5
T_7	275.1	28.2	291.0	277.0	28.17	296.5	273.2	27.4	299.2	276.2	27.2	297.5
T_8	276.8	28.9	303.1	278.0	29.10	297.0	274.1	28.4	306.2	281.8	28.2	299.4
T_9	273.6	27.8	284.9	276.1	27.70	293.6	268.8	26.8	294.0	271.5	26.6	292.0
T_{10}	275.4	28.6	297.8	277.0	28.65	296.9	273.9	27.9	304.4	279.4	27.7	298.8
T_{11}	283.6	29.4	313.8	282.7	29.72	306.5	281.1	29.1	313.7	289.0	29.0	315.5
T_{12}	**290.9**	**31.4**	**319.9**	**291.3**	**32.29**	**324.2**	**298.2**	**31.8**	**323.7**	**302.2**	**31.9**	**330.9**
T_{13}	281.0	29.3	310.2	281.0	29.63	300.3	280.1	28.9	309.9	286.7	28.9	314.3
T_{14}	287.0	30.5	317.8	288.4	31.09	321.0	294.0	30.6	320.3	295.6	30.6	324.3
S.Em ±	**3.0**	**0.8**	**5.7**	**3.0**	**0.97**	**8.8**	**7.9**	**1.0**	**5.8**	**5.3**	**1.1**	**10.4**
C.D.(P= 0.05)	**8.8**	**2.2**	**16.5**	**8.6**	**2.83**	**25.7**	**23.0**	**3.0**	**16.8**	**15.5**	**3.1**	**30.3**

Table 11: Effect of human urine, cow urine and fertilizer application on available nitrogen, phosphorus and potassium (kg ha^{-1}) content of different soils after harvest of tomato under green house condition

Treatments	Red soil			Laterite soil			Black soil		
	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O
T_1	231.9	24.5	316.1	207.3	11.0	104.3	356.3	17.8	502.8
T_2	241.7	28.1	330.7	216.1	12.6	109.1	392.4	20.4	529.0
T_3	261.5	30.7	344.7	225.6	13.8	119.6	412.0	21.5	556.9
T_4	227.7	25.5	309.9	203.5	11.5	102.3	348.0	17.5	498.7
T_5	251.8	29.7	345.5	225.1	13.4	114.0	388.6	20.2	522.3
T_6	262.1	32.0	355.7	228.6	14.4	123.6	409.4	21.5	549.0
T_7	224.5	25.2	309.0	200.6	11.3	102.0	341.9	17.2	486.7
T_8	249.1	28.8	340.4	222.7	13.0	112.3	380.8	19.9	519.6
T_9	262.0	31.8	349.1	226.3	14.3	120.0	402.2	20.9	543.3
S.Em±	**6.65**	**1.3**	**10.3**	**5.8**	**0.5**	**3.4**	**12.2**	**0.5**	**11.7**
C.D. (P=0.05)	**27.25**	**5.4**	**42.1**	**23.8**	**2.2**	**14.0**	**50.0**	**1.9**	**48.0**

Table 12: Yield of tomato as influenced by rate of application of human urine, cattle urine and fertilizer for different soils

Treatments	Red soil	Laterite soil	Black soil
	Fruit yield (kg $plant^{-1}$)	Fruit yield (kg $plant^{-1}$)	Fruit yield (kg $plant^{-1}$)
T_1	2.2	1.97	
T_2	3.0	2.86	3.36
T_3	3.5	3.21	3.67
T_4	2.3	2.17	2.10
T_5	3.1	3.14	3.30
T_6	3.6	3.45	3.53
T_7	2.2	2.01	2.03
T_8	3.1	3.05	3.27
T_9	3.6	3.32	3.45
S.Em ±	**0.17**	**0.15**	**0.16**
C.D. (P=0.01)	**0.70**	**0.62**	**0.68**

Conclusion

From the research work conducted so far it can be concluded that human urine can be used as a liquid fertilizer and can be a supplement to fertilizers.

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