Title	Urine treatment and use in the Andes
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Author(s)	Jenny ARAGUNDY
Address	Ciudadela Jardines del Pichincha, Pasaje B, N63-204, Quito - Ecuador
Telephone	+593-2-2275-178 / +593-2-2535-950
Fax	+593-2-2868-578
Mobile	+593-9-7781-536
E-mail	jennyaragundy@web.de ó jaragundy@hotmail.com
Short CV for Introduction Purposes (100 words max)	Ecuadorian, Civil Engineer and M.Sc. in Resources Engineering. Assistance in the organization of the 2nd International Symposium on Ecological Sanitation – Lübeck. GTZ-ecosan Consultant in 2002 and 2003. Inventory of the ecological sanitation projects of Ecuador in 2003 and 2004. Diagnosis study of the possibility to implement an ecological sanitation project in the Easter Island – Chile. WASTE of Holland Consultant in 2003. Water quality and human needs in Cotacachi, by SANREM Program (Sustainable Agricultural Natural Resources Management) of the University of Georgia, USA Consultant. Sanitation improvement of the indigenous communities of Yuvientza and Sharamentza. Indio-Hilfe Consultant since 2005.
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URINE TREATMENT AND USE IN THE ANDES

KEY WORDS

Fast-growing vegetables, fertilizer, pH value, temperature, and urine.

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INTRODUCTION

Ecological sanitation technologies are not widely used in Ecuador, although in rural areas there is a big potential for ECOSAN solutions. On one hand, organic fertilizers are preferred for cropping and there is a lack of sanitation in rural zones. On the other hand, ECOSAN promotion in these areas has shown a high level of population acceptance and motivation to use ECOSAN technologies. Some projects have been implemented in the country with successful results (Aragundy and Zapata, 2004), but there is a knowledge gap about faeces and urine treatment and use for local conditions. Urine separation, its treatment and use play a basic role for ECOSAN. The use of urine in agriculture demands its previous sanitation. Several papers have been written about treatment, application and pathogens survival in urine. However, research has been generally done in European countries. Therefore, it is important to study urine and faeces treatment for local conditions in order to assist people in the use of ECOSAN technologies in an effective way.

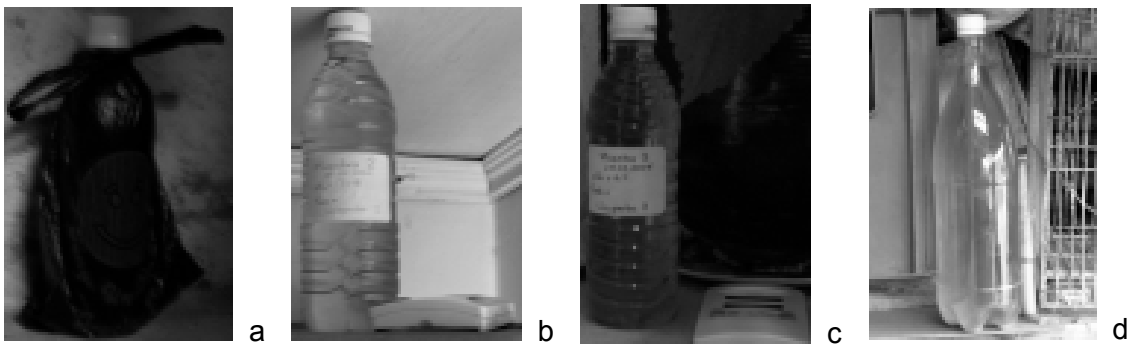
This paper discusses urine treatment and use in the Andean region of Ecuador. Weather conditions in Ecuador differ radically from those in the northern and southern hemispheres. In Ecuador, there are only two seasons during the year, the dry and the rainy seasons. Quito, the capital of the country, is located at an altitude of 2800 m. The annual average temperature is 13,4 °C during the year, but there are strong temperature variations in a day, going from 1,5 °C to 29,9 °C. The average annual precipitation is 1200 mm. The humidity is around 65 - 85% (Pourrut, 1995:15). The main objective of this research is to determine the local conditions for urine treatment and use. The main research questions are: How long urine has to be stored until it reaches a pH value of 9? Are there visual changes in urine that could help people to identify when urine is ready to use? Are there visual changes in plants that are fertilized with urine compared to those without this fertilizer?

METHODOLOGY

This experiment was done at a house level. A simple dry urine-diversion toilet was simulated. Urine was collected and stored in transparent plastic bottles. The bottles were stored in different environments and temperatures. Environmental temperature and pH values were constantly monitored through a thermometer and color-fixed indicator sticks, respectively. These two parameters were monitored until the urine had a pH value of 9; considering that pathogens survival in urine is limited by high pH values of 9, temperature, storage time and dilution (JØrgensen, 2003:423).

The experiment had two phases. First, three samples of 500 cc and one of 1500 cc were taken. The first two samples were collected in one day, while the third and fourth were collected in 3 different days (Figure 1). Samples 1, 2 and 4 belonged to the same person

whereas sample 3 was from a different person. The pH value was measured monthly. When samples 1 and 2 reached the desired pH value of 9, they were diluted in water at a rate of 1:2 and applied to ornamental flowers.



a. Sample 1, b. Sample 2, c. Sample 3, d. Sample 4

Figure 1: Storage places of the urine samples

Second, the third sample was used to fertilize fast-growing vegetables. For this purpose, five vessels were seeded with spinaches and radishes. One part of each crop was not fertilized in order to have a parameter to compare with. The other parts received different urine-water dilutions at various growing stages. Five persons were interviewed to establish the visual differences between radishes and spinaches fertilized and unfertilized.

RESULTS

First phase of the experiment:

The characteristics of the samples were:

- **Sample 1:** initial pH value of 7, located in a dark place with a plastic cover and at almost constant temperature of 18 °C. The maximum environmental temperature was 19,7 °C. There was some oxygen left in the bottle. This sample reached the pH value of 9 in four months. After three storage months the color of the sample started to turn orange. Finally, when it reached the desired pH it was lightly orange. Odor changed also during the storage time. After the first storage month it had a very strong odor like urea. On the second month measurement the odor was not too strong while on the third measurement it was odorless. When pH value was 9 the sample had a strong odor.
- **Sample 2**: initial pH value of 7,5, located in a bright place at a temperature range of 24 °C to 25 °C. The maximum temperature was 29,5 °C. The bottle was full. The pH value of 9 was reached in two months. The color of the sample varied very fast compared with the first sample. On the first measurement it was already a color change and the color was red orange at a desired pH. At the first measurement the sample was almost odorless changing that to a strong odor when the pH was 9.
- **Sample 3:** initial pH value of 6,5, located in a bright place at a temperature of 18 °C. The maximum temperature was 21 °C. The bottle was full. The pH value of 9 was reached after eight months. A year later the pH value of the sample still being 9. Color changes in this case were almost imperceptible during the first five months. On the sixth month the color of the sample started turning into orange, being orange when pH reached the value of 9. After a year of storage the color was light brown like tea. This sample did not smell during the whole storage period. Even after a year there was little odor on the sample.

- **Sample 4:** initial pH value of 7, located in a bright place with strongly variations of temperature. The mean environmental temperature was 16,7 °C. The maximum temperature had a value of 22,9 °C. The bottle had some oxygen left. After nine months the pH value is 8,5. The color of the sample started changing to light orange after three months. Odor characteristics were similar to sample 1(Figure 2).

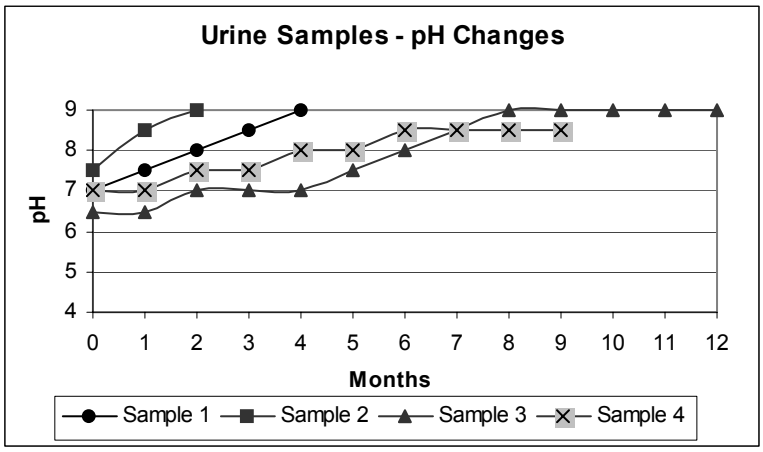


Figure 2: pH changes in the fourth samples

Characteristics of plastic bottles changed when pH reached the value of 9. At the beginning, bottles were rigid whereas they became flexible, like a balloon full of water, when samples reached a pH value of 9. However, once the bottle is opened and emptied through the time bottle's material recovers its initial characteristics.

Samples one and two where diluted at a rate of 1:2 when pH value was 9 and used to fertilize carnations, tulips and geraniums (Figure 3). Urine odor was strong and still being noticed about two hours after the fertilization. Ornamental plants experimented some changes: their green color was darker; plants grew faster and were flowery longer.

Figure 3: Diluting urine and fertilizing carnations

Second phase of the experiment:

The main purpose of second phase was to prove the benefits of urine as a fertilizer. In this phase sample 3, which was one year old, was used to fertilize fast-growing vegetables. Radishes and spinaches were selected among other fast-growing vegetables, since the expected harvesting time for radishes was one month and for spinaches was 45 days. Two

dilutions rates where applied 1:2 and 1:5 (Figure 4). The dilution of 1:5 was chosen because it has been used in Mexico giving good results (Esrey et al, 2001:19). The dilution of 1:2 was applied to verify if benefits were greater when more fertilizer is applied, and also because this dilution rate was used before to fertilize ornamental plants in the first phase of the experiment. One vessel of radishes and one of spinaches were fertilized with each dilution rate. Radishes and spinaches were seeded in an extra vessel and were not fertilized.

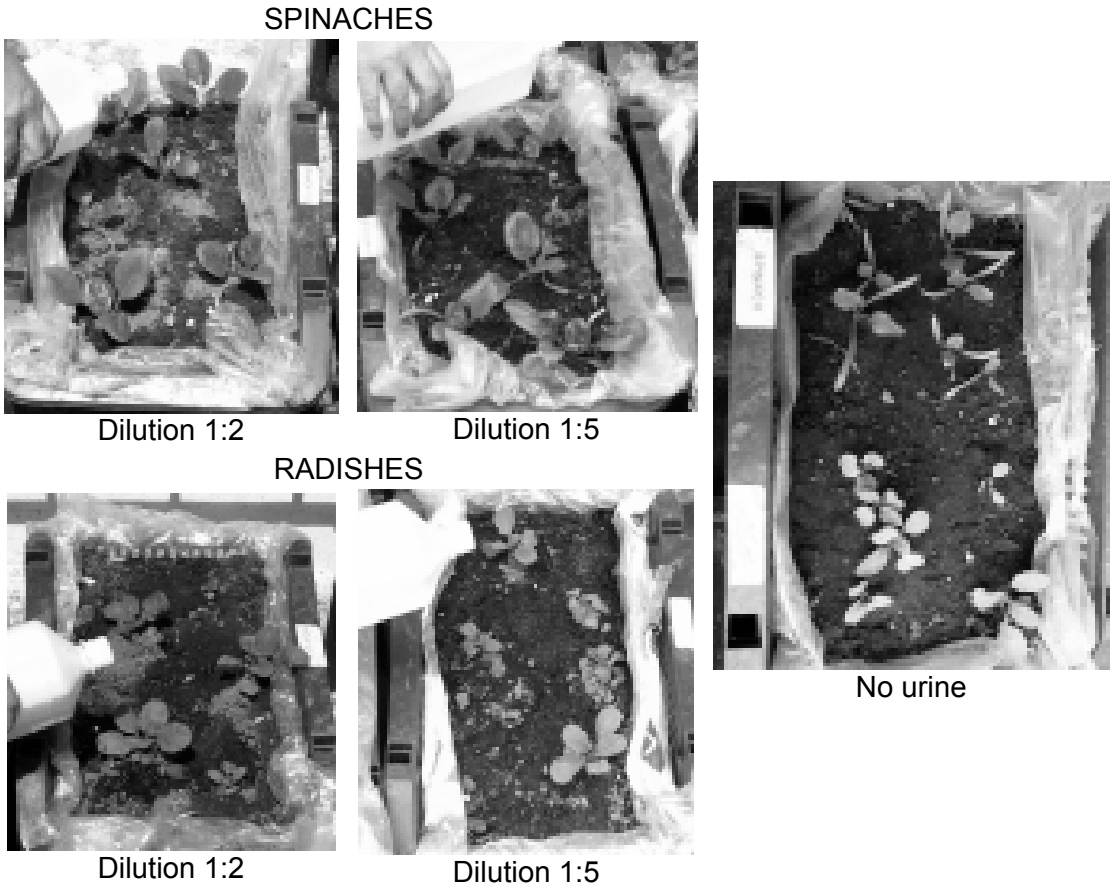


Figure 4: Fertilization of spinaches and radishes with different dilution rates of urine and unfertilized spinaches and radishes

Fast-growing vegetables were seeded and germinated a week later. Radishes and spinaches were fertilized three times. The first time that radishes and spinaches were fertilized was three days after they germinated. Fertilization was repeated each ten days during the first month. To have a better parameter to establish the visual differences between radishes and spinaches fertilized and unfertilized five people were interviewed. The results are summarized in the following table.

PERSON	RADISHES						SPINACHES					
	GREEN COLOR			SIZE			GREEN COLOR			SIZE		
	None	1:5	1:2	None	1:5	1:2	None	1:5	1:2	None	1:5	1:2
1	+	+	+++	+	+	+	+	++	+++	+	+++	++
2	+	++	+++	+	+++	++	+	++	+++	+	+++	++
3	+	++	+++	+	+++	++	+	++	+++	+	+++	++
4	+	+	+	+	+++	++	+	++	+++	+	+++	++
5	+	+	++	+	+++	++	+	++	+++	+	+++	++

Green color: + light green, ++ green, +++ dark green

Size: + small, ++ big, +++ bigger

Table 1: Visual perceptions of differences between fertilized and unfertilized fast-growing vegetables.

Spinaches grew better with a fertilization rate of 1:5, but were greener with a rate of 1:2. The majority of people saw in radishes a similar patron to spinaches. However, they did not notice a green color difference between unfertilized radishes and 1:5 urine dilution fertilized radishes. To get a better conclusion about radishes it is necessary to harvest them to compare the crops' yield.

CONCLUSIONS

- Sample 2, which was in a warm place (24 °C), reached a pH value of 9 in less time than the other samples which were in template places (17 – 18 °C).
- Initial pH influences the time in which a pH of 9 is reached also. In the case of sample 3 it tooks longer than for samples 1 and 2 to reach this desired pH.
- Temperature variations influenced negatively the time required to reach a pH value of 9 in sample 4.
- Color intensity of the sample, when pH reaches the value of 9, is related to sunlight, since sample 1, stored in a dark place, had a lighter color than samples 2 and 3, which were stored in bright places.
- Color still changing even though the sample has already reached the pH value of 9. The color of sample 3 when reached a pH value of nine was orange and after a year of storage was light brown.
- The pH value variation influences changes in the plastic bottle characteristics used to store urine. People, who do not have color-fixed indicator sticks to measure pH, can use this change in the consistence of the bottle and color changes as parameters to know when urine can be used.
- After a year of storage the pH value of sample 3 stilled being 9. It seems to be stabilized while reaching this value.
- In a single house the urine required storage time is not the same. It depends on where the sample is stored, the initial pH value and the temperature. However, these variations could give an idea of what could happen in places with similar conditions. For example, the environment in which sample 2 was stored could be comparable to the warm regions of the country and the environment in which sample 4 was could be equivalent to the conditions of higher places in Ecuador.
- Spinaches grew faster and better with a urine dilution rate of 1:5.
- Nitrogen gives a dark green color to plants and contributes for leaf grow (Esrey S. et al, 2001:45). While spinaches and radishes that were not fertilized with urine had a light green color, spinaches and radishes fertilized with urine had a dark green color. The green color was darker in the vegetables fertilized with a higher content of urine.
- Growing rate of radishes and spinaches unfertilized was slower than growing rate of the fertilized ones.
- Fertilized spinaches had a good taste.
- An advantage of fertilizing radishes with urine in terms of potassium addition was not yet corroborated since radishes were not yet harvested.
- More research in this field is required, since there are no precise rules for people to make sure that urine is ready to use as a fertilizer. Also, the best dilution factor for each crop must be analyzed.

- The enlargement of this house experiment to other regions of the country and other countries could help to exchange results and provide a better idea about urine agricultural use to the fertilizer users.
- Laboratory analyses of soil should be added to the experiment in order to determine the nutrients availability in fertilized and unfertilized soils. Fertilized and unfertilized radishes and spinaches should be analyzed too to verify the absence of pathogens in them.

REFERENCES

Aragundy J., and Zapata X., (2004). "Inventario de los proyectos de saneamiento ecológico en Ecuador." *Ecosan - Newsletter No.12,* GTZ-ecosan (August): 10

Esrey S., Andersson I., Hillers A., and Sawyer R. (eds.), (2001). *Closing the loop: Ecological sanitation for food security*, Mexico: Publications on Water Resources No. 18

JØrgensen L.T., Tarnow I., Forslund A., Dalsgaard A., and Enemark H. L., (2004). "Survival of faecal indicators and bacterial and parasitic pathogens in source separated human urine." In: Werner C. (ed.), *Ecosan – closing the loop: Proceedings of the 2nd international symposium on ecological sanitation, incorporating the 1st IWA specialist group conference on sustainable sanitation*, 7–11 April 2003, Lübeck, Germany: GTZ Deutsche Gesellschaft für Technische Zusammenarbeit.

Pourrut P., (1995). *El agua en el Ecuador: Clima, precipitaciones y escorrentía*, Quito: Corporación Editora Nacional.