Urine as Liquid Fertilizer in Agricultural Production in the Philippines

A Practical Field Guide

Xavier University Sustainable Sanitation Center

caps Center for Advanced Philippine Studies

Philippine Ecosan Network

CIM Centre for International Migration and Development
a joint operation of GIZ and the German Federal Employment Agency

partner of
sustainable sanitation alliance

Acknowledgement

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A Practical Field Guide

Robert Gensch, Analiza Miso, Gina Itchon

Xavier University Press
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This Practical Field Guide on Urine Reuse in Agriculture in the Philippines is a landmark publication of the Sustainable Sanitation Center (SUSAN Center) of Xavier University in the field of Ecological Sanitation in the Philippines. Not many people, especially our farmers, realize that human urine is a valuable resource rich in plant nutrients beneficial to sustainable agriculture, much less how to apply it and in what quantity. In this present day of high cost of inorganic fertilizer, human urine can be the miracle relief for the agriculture sector especially for the small subsistence farmers. The Guidebook shows that urine, if harnessed properly and adequately, can equal the productive benefits derived from inorganic fertilizer.

This Field Guide is based on a collaborative scientific field study designed, implemented and coordinated by the SUSAN Center. Urine testing and field trials were done in 2010 by study teams from San Fernando City in La Union, Bayawan City in Negros Oriental, and Xavier University in Cagayan de Oro City. Urine collected from these sites was analyzed for nutrient content. The results of this study comprise the initial baseline information on local urine composition. Future local researchers do not have to use urine figures from other countries in estimating the economic value of Filipino urine and volume for agricultural application. The book tells the reader what is the average Nitrogen, Phosphorous and Potassium content of our urine and how much of this free “liquid gold” must be applied by farmers to crops like corn, eggplant and pechay. This makes the Field Guide a landmark publication.

I would like to congratulate the authors, Robert Gensch, Analiza Miso, and Gina Itchon for writing and publishing this guidebook. I know for a fact that this publication embodies your commitment, sacrifices and life’s work to help the Filipino people attain healthy lives and food security. I thank you for making CAPS, along with our support partners, namely the Stockholm Environment Institute and WASTE, a part of this publication.

Dan Lapid

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Content

Rationale

The reuse-oriented sustainable sanitation approach and the consideration of urine and feces as valuable resources that can be productively used as fertilizers and soil conditioners in agriculture are slowly gaining popularity in the Philippines. Several good practice examples from all over the Philippines show that human waste can be turned into effective community assets.

Particularly the easy-to-treat and nutrient-rich human urine has a high potential to provide a continuous liquid fertilizer source that is freely and immediately available. It can help reduce the dependence on expensive synthetic fertilizer resources and can have a considerable impact on the mitigation of poverty, malnutrition and food insecurity.

This field guide has been developed to accommodate the ever-increasing demand for more detailed and scientifically backed information on how to use urine in agricultural production. It provides practical, easy-to-understand and mostly picture-based guidance and covers key aspects of the urine use starting from the link between sanitation and agriculture, basic plant requirements, characteristics of human urine and its potential as a liquid fertilizer over health risk management, to the use of urine as liquid fertilizer including detailed application recommendations and alternative urine use options.

It is intended primarily for practitioners and experts in the water, sanitation, planning and agriculture sectors, as well as local and national government officials from the various sectors, NGO representatives, and individuals interested and working in the field of agriculture and sustainable sanitation in the Philippines and the wider Southeast Asian region.

The manual has been produced as a collaborative effort of the XU Sustainable Sanitation Center, the Philippine Sustainable Sanitation Knowledge Node, the Philippine Ecosan Network, and the Sustainable Sanitation Alliance (SuSanA) working group on food security and productive sanitation. The manual is based on the existing international SEI EcoSanRes publication ‘Practical Guidance on the Use of Urine in Crop Production’ (RICHERT et al. 2010), research findings of a countrywide urine reuse study conducted in 3 study locations representing the 3 main Philippine regions (Luzon, Visayas and Mindanao) and on the existing practical experiences from all over the Philippines.

1

The Link between Sanitation and Agriculture

The aspect of growing food is historically strongly linked with the idea of reusing nutrient and organic matter-rich human waste from households in agriculture. In the past, human and animal excreta played a crucial role in maintaining soil fertility and providing essential plant nutrients for food production.

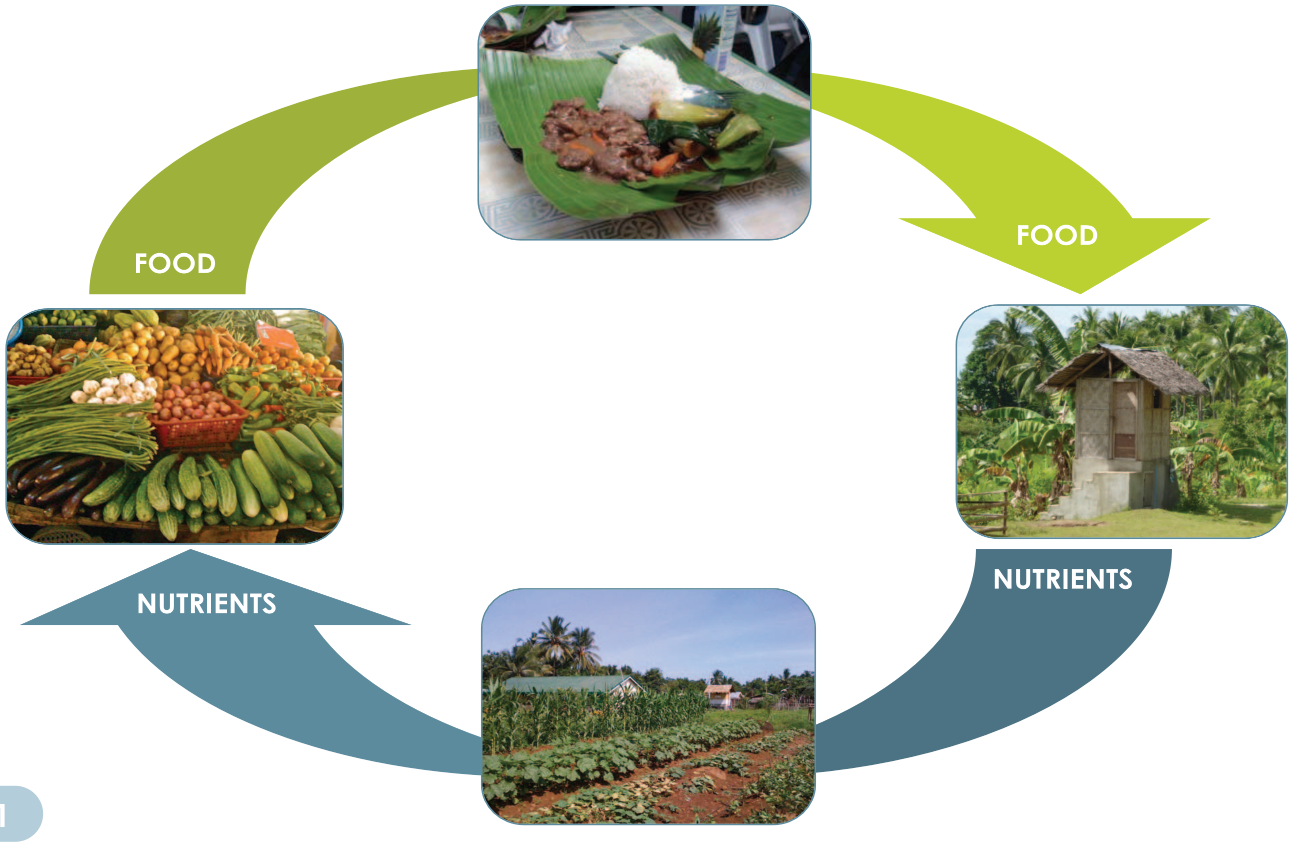
The loss of soil fertility is inherent in all agricultural systems. Nutrients are taken up from the soil through the plants that are harvested, then transported, eaten, and finally excreted. In former centuries, it was therefore a common practise to compensate the nutrient loss by returning the consumed nutrients through the application of animal manure, human excreta, and compost.

In modern agriculture, however, the loss of the most important macronutrients has been partly compensated through application of synthetic fertilizers. However, despite of the fertilizer use, a negative nutrient balance in most soils is observed. Beyond that, the production of the most important and commonly used synthetic fertilizer ingredients - Nitrogen (N), Phosphorus (P), and Potassium (K) - relies on non-renewable resources and its supply is finite, particularly for phosphorus and potassium. Synthetic fertilizers are expensive commodities and their prices are expected to increase in the coming years due to their declining availability and rising fuel prices. Even now, many small-scale farmers cannot afford to buy fertilizers in quantities needed to maintain soil fertility.

At the same time, the flow of plant nutrients in commonly used sanitation systems is predominantly linear where landfills and water bodies are used as a sink for nutrients, organic matter and pathogens. The vast majority of excreta and wastewater do not receive adequate treatment, leading to large-scale environmental pollution, biodiversity degradation, through eutrophication and soil degradation and severe health risks, while losing valuable resources that could have been used in agriculture.

The idea that human residues including excreta are wastes with no useful purpose can be seen as a modern misconception. The development of the existing disposal-oriented and often water dependent sanitation systems was initially an emergency solution and a welcome response to an acute health crisis in most cities. Only with the discovery and production of inorganic fertilizers in the 19th century it seemed feasible to uncouple from ecological requirements of returning the nutrients and organic matter of our human excreta directly to the agricultural production sites. With an ever-increasing population and a massive flow of nutrients from rural to urban areas that are not returned but discharged into the waterways, it is about time to enter a more sustainable path that links our existing sanitation systems again with agricultural production.

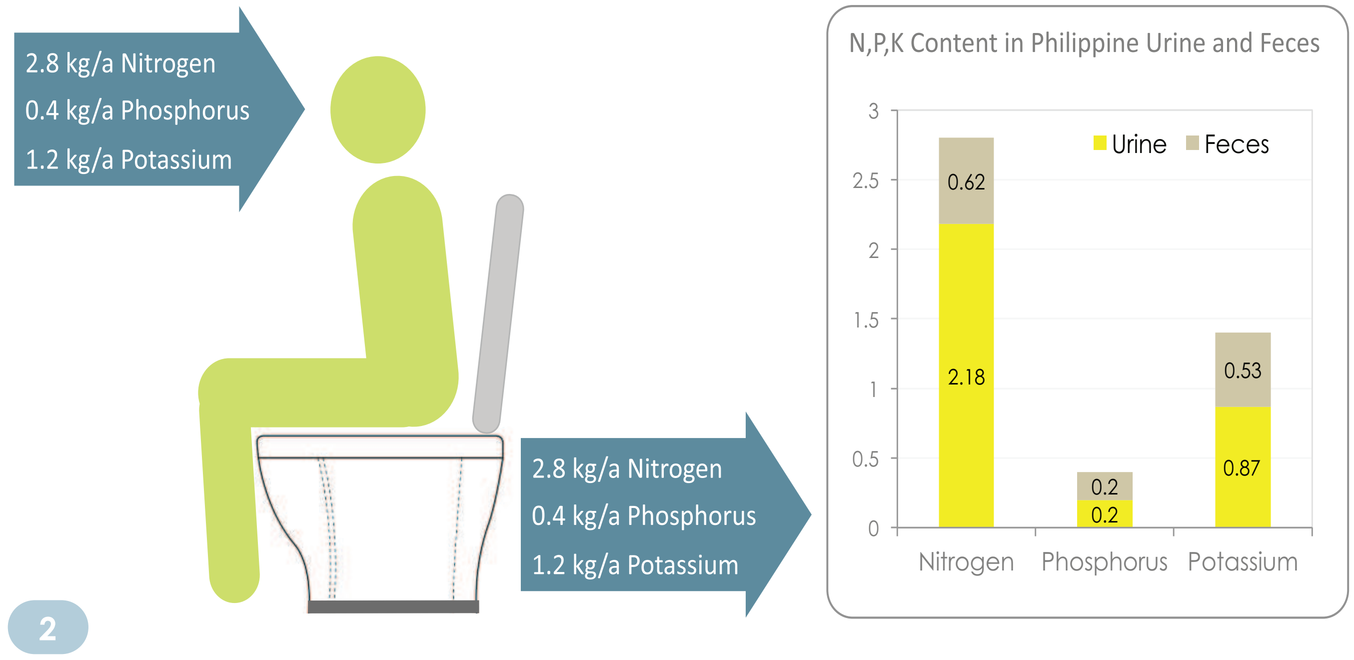
The sustainable sanitation approach recognizes human excreta and water from households not as waste but as valuable resources that have to be recovered, treated where necessary, and safely reused. The underlying principle is to look at the sanitation issue from a system perspective, where sanitation does not end with the toilet but goes to include the proper collection, treatment, transport, and final reuse of excreta and household wastewater in agriculture in order to effectively close the water and nutrient loop.



1

Pic 1: Closing the Loop (adapted from GIZ)

Human excreta contain all important nutrients and organic matter necessary for crop production, and there is almost a balance between nutrient consumption and excretion. Based on FAO statistics (FAO, 2011) for the Philippines with a grand protein consumption of around 60 g/person and total vegetable products consumption of around 35 g/person and the equation developed by JOENSSON (2003) to calculate the corresponding nutrient content, the resulting average nutrient content in Philippine excreta (urine & feces) can be estimated with around 2.8 kg/person/year for Nitrogen, 0.4 kg/person/year for Phosphorus and 1.2 kg/person/year for Potassium.



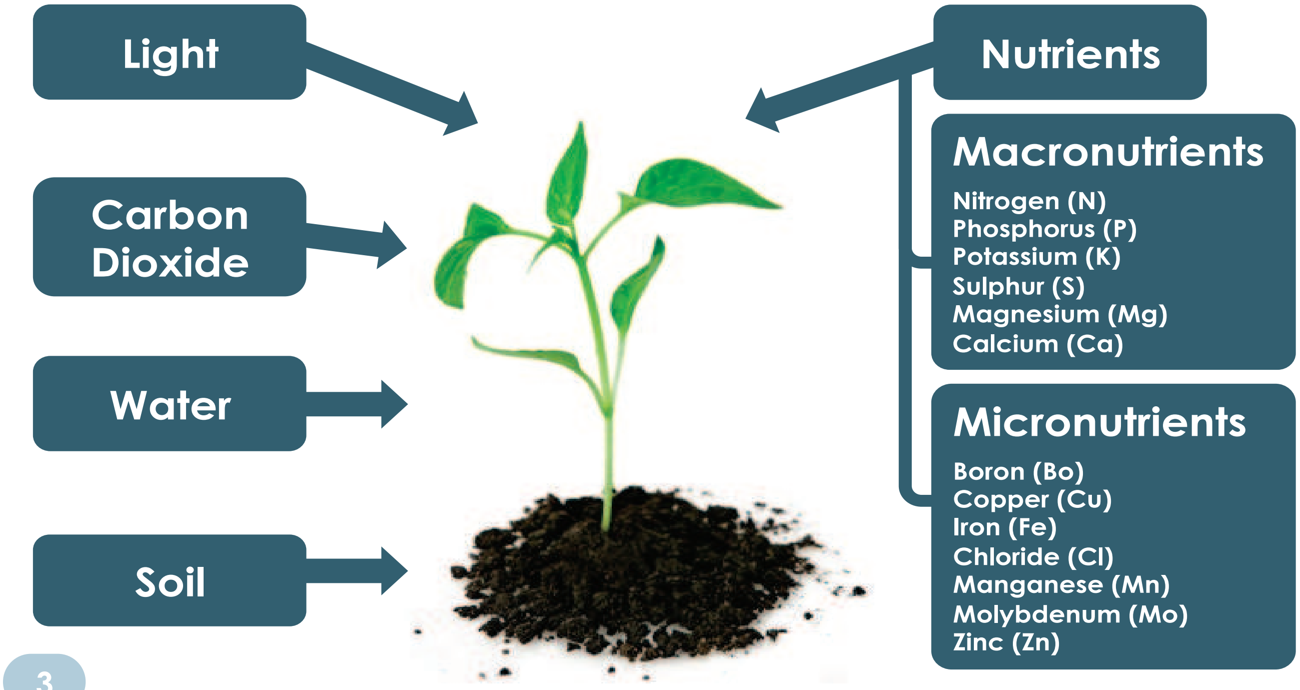
Pic 2: Estimated Average Nutrient Consumption and Excretion (in kg/person/year) in the Philippines

Most of the essential plant nutrients in human excreta can be found in the urine, roughly 80% of Nitrogen, 60% of Potassium, and 55% of Phosphorus (RICHERT et al., 2010). Based on a recent study (GENSCH et al., 2011), the actual determined average nutrient content per person/year in Philippine urine is 2.18 kg of Nitrogen, 0.20 kg of Phosphorus and 0.87 kg of Potassium. Due to the high nutrient content and the low and manageable health risks urine can be used almost immediately as a liquid, quick-acting complete mineral fertilizer that would allow substituting considerable amounts of synthetic fertilizers.

2

Plant Requirements

Apart from the easily available carbon dioxide and light, plants require primarily water, adequate soil structure for the roots to grow in, and nutrients in suitable quantities for their growth. Plant nutrients can be divided into macro- and micronutrients. Since nutrients are taken up from the soil by the plants and finally leave the fields with the harvested products, it is essential that these nutrients be replaced in an amount corresponding to the amount removed during the harvest. It is important to note that fertilization increases crop yield only if the respective plant nutrient supplied is one of the limiting growth factors. If factors other than nutrients are limiting, e.g. water, light, pH, salinity, light or temperature, adding more nutrients will not increase the yield. As Liebig's law of the minimum goes: Plant growth is controlled not by the total of resources available but by the most limited resource.



3

Pic 3: Basic Plant Requirements

Nutrients can be divided into two categories; macronutrients and micronutrients. The 3 most important primary macronutrients are Nitrogen, Phosphorus, and Potassium. There are other macronutrients like Sulphur (S), Calcium (Ca) and Magnesium (Mg) as well as several micronutrients such as Boron (B), Copper (Cu) and Zinc (Zn) that are essential for plant growth but are needed in much smaller amounts.

N is frequently the most limiting nutrient for plant growth, and the use of N is usually higher than the total use of the other macronutrients and micronutrients together. However, the N-demand of the planted crops can differ considerably as can be seen in Table 1.

Nitrogen demand of plants	Kind of plants	Approximate N-demand of plants (kg/ha/year)
Low	Herbs, Beans, Peas, Lettuce etc.	~45
Medium	Onion, Pepper, Potato, Rice etc.	~100
High	Corn, Tomato, Spinach, Eggplant etc.	~160

Table 1: N-demand of different crops (adapted from Valley View University 2008)

Pic 4: Eggplants fertilized with urine in Allotment Gardens in Cagayan de Oro

3

Urine Characteristics

Urine is a liquid product of the human body that is secreted by the kidneys. It consists of 95% water with the remaining 5% made up of soluble wastes and excess substances of the human body like urea, creatinine, dissolved ions (e.g. chloride, sodium, potassium), inorganic and organic compounds or salts (RICHERT et al., 2010). Bigger shares of soluble substances in urine are essential plant nutrients like N, P and K often referred to as macronutrients as well as smaller fractions of micronutrients, in a plant available form. Those nutrients are coming from the food consumed every day, and almost all consumed nutrients leave the body again with the excreta (JOENSSON et al., 2004).

As there is nearly a mass balance between nutrient consumption and excretion, the nutrient content in urine strongly depends on the food intake. Since diets can differ from region to region, the actual nutrient content in urine varies between countries, regions as well as between individuals and even in the time of the day when excreted. Table 2 below shows the average nutrient content in 1 month stored urine from 3 different representative areas in the Philippines, namely Cagayan de Oro, La Union, and Bayawan, as well as the calculated Philippine average urine nutrient content.

Location	**Nitrogen** (g/liter)	**Phosphorus** (g/liter)	**Potassium** (g/liter)
Mindanao (Cagayan de Oro)	4.41	0.40	1.76
Luzon (La Union)	4.79	0.54	1.71
Visayas (Bayawan)	3.85	0.26	1.75
Philippine average	**4.35**	**0.40**	**1.74**

Table 2: Average nutrient content in Philippine urine in g/liter (GENSCH et al. 2011)

The nutrients in urine are plant available with a formulation similar to ammonia- and urea-based fertilizers and comparable results on plant growth. The amount of urine produced by each person per day depends on the amount of liquid a person drinks, but usually lies within a range of 1.0 to 1.5 liter per day for an adult person and about half as much for children, respectively (WHO, 2006). On average, an adult person produces around 500 liters of urine per year. Multiplied with the nutrient content per liter, it results in around 2.18 kg of N, 0.20 kg of P, and 0.87 kg of K that each person in the Philippines excretes with urine.

Location	Nitrogen (kg/person/year)	Phosphorus (kg/person/year)	Potassium (kg/person/year)
Mindanao (Cagayan de Oro)	2.21	0.20	0.88
Luzon (La Union)	2.40	0.27	0.86
Visayas (Bayawan)	1.93	0.13	0.87
Philippine average	**2.18**	**0.20**	**0.87**

Table 3: Average nutrient content excreted with urine per person/year (GENSCH 2011)

Due to the high N content in urine, the P/N and K/N ratios are slightly lower than in many mineral fertilizers, and lower than what many crops need according to fertilizer recommendations (RICHERT et al., 2010). However, urine can still be considered a well-balanced N-rich fertilizer.

Human urine, when coming out of the body, is an almost sterile medium that can be considered generally pathogen-free while most of the actual pathogen load in human excreta is associated with the feces. However, during source-separation and collection, cross-contamination with fecal material can occur and it is always recommendable to store the collected urine prior to agricultural use.

Human beings not only excrete nutrients and water but also hormones and pharmaceuticals. It is estimated that around 2/3 of these pharmaceutical residues are excreted with urine. If urine is used in agriculture, there is a possibility that these micro-pollutants would be taken up by plants and enter the human food chain (RICHERT et al., 2010). However, it also needs to be put in perspective, compared to pharmaceutical residues contained in animal manure used in agricultural production, the risks from pesticide use or the direct discharge of untreated wastewater into water bodies. In the Philippine context particularly in rural areas, the medicine consumption, however, might be comparatively low, which reduces the risk that such substances enter the human food chain.

The characteristic smell of urine that some may find unpleasant can unfortunately not be fully eliminated but considerably reduced if urine is diluted before application and immediately incorporated into the soil. During storage, part of the N containing urea in urine is hydrolyzed to volatile ammonia, which causes the characteristic urine smell. The urine smell, therefore, can be seen as a good indication for the amount of Nitrogen contained in urine. Despite the characteristic smell, experience has shown that farmers usually get used to the urine smell easily after using it a few times.

4

The Potential of Urine as Liquid Fertilizer

As a collaborative effort of the Philippine Sustainable Sanitation Knowledge Node, a countrywide study has been conducted (GENSCH, 2011) to investigate the potential of urine as liquid fertilizer in agricultural production under Philippine conditions.

The study aimed at determining appropriate urine application rates for several commonly planted vegetable crops in the Philippines (sweet corn, eggplant, petchay) and comparing it with conventional synthetic fertilizer as well as no fertilizer application.

The study was conducted in three different locations all across the country (La Union, Bayawan and Cagayan de Oro) representing the 3 main regions: Luzon, Visayas and Mindanao, respectively.

Pic 5: Map with study locations of the 2010/2011 Philippine-wide urine use study

Results in terms of marketable yield for different study locations as well as for each planted crop are shown on the following three pages.

A randomized complete block design (RCBD) was used for the agricultural experiments with 5 treatments and 4 replications for each of the 3 vegetable crops per study site (see also pic 53). The planting bed size was 5m x 1.5m for eggplant and sweet corn and 2.5m x 1m for petchay with 20 plants/bed, planted in 2 rows, to imitate actual field conditions as far as possible.

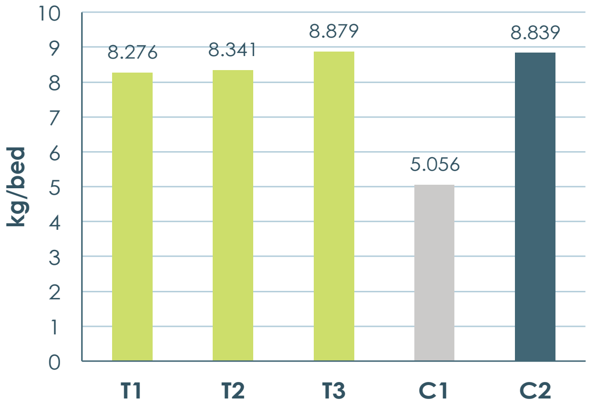
Urine was applied in 3 different dosages: 75% (T1), 100% (T2), and 125% (T3) of the calculated optimum N-requirements of the plants plus 1 treatment with application of synthetic fertilizer (C2) using existing synthetic fertilizer recommendations, to serve as the positive control, and 1 treatment without any urine or synthetic fertilizer application (C1), to serve as the negative control.

Standard operating procedures (PUVEP, 2008) for eggplant, sweet corn, and petchay were followed with basal fertilizer application (at transplanting) for all 3 vegetable crops and side dressings (after transplanting), 1 week and 3 weeks for eggplant and 1 week and 4 weeks for sweet corn.

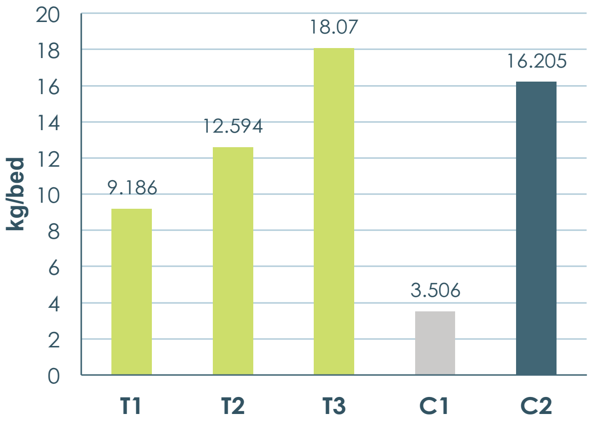
Field Trial Results from Cagayan de Oro (Mindanao)

T1	Application of urine corresponding to 75% of the calculated optimum N requirements of the plant
T2	Application of urine corresponding to 100% of the calculated optimum N requirements of the plant
T3	Application of urine corresponding to 125% of the calculated optimum N requirements of the plant
C1	Control with no urine/synthetic fertilizer application
C2	Application with synthetic fertilizer

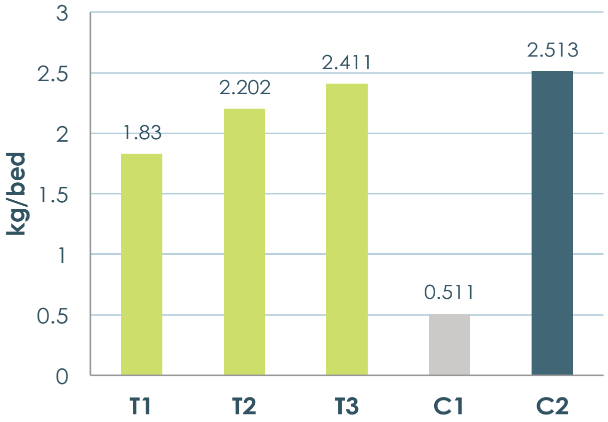
Average marketable yield – Sweet Corn
Cagayan de Oro (Mindanao)



Average marketable yield – Eggplant
Cagayan de Oro (Mindanao)



Average marketable yield – Petchay
Cagayan de Oro (Mindanao)



The research variables used were the fresh weight of the marketable yield at harvest as well as the height of the plants (not reflected in the graphs).

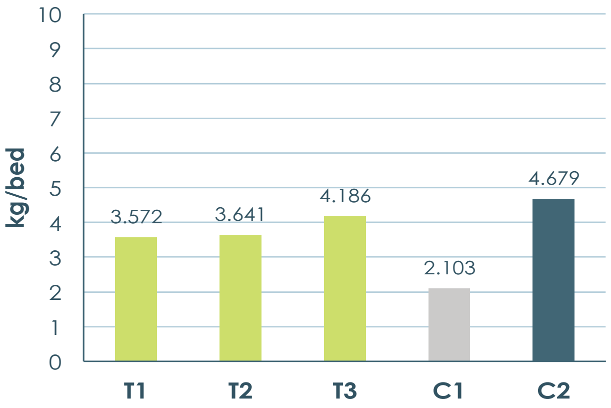
Among the 3 study areas, considerable differences in the overall average yield of the 3 planted vegetable crops were observed, which could be attributed to other local site conditions such as available sunlight, water, and organic matter content in the soil. Despite the differences in the overall yields and plant heights, the general trends and results per treatment, however, remained comparable.

In general, of the 3 investigated urine treatment groups, in most cases the T3 with 125% of the calculated optimum urine application showed the best results in terms of average marketable yield in the 3 study areas. This finding can be attributed to the fact that the study was conducted during the rainy season when some nutrients might have been washed out during rainfall.

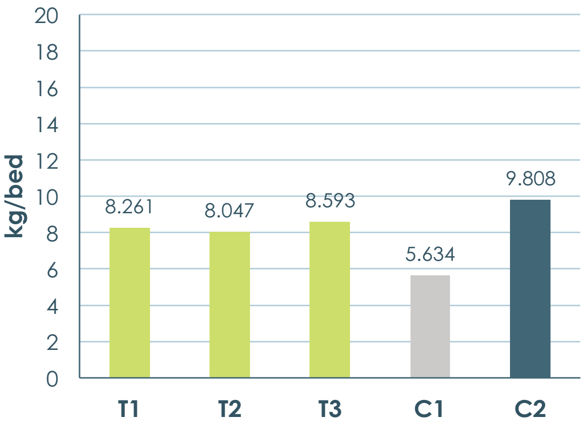
Field Trial Results from La Union (Luzon)

T1	Application of urine corresponding to 75% of the calculated optimum N requirements of the plant
T2	Application of urine corresponding to 100% of the calculated optimum N requirements of the plant
T3	Application of urine corresponding to 125% of the calculated optimum N requirements of the plant
C1	Control with no urine/synthetic fertilizer application
C2	Application with synthetic fertilizer

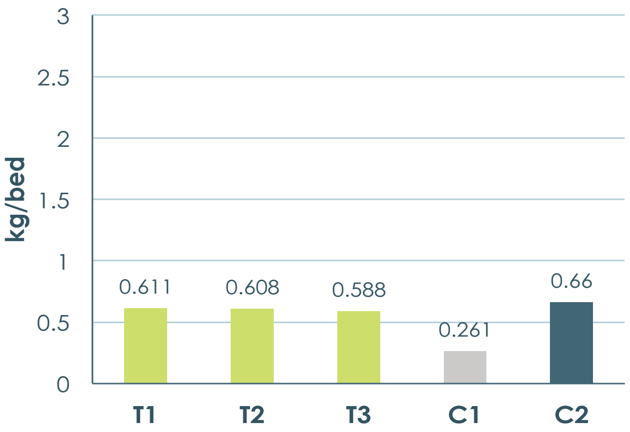
Average marketable yield – Sweet Corn
La Union (Luzon)



Average marketable yield – Eggplant
La Union (Luzon)



Average marketable yield – Petchay
La Union (Luzon)



Results of the urine treatment (T3), which produced the best marketable yield, were comparable to results of the synthetic fertilizer treatment, which produced no significant difference or slightly lesser yields.

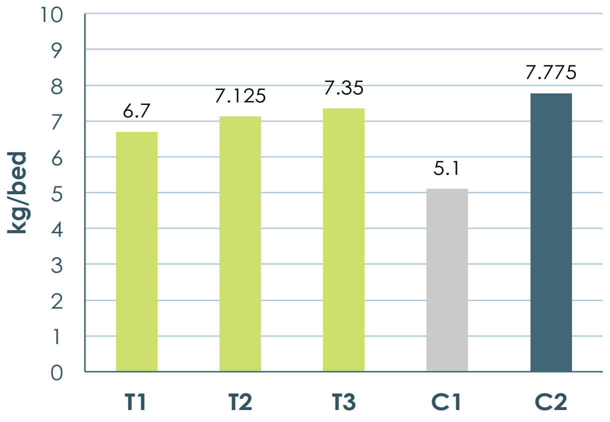
Compared with no fertilizer application, the addition of urine in quantities corresponding to plant needs significantly increased the marketable yield by 1.5 to 5 times, depending on the type of plant and the study location.

Therefore, urine can be considered a valuable liquid nutrient source and a potential synthetic fertilizer substitute in agricultural production.

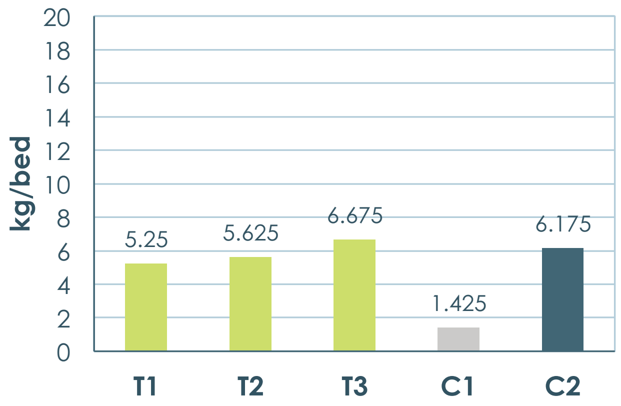
Field Trial Results from Bayawan (Visayas)

T1	Application of urine corresponding to 75% of the calculated optimum N requirements of the plant
T2	Application of urine corresponding to 100% of the calculated optimum N requirements of the plant
T3	Application of urine corresponding to 125% of the calculated optimum N requirements of the plant
C1	Control with no urine/synthetic fertilizer application
C2	Application with synthetic fertilizer

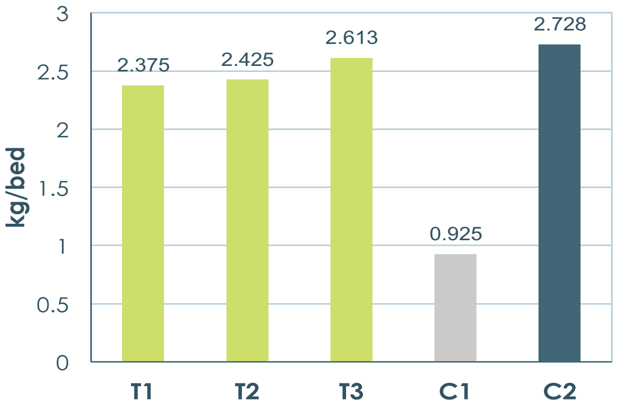
Average Marketable Yield – Sweet Corn
Bayawan (Visayas)



Average Marketable Yield –Eggplant
Bayawan (Visayas)



Average Marketable Yield - Petchay
Bayawan (Visayas)



Pic 6: Fertilization of Eggplants (2nd side dressing) during the conduct of the urine study in Cagayan de Oro

5

The Economic Value of Urine

The monetary value of the nutrients in urine can be calculated by determining the synthetic fertilizer equivalent of the basic macronutrients (N, P, K) in urine times the current local synthetic fertilizer prices. Commonly used fertilizers in the Philippines are Complete fertilizer (14/14/14), Urea (46/0/0), and Muriate of Potash MOP (0/0/60). The figures in brackets describe the total percentage of available Nitrogen (N), Phosphorus (measured in % of P_2O_5), and soluble Potassium (measured in % of K_2O) in each of the fertilizers.

To calculate the nutrient value of Philippine urine excreted per person and year, the average Philippine nutrient content of urine (taken from Table 3) can be translated into the equivalent amount of synthetic fertilizers (see Table 4). Since the nutrient ratio in the urine does not fully correspond with the Complete fertilizer (14-14-14) nutrient ratio, the first row only reflects the necessary amount of Complete fertilizer (14-14-14) based on the total P content in the urine because P is available in the least amount in human urine. The following 2 rows reflect the amount of Urea and Potash to be added to compensate the remaining Nitrogen and Potassium amount.

Average N,P,K content in PH urine (kg/pax/year)				**Equivalent amount of synthetic fertilizer** (kg)	
N (2.18 in total)	**P** (0.20 in total)	**K** (0.87 in total)			
0.49	**0.20**	0.38	➔	Complete (14-14-14)	3.27
1.69	0	0	➔	Urea (46-0-0)	3.67
0	0	**0.49**	➔	MOP - Muriate of Potash (0-0-60)	0.98

Table 4: Synthetic fertilizer equivalents (in kg) of annual nutrient excretion with the urine (person/year)

The equivalent amount of synthetic fertilizer can then be multiplied by the current local market prices for these fertilizers and extrapolated per person, per household or even for the entire country (see Table 5).

Equivalent amount of synthetic fertilizer (kg/year)		**Market price** (PhP/kg, as of 02/2011	**Subtotal** (PhP/year)
Complete (14-14-14)	3.27	23.00	75.21
Urea (46-0-0)	3.67	22.00	80.74
MOP (0-0-60)	0.98	25.00	24.50
Total per person			**PhP 180.45** (US$ 4.13)
Total per family (average household size of 5)			**PhP 902.25** (US$ 20.65)
Total Philippines (current population of around 92 million)			**PhP16,601,400,000.00** (US$ 380 million)

Table 5: Monetary value (PhP/person/year) of N,P,K nutrients found in Philippine urine

Table 5 shows that the annual nutrient value of urine produced by each Filipino can be estimated with around 180 PHP (US$ 4.13). For an entire family (with an average Filipino family size of 5), this already sums up to around 900 PHP (US$ 21.00) per year. And if one would calculate this for the entire country, the fertilizer value of the nation's urine would reach approximately 16.6 billion PHP (US$ 386 million). This calculation only reflects the value of the nutrients found in urine. The additional value of the nutrients found in the feces is not considered here and can be estimated with an additional 50-100 PHP per person and year.

The nutrient value in a 20l jerrican/container is equivalent to around 7-10 pesos (US$ 0.16 - 0.23). This is the amount of urine a family of 5 will produce every 3 days.

The calculations made are still very much conservative, not considering that fertilizers are much more expensive in inland areas compared to regions that are close to cities and harbors. In addition, it is expected that fertilizer prices are about to increase further in the coming years, which will make an even stronger case for using this valuable resource.

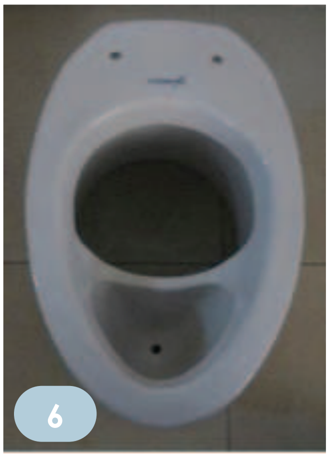
It should also be considered that the actual value of reusing urine in agriculture is much higher than the mere nutrient value. Depending on what crops are locally planted, the yield increase attributed to urine use can be several times as much as compared to no fertilizer application. A recent Philippine-wide study has shown that the yield increase attributed to urine application for sweet corn, petchay and eggplant was between 2-5 times compared to the non-fertilized control (GENSCH, 2011), which further adds value to the urine use and makes a stronger case for the resource reuse in agriculture especially when the use of synthetic fertilizers is not an affordable option.

6

How to get Urine from the Toilet to the Field

To make direct use of urine in agriculture, it needs to be collected separately from the fecal material, which requires a certain type of source separating facility directly inside the toilet. The collection can be done either through a source-separating dry toilet bowl as it is used in the more and more popular Urine Diversion Dehydration Toilets (UDDT) or through waterless urinals or Ecopees.

A source-separating bowl has two compartments for the urine and feces segregation (see pictures). A ceramic version of the urine diversion (UD) bowl is locally fabricated in Luzon and available nationwide (see contact details of the Center of Advanced Philippine Studies at the end). A concrete type of the same bowl design is produced in Northern Mindanao and molds can be obtained from the WAND Foundation (see contact details at the end). If money is not a constraint, it is always recommended to use the more expensive ceramic urine diversion (UD) toilet bowls, otherwise, the toilet bowls can be locally made out of concrete. The concrete bowls are a lot cheaper to produce and can easily be made locally but might cause smell problems in the long term.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8

Pic 6/7: Seat Type Urine Diversion Ceramic Bowls (from Center of Advanced Philippine Studies (CAPS), Manila)
Pic 8: Bench Type Urine Diversion Ceramic Bowls (from CAPS, Manila)

Pic 9/10: Construction of Urine Diversion Concrete Bowls (by WAND Foundation, Libertad)

Several different UDDT designs, with either a 1-chamber system that has a movable container for the feces collection or a 2-chamber system that serves as a collection and treatment facility at the same time, are in use in the Philippines (see also the recent Xavier University Press Publication: “Low-Cost Sustainable Sanitation Solutions for Mindanao and the Philippines” by GENSCH et al., 2010). Also, the material for constructing the toilets can vary depending on what is locally available and how much can be spent. Plenty of publications on appropriate design, operation mode, and proper use of such toilets are locally available (see also the further information chapter at the end). Urine should always be collected and stored in closed containers to reduce odor problems, to avoid Nitrogen loss, and for hygienic reasons.

Pic 11-13: Different UDDT Designs from Cagayan de Oro, Bayawan and Libertad (left to right)

Pic 14: Urine Diversion Dehydration Toilet (Bayawan)
Pic 15: Urine collection container of a UDDT (Cagayan de Oro)
Pic 16: EcoPee men's urinal for direct urine collection (Libertad)

Before application in agriculture, it is recommended to store urine in closed containers. For individual households where urine is used for fertilization on individual plots, no storage is needed. The family's exposure to disease due to day-to-day activities is higher than the risks of using non-stored urine as fertilizer, which renders storage unnecessary (WHO, 2006). In larger systems, however, a minimum storage of at least 1 month should be observed. As a rule of thumb: The longer the storage, the better. Urine can either be directly stored in jerricans or transported to bigger storage facilities close to agricultural fields.

Pic 17/18: Urine Storage in Tanks and Jerricans
Pic 19: Transport of Urine from the Households to the Agricultural Production Site (Initao)

At a small-scale household level, where urine is directly applied to fields close to the toilet, the issue of transporting the urine is negligible. However, in slightly bigger or urban scenarios, where urine cannot be used directly, the transport of urine to the fields and the cost of such services need to be considered. Urine should be transported in closed containers to avoid spill.

For the application of source-separated urine in agriculture, several options are possible. The urine can be applied to small fields and beds, vertical gardens, school gardens, smaller plant pots on terraces, rooftops, and almost everywhere where space, adequate soil and sunlight can be ensured. The use of urine is not at all limited to rural areas. It can easily be adopted in urban environments as long as enough space is available.


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Pic 20: Vertical Container Gardening
Pic 21: Allotment Garden (Cagayan de Oro)
Pic 22: School Garden (Bukidnon)
Pic 23: Vertical Container School Garden (Cagayan de Oro)

7

Recommendations for Direct Urine Application

Application Rate

Because of its high Nitrogen content, urine should always be applied at a rate corresponding to the desired Nitrogen requirements of the plant. For optimal plant growth, additional application of Phosphorus or Potassium containing synthetic fertilizers (e.g. Di-Ammonium Phosphate or Muriate of Potash) or the application of material rich in organic matter (e.g. compost, vermicompost or dried and sanitized feces) might be necessary to sustain soil fertility in the long run, since urine can only partly replace Phosphorus and Potassium and not organic matter.

For the application of urine to larger fields, it is recommended to make use of the commonly applied existing synthetic fertilizer application recommendations (e.g. production guides for different crops from the Department of Agriculture or from seed companies) and determine the corresponding amount of urine based on the Nitrogen content of the recommended synthetic fertilizers.

For small-scale vegetable production, the table below gives a good indication on appropriate rates of urine to be applied for different vegetable crops. The recommended rates are based on existing synthetic fertilizer recommendations for commonly planted vegetable crops in the Philippines (taken from the Philippine Allotment Garden Manual by PUVEP 2008). Based on the synthetic fertilizer recommendations, the corresponding amount of urine has been calculated. These theoretical estimates have been tested and verified for sweet corn, petchay and eggplant in a Philippine-wide field trial and extrapolated for all other vegetables.

It is important to note that these are only very general recommendations showing the estimated range of urine to be applied for a certain crop and that might help local farmers to identify their initial urine application rates. Local experiments should be done to establish the exact application rates. Over time, the farmers can determine the right amount of urine needed for optimal plant growth.

	Vegetable Crops	Planting distance & density	Synthetic fertilizer recommendations and its elementary N, P, K equivalent (g/hill) Based on Allotment Garden Manual 2008			 Estimated urine amount to be applied per hill based on N-demand of crops (in liter/hill)			 Estimated urine amount per bed (20mx1.3m) based on N-demand of crops (in liter/bed)		
			Basal (at planting)	1st side dressing	2nd side dressing	Basal (at planting)	1st side dressing	2nd side dressing	Basal (at planting)	1st side dressing	2nd side dressing
CRUCIFERS	**Cauliflower** localname: Koliflawer	• 1 plants/hill • 30 cm btw. hills • 4 rows/bed • 267 hills/bed • 267 plants/bed	10.0 DAP +100g chicken dung 1.80 Nitrogen 2.02 Phosphorus 0.00 Potassium	3.8 MOP (1 WAT) 0.00 Nitrogen 0.00 Phosphorus 1.89 Potassium	4.6 Urea (3 WAT) 2.12 Nitrogen 0.00 Phosphorus 0.00 Potassium	**0.4-0.5** +100g chicken dung	**no application**	**0.4-0.5** (3 WAT)	**100-120** +26.7 kg chicken dung	**no application**	**120-140** (3 WAT)
	Broccoli localname: Brokkoli	• 1 plants/hill • 30 cm btw. hills • 4 rows/bed • 267 hills/bed • 267 plants/bed	10.0 DAP +100g chicken dung 1.80 Nitrogen 2.02 Phosphorus 0.00 Potassium	3.8 MOP (1 WAT) 0.00 Nitrogen 0.00 Phosphorus 1.89 Potassium	4.6 Urea (3 WAT) 2.12 Nitrogen 0.00 Phosphorus 0.00 Potassium	**0.4-0.5** +100g chicken dung	**no application**	**0.4-0.5** (3 WAT)	**100-120** +26.7 kg chicken dung	**no application**	**120-140** (3 WAT)
	Pak Choy localname: Petchay	• 1 plant/hill • 20cm btw.hills • 4 rows/bed • 400 hills/bed • 400 plants/bed	10.0 Complete +100g chicken dung 1.40 Nitrogen 0.62 Phosphorus 1.16 Potassium	**no application**	**no application**	**0.3-0.4** +100g chicken dung	**no application**	**no application**	**120-140** +40 kg chicken dung	**no application**	**no application**
others	**String Bean** Localname: Sitaw	• 2 plants/hill • 30cm btw. hills • 70cm btw. rows • 2 rows/bed • 133 hills/bed • 266 plants/bed	10.0 Complete +50g chicken dung 1.40 Nitrogen 0.62 Phosphorus 1.16 Potassium	10.0 Complete (2 WAS)* 1.40 Nitrogen 0.62 Phosphorus 1.16 Potassium	10.0 Complete (4 WAS)* 1.40 Nitrogen 0.62 Phosphorus 1.16 Potassium	**0.3-0.4** +50g chicken dung	**0.3-0.4** (2 WAS)	**0.3-0.4** (4 WAS)	**40-50** +6.7kg chicken dung	**40-50** (2 WAS)	**40-50** (4 WAS)
	Sweet corn Localname: Mais	• 1 plants/hill • 30 cm btw. hills • 2 rows/bed • 133 hills/bed • 133 plants/bed	7.0 Complete +100g chick dung 0.98 Nitrogen 0.43 Phosphorus 0.81 Potassium	4.0 Urea (1 WAT) 1.84 Nitrogen 0.00 Phosphorus 0.00 Potassium	7.0 Urea 4.0 MOP (4 WAT) 3.22 Nitrogen 0.00 Phosphorus 1.99 Potassium	**0.2-0.3** +100g chicken dung	**0.4-0.5** (1 WAT)	**0.7-0.8** (3 WAT)	**25-35** +100.0 chicken dung	**50-60** (1 WAT)	**90-100** (3 WAT)
	Ladies' Finger Localname: Okra	• 1 plants/hill • 30 cm btw. hills • 2 rows/bed • 133 hills/bed • 133 plants/bed	15.0 Complete +150g compost 2.10 Nitrogen 0.92 Phosphorus 1.74 Potassium	10.0 Complete (3 WAT) 1.40 Nitrogen 0.62 Phosphorus 1.16 Potassium	10.0 Complete (6 & 9 WAT) 1.40 Nitrogen 0.62 Phosphorus 1.16 Potassium	**0.4-0.5** +150.0 compost	**0.3-04** (1 WAT)	**0.3-0.4** (3 WAT)	**60-70** +150.0 compost	**40-50** (1 WAT)	**40-50** (3 WAT)

	Vegetable Crops	Planting distance & density	Synthetic fertilizer recommendations and its elementary N, P, K equivalent (g/hill)			Estimated urine amount to be applied per hill based on N-demand of crops (in liter/hill)			Estimated urine amount per bed (20mx1.3m) based on N-demand of crops (in liter/bed)		
			Basal (at planting)	1st side dressing	2nd side dressing	Basal (at planting)	1st side dressing	2nd side dressing	Basal (at planting)	1st side dressing	2nd side dressing
NIGHTSHADE FAMILY	**Egg plant** Localname: Talong	• 1 plants/hill • 40cm btw. hills • 70cm btw. rows • 2 rows/bed • 100 hills/bed • 100 plants/bed	10.0 DAP +100g chicken dung 1.80 Nitrogen 2.02 Phosphorus 0.00 Potassium	3.9 Urea 5.8 MOP (1 WAT) 1.79 Nitrogen 0.00 Phosphorus 2.89 Potassium	7.9 Urea 5.8 MOP (3 WAT) 3.63 Nitrogen 0.00 Phosphorus 2.89 Potassium	**0.4-0.5** +100g chicken dung	**0.4-0.5** (1 WAT)	**0.8-0.9** (3 WAT)	**40-50** +10kg chicken dung	**40-50** (1 WAT)	**40-50** (3 WAT)
	Tomatoes Localname: Kamatis	• 2 plants/hill • 40cm btw. hills • 70cm btw. rows • 2 rows/bed • 100 hills/bed • 200 plants/bed	10.0 DAP +100g chicken dung 1.80 Nitrogen 2.02 Phosphorus 0.00 Potassium	3.9 Urea 5.8 MOP (1 WAT) 1.79 Nitrogen 0.00 Phosphorus 2.89 Potassium	7.9 Urea 5.8 MOP (3 WAT) 3.63 Nitrogen 0.00 Phosphorus 2.89 Potassium	**0.4-0.5** +100g chicken dung	**0.4-0.5** (1 WAT)	**0.8-0.9** (3 WAT)	**40-50** +10kg chicken dung	**40-50** (1 WAT)	**40-50** (3 WAT)
	Sweet Pepper Localname: Atsal	• 2 plants/hill • 40cm btw. hills • 70cm btw. rows • 2 rows/bed • 100 hills/bed • 200 plants/bed	10.0 DAP +100g chicken dung 1.80 Nitrogen 2.02 Phosphorus 0.00 Potassium	3.9 Urea 5.8 MOP (1 WAT) 1.79 Nitrogen 0.00 Phosphorus 2.89 Potassium	7.9 Urea 5.8 MOP (3 WAT) 3.63 Nitrogen 0.00 Phosphorus 2.89 Potassium	**0.4-0.5** +100g chicken dung	**0.4-0.5** (1 WAT)	**0.8-0.9** (3 WAT)	**40-50** +10kg chicken dung	**40-50** (1 WAT)	**40-50** (3 WAT)
CUCURBITS	**Bittergourd** Localname: Ampalaya	• 1 plants/hill • 50 cm btw. hills • 2 rows/bed • 80 hills/bed • 80 plants/bed	18.0 Complete +100g chicken dung 2.52 Nitrogen 1.11 Phosphorus 2.09 Potassium	9.0 Complete (3 WAT) 1.26 Nitrogen 0.55 Phosphorus 1.05 Potassium	9.0 Complete (6 WAT) 1.26 Nitrogen 0.55 Phosphorus 1.05 Potassium	**0.5-0.6** +100g chicken dung or compost	**0.3-0.4** (3 WAT)	**0.3-0.4** (6 WAT)	**40-50** +8 kg chicken dung or compost	**20-30** (3 WAS)	**20-30** (6 WAS)
	Cucumber Localname: Pepino	• 1 plants/hill • 40 cm btw. hills • 2 rows/bed • 100 hills/bed • 100 plants/bed	18.0 Complete +100g chicken dung 2.52 Nitrogen 1.11 Phosphorus 2.09 Potassium	9.0 Complete (3 WAT) 1.26 Nitrogen 0.55 Phosphorus 1.05 Potassium	no application	**0.5-0.6** +100g chicken dung	**0.3-0.4** (3 WAT)	**no application**	**50-60** (+10 kg chicken dung or compost)**	**25-35** (3 WAS)	**no application**

Complete:	Widely used general fertilizer that contains 14% Nitrogen, 14% Phosphate (P_2O_5- equivalent to 6% Phosphorus) and 14% of soluble Potash (K_2O – equivalent to 12% Potassium)
MOP:	MOP (0-0-60) or Muriate of Potash is a widely used synthetic Potassium fertilizer with a minimum content of 60% Potash (equivalent to around 50 % elemental Potassium)
DAP:	DAP (18-46-0) or Diammonium Phosphate is a widely used Phosphorus and Nitrogen fertilizer that contains 18% Nitrogen and 46% P_2O_5(equivalent to 22% elemental Phosphorus)
Urea:	Urea (46-0-0) is a widely used synthetic nitrogen fertilizer with a minimum content of 46% Nitrogen
*)	on a need basis if plants show nutrient deficiency symptoms
**)	fertilizer amounts given in gram per linear meter (not per hill)
WAT	weeks after transplanting
WAS	weeks after sowing

Table 6: Urine Application Recommendations for Commonly Planted Philippine Vegetable Crops

Dilution

Urine can be applied neat or diluted with water. There is no standard recommendation for dilution or non-dilution, and the existing recommendations vary widely. However, if urine is applied at a small-scale level where the transport of the relatively heavy liquid medium is not a constraint, it is recommended to dilute the urine. Advantages of the dilution are a noticeable odor reduction and a decreased risk of over-application. However, dilution increases the total volume to be spread and thus labor and transport. The easiest way to dilute urine is to mix urine and water in a separate container (see picture below).

It is important to note that urine should always be applied at the rate corresponding to the desired application rate of Nitrogen, while additional water should be applied according to the water needs of the plants. When applying undiluted urine, water should be applied right after the application of urine.

Pic 24: Dilution of urine by mixing 1 part of urine with 1 part of water (1:1 ratio)

Application Time

Good availability of nutrients is particularly important in early stages of cultivation. Once crops enter the reproductive stage, they hardly take up any more nutrients. As a rule of thumb, fertilization should stop after 2/3 to 3/4 of the time between sowing and harvest (RICHERT et al., 2010). A waiting period of 1 month between fertilization and harvest should always be kept (see also chapter on health risks and multi-barrier approach). Basic recommendations on the time of fertilization (basal, 1st and 2nd side dressing) can be drawn from Table 6.

During the dry season with high temperatures during the day, urine should be applied in the early mornings or evenings and be heavily diluted with water to adequately irrigate the plants. During the rainy season urine may be applied repeatedly in smaller doses to reduce the risk of nutrients leaching.

Application Techniques

For best fertilizing effect and to avoid ammonia losses, urine should always be applied close to the ground and be incorporated into the soil as soon as possible after application, instantly if possible. Equipment that can be used for the application comprises watering cans, dippers, empty water bottles cut into half, empty sardine cans, etc.

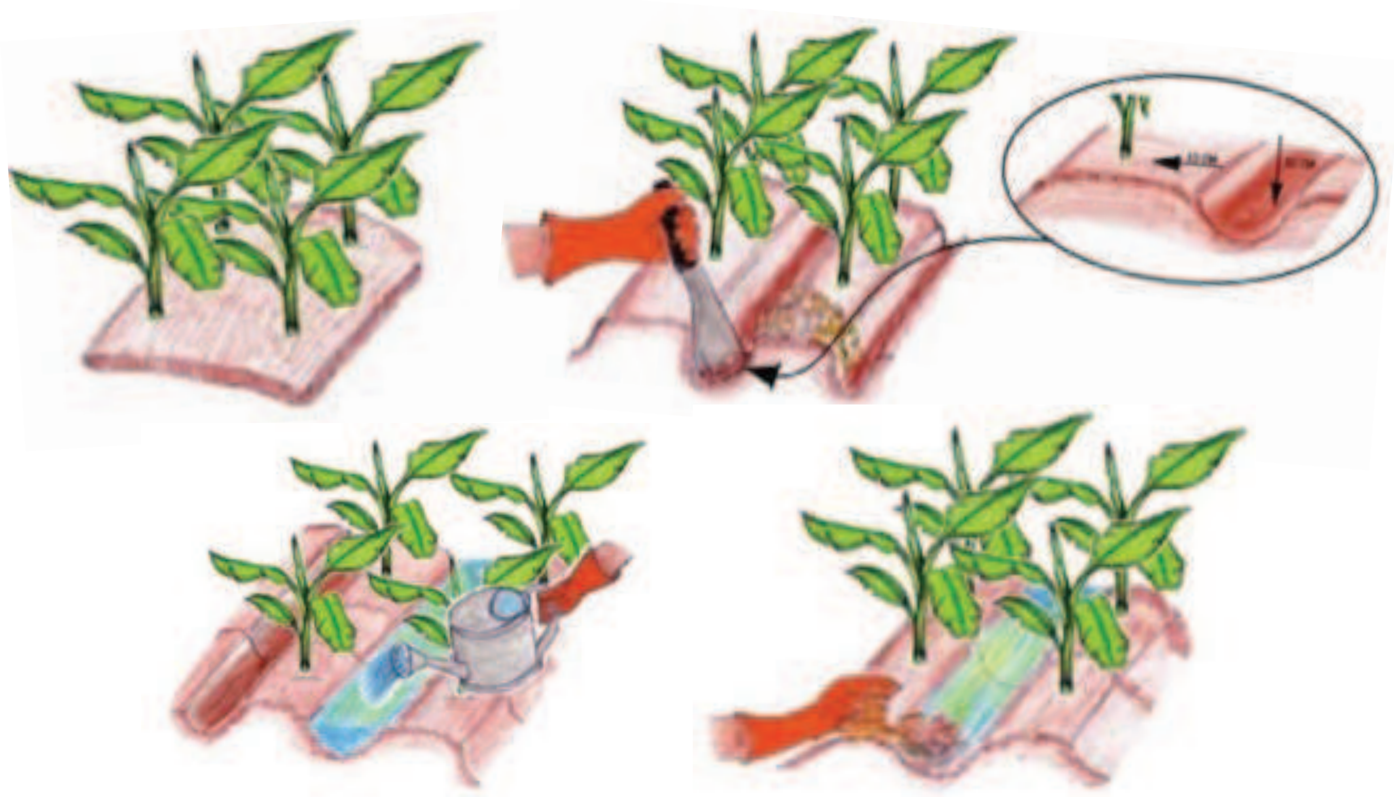
Some plants in their early stages are sensitive to having their roots exposed to urine (e.g. tomatoes), while for many crops no negative effect is seen at all. Therefore, before the sensitivity of a crop is known, it is wise not to simultaneously expose all the roots of the plant to urine, be it neat or diluted. Instead, urine can be applied either prior to sowing/planting or at such a distance from the plants (about 10 cm) that the nutrients are within reach of the roots. When spreading urine, it should not be applied to leaves or other parts of the plants, as this can cause foliar burning. Spraying urine in the air should also be avoided due to the risk of Nitrogen loss through gaseous emissions of ammonia and the hygiene risk through aerosols.

The above mentioned application recommendations are also beneficial from a health perspective since they avoid direct contact of urine with the planted crops (RICHERT et al., 2010). A shallow incorporation of urine into the soil is usually enough, and different methods are possible. The choice of application technique varies for different types of crops.

Potential application techniques include (1) application in furrows, (2) application in dug holes, (3) application on trees, and (4) urine application using drip irrigation systems. The different application techniques are described in detail on the following pages.

Application Technique 1: Urine Application in Furrows

For crops that are grown in rows, urine can be applied in small furrows along one (or both) side(s) of the planting row. Furrows should be dug at a distance of around 10 cm away from the plants. Urine should then be applied according to the plant requirements (see also chapter on application rates above) with subsequent application of water and covering of the furrows after urine and water application.



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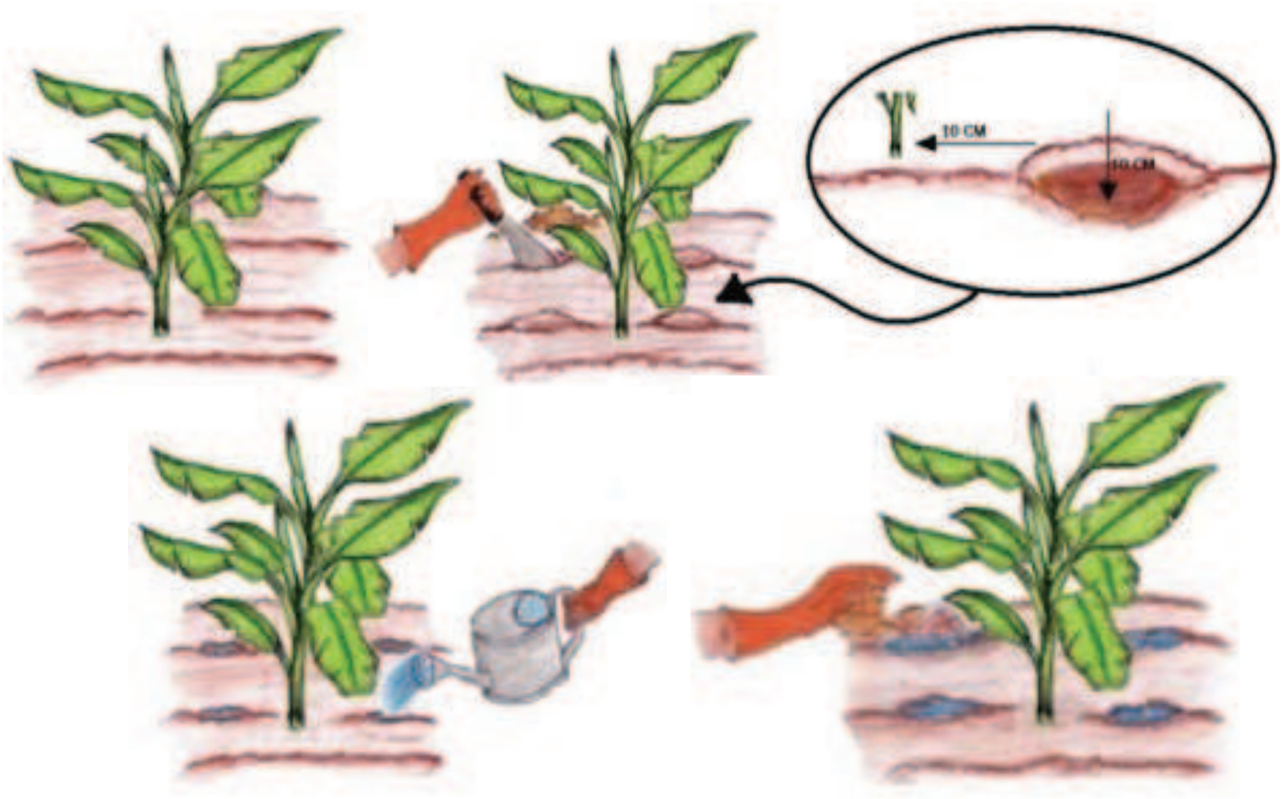
Pic 25-27: Furrow Irrigation: (1) digging of furrow, (2) urine application, (3) covering with soil after urine application

Pic 28: Furrow Application with subsequent Soil Covering during a Urine Reuse Workshop in Cagayan de Oro

Application Technique 2: Urine Application in Holes

For crops with spacing between the plants, urine can also be applied in small dug holes next to the crop. The holes should be dug at a distance of around 10 cm away from the plants and around 10 cm deep without hurting the roots of the plants. Urine can then again be applied according to the plant requirements with subsequent application of water and covering of the holes after urine and water application.

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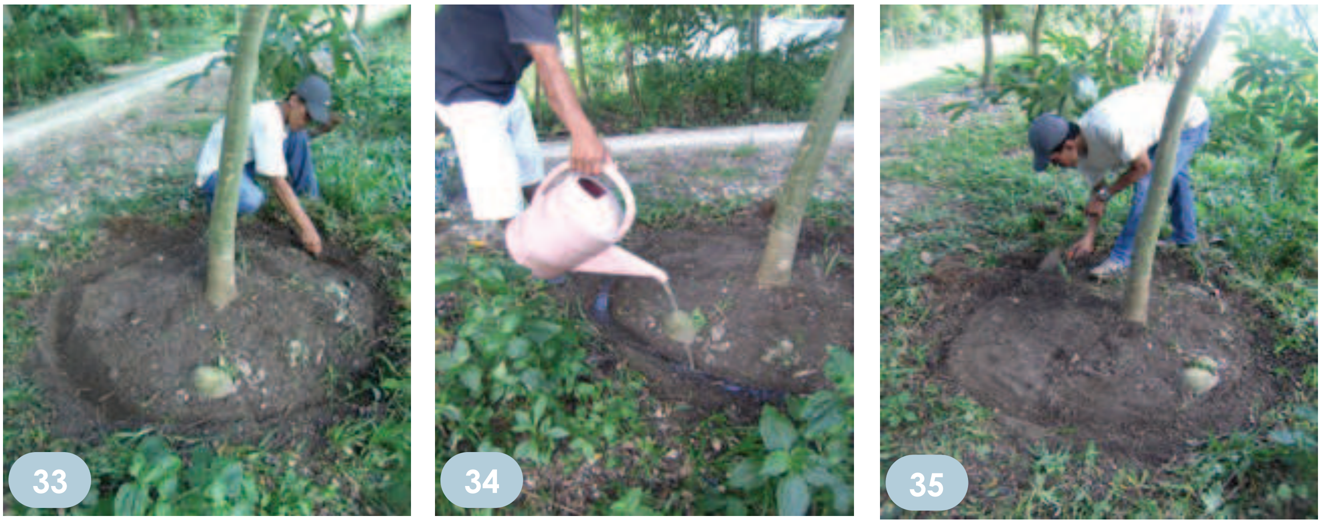
Pic 29-31: Hole Irrigation: (1) digging of hole, (2) urine application, (3) covering with soil after urine application

Pic 32: Urine Application in dug holes (Cagayan de Oro)

Application Technique 3: Application on Trees

For trees (e.g. banana, mango or coconut), urine should be spread in a circle around the tree that corresponds to the circumference of the branches. A small circular furrow should be dug around the tree with subsequent application of urine and water and closing of the furrow afterwards.



Pic 33-35: Application on trees (1) digging of circular furrow, (2) application of urine, (3) covering with soil

Application Technique 4: Drip Irrigation

Drip irrigation with urine is another possible application technique. However, when this technique is used, measures must be taken to avoid clogging of emitters. Subsequent use of water to 'clean' the pipes is a recommended option here.

Pic 36-38: Drip Irrigation System

8

Alternative Agricultural Urine Use Options

In addition to the use of urine solely as a liquid mineral fertilizer that is substituting commonly used synthetic fertilizers, there are several alternatives how urine can be used in a productive way.

1. Storage of urine in the soil

If larger amounts of urine accumulate in times when usually no cultivation takes place (e.g. during dry season) and when the necessary storage capacity of available tanks, jerricans, etc. is not sufficient, the direct storage of urine in the soil might be an alternative to be considered.

Here, urine is directly applied to and incorporated into the soil, followed by regular cultivation of the already urine-fertilized soil during the next cropping season. Although a considerable amount of the Nitrogen might leave the system through volatile Ammonia, still more than 50% of the Nitrogen, as well as most of the other nutrients like Phosphorus, Potassium and Sulphur, will remain in the soil and will be available for the plants during the next cropping season.

In the Philippines, however, this is only applicable and recommended during the dry season also in order to avoid the leeching of nutrients during heavy rainfalls. An additional advantage of soil storage is that the labor of applying the urine is carried out during the dry season.

2. Urine use for biomass production

Urine can be used productively for the fertilization of fast growing trees that are able to take up bigger amounts of nutrients in order to produce fodder crops for animals, biomass for energy production, or biomass as a carbon source for composting purposes. Possible tree species to be planted in the Philippines are Ipil-Ipil (*Leucaena leucocephala*) or Madre de Cacao (*Gliricidia*).

3. Comfrey production

Urine can also be used for the production of Comfrey (Symphytum officinale). The Comfrey plant is a fast growing plant that is able to take up huge amounts of nutrients (particularly Nitrogen) that are accumulated in the leaves. Comfrey can be harvested almost monthly and due to the lack of fiber in the plant, the leaves break down quickly to a thick black nutrient-rich liquid after harvest. Comfrey can be used as follows:

1. As a compost activator that adds Nitrogen to the heap and helps to heat the compost heap,
2. As a liquid fertilizer (Comfrey tea) produced by rotting the leaves down in rainwater for around 4-5 weeks,
3. As a mulch or side dressing with a 2-inch layer of Comfrey leaves around the plants that will slowly break down and release the plant nutrients.

The production of Comfrey offers an additional safety barrier in the system and it allows the urine nutrients to be stored in the Comfrey plants.

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Pic 39: Ipillpil (*Leucaena leucocephala)*
Pic 40: *Madre de Cacao (Gliricidia sepium)*
Pic 41: *Comfrey (Symphytum officinale)* taken from www.nutritionist-world.org

4. Urine Composting

Another alternative urine use is to add urine as a nutrient source in compost production. While the direct use of urine as a liquid fertilizer only mimics conventional agricultural practices by adding mere mineral nutrients to the plants, the production of urine-enriched compost offers a way of improving the soil condition as a whole.

4.1 Adding of Urine to the Compost Heap

Urine can be added to regular compost heaps as an additional source of Nitrogen (as well as other macro- and micronutrients). For compost heaps with a high carbon/Nitrogen (C/N) ratio, the urine helps to add the missing Nitrogen element and can therefore be considered a good compost activator. During the composting process, however, considerable amounts of Nitrogen might get lost through volatile Ammonia in the composting process. The adding of urine usually increases the temperature in the compost, which is also beneficial to destroy any remaining pathogens and unwanted seeds in the heap.

4.2 Urine Composting

Here, the urine together with a microbial solution is added to a mix of around 10% of garden soil, around 10% of ground charcoal, and around 80% of a finely sliced wood source (e.g. woodchips) and left for (vermi-)composting for a period of 1-2 months with occasional watering of the compost heap (based on RECKIN, 2010). The final (vermi-)composted product is a nutrient-rich, humus-like substance with a high organic carbon content that allows for improved water retention and a longer lasting fixation of essential nutrients.

The addition of charcoal (coming from carbonized rice husks, coconut shells, tree clippings, etc.) aids in the absorption of nutrients. The wood source provides lignocellulose and increases the C/N ratio needed for the composting process. The desirable C/N ratio for humification lies between 21 to 24 (RECKIN, 2010).

The microbial mix added to the urine contains selected microbes that aid in the formation of humic acids and helps inhibit the bacterial urease process that hydrolyses urea into Ammonia and bicarbonate, thereby avoiding significant losses of Nitrogen through volatile Ammonia (RECKIN, 2010). As a positive effect, the characteristic smell of urine coming from the Ammonia is considerably reduced as well. The microbial mixture contains 5 key microbes (*Bacillus subtilis, Bacillus mesentericus, Geobacillus stearothermophilus, Azotobacter croococcum, Lactobacillus spec*). The mix can be obtained free of charge from the XU SUSAN Center (see contact details at the end) and can be easily propagated by adding water, milk, and a sugar source to feed the microbes regularly.


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Pic 42: Garden Soil **Pic 43:** Charcoal **Pic 44:** Woodchips **Pic 45:** Adding of soil & charcoal to wood **Pic 46:** Mixing of woodchips, charcoal and garden soil **Pic 47:** Adding microbial mix to urine **Pic 47:** Adding urine-microbe-mix to charcoal-wood-soil-mix **Pic 49-51:** Covering of mixed substrate with old leaves, occasionally watering and vermicomposting for 1-2 months

9

Experimental Demonstration Sites

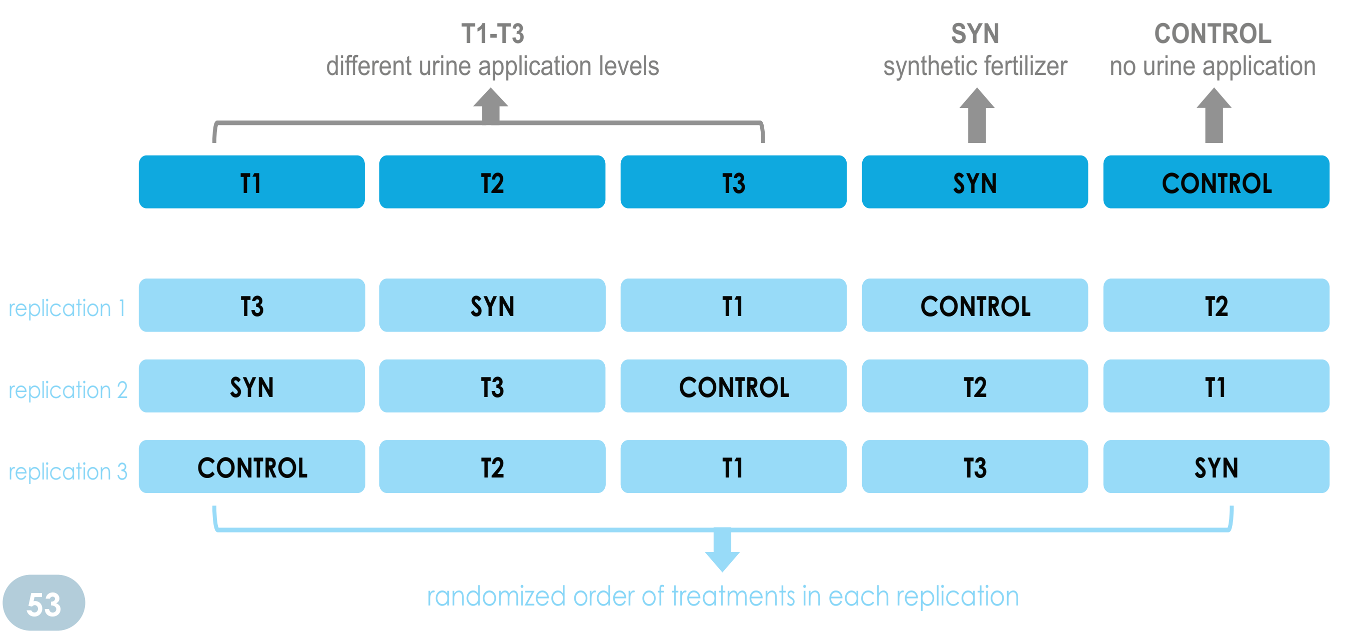
Demonstration experiments can be the first step to gain local experiences with using urine in agricultural production. They are relatively cheap, easy to set up, and can be done almost everywhere. Experiments can range from small pot trials to larger field experiments. Providing first-hand experiences under local soil and climate conditions, experiments are helpful and convincing advocacy tool to stir interest and acceptance among local stakeholders. It is therefore recommendable to set up small demo trials just outside the entrance doors of extension offices, in schools or other places in the center of society where many persons can be reached (RICHERT et al., 2010).

Pic 52: Urine reuse research with sweet corn, eggplant and petchay (Cagayan de Oro, 2010)

The level of experimentation can range from simple demonstration trials to scientifically rigorous research. Demonstration trials should be started in places that are easily accessible to farmers and household owners. For simple demo experiments, there is no need for repetition and documentation. The results, however, should be clearly visible and fertilization levels should be preferably high.

For setting up own field trial experiments on the fertilizing effect of urine, it is recommended to have at least 150 m^2 of farm/vegetable garden available. In addition to the experimental area where urine is used in fertilizing the plants (following recommended, standardized dosage), control areas (with no urine application and/or with synthetic fertilizer application) should be provided to allow for direct comparison.

In field trials, it is recommended that a single vegetable be used for result comparability. Water, as well as exposure of plants to sunlight, should remain a constant factor. Data to be recorded should include height, fruiting, or marketable yield. For all types of crop experiments, the experimental plots should be as even as possible. The treatments should be repeated several times, if possible 3-5 times in the same field. The treatment order should be randomized within each repetition.



	T1	T2	T3	SYN	CONTROL
replication 1	T3	SYN	T1	CONTROL	T2
replication 2	SYN	T3	CONTROL	T2	T1
replication 3	CONTROL	T2	T1	T3	SYN

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Pic 53: Possible Experimental Layout

10

Health Considerations and Risk Management

Health risks associated with the use of human urine in plant production are generally low. However, during the source separation at the toilet, fecal cross-contamination of urine can occur. The amount of fecal cross-contamination is directly proportional to the health risks.

Groups that are potentially at risk comprise collection personnel and field workers, local communities, and product consumers. As regards other contaminating substances in human urine (heavy metals, hormones and pharmaceuticals), there are many indications that possible health risks are far smaller than those associated with the common sanitation system and that it is reasonable to believe that the risk for negative effect on the quantity and quality of the crops is negligible.

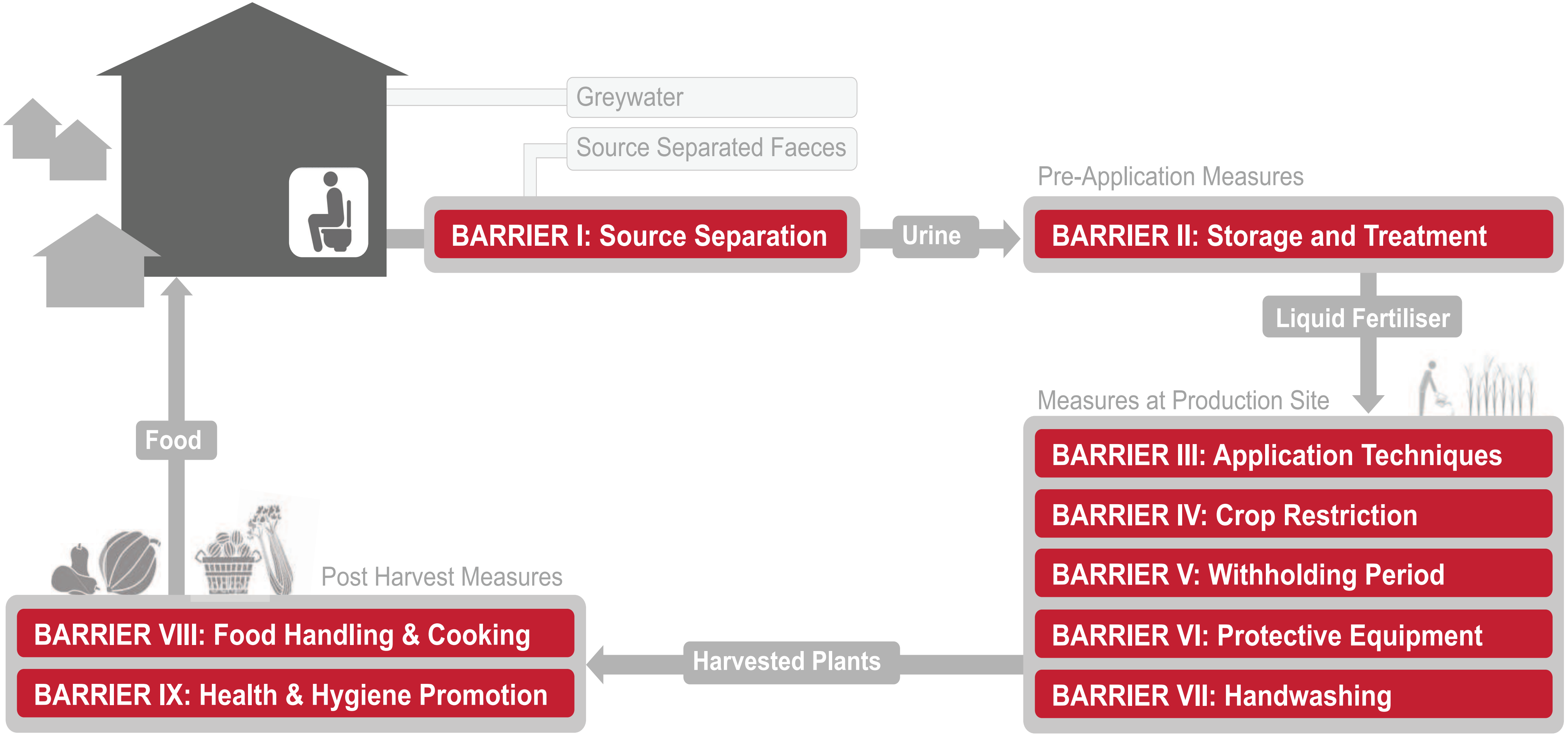
The 'WHO Guidelines for Safe Use of Wastewater, Excreta and Greywater' (2006) recognize the potential of using excreta in agriculture and promote a flexible multi-barrier approach for managing the health risks associated with the use of excreta in agriculture.

This multi-barrier concept consists of a series of measures/barriers along the entire sanitation system from 'toilet to table' (see schematic on the next page). Each of the barriers has a certain potential to reduce health risks associated with the excreta use, and it is recommended by WHO to put in place several of these barriers if needed to reduce the level of health risks to a minimum.

BARRIER I: Source Separation

The proper separation of urine and feces directly at the source/toilet is the most efficient barrier to eliminate nearly the health risks associated with urine use. Since the urine itself is an almost sterile medium, the key objective of the source separation and urine collection is to avoid or minimize fecal cross-contamination. If a certain fecal cross-contamination cannot be ruled out completely (e.g. improper or inexperienced use of the urine diversion toilet bowl might lead to some cross-contamination when feces unintentionally enter the wrong/urine compartment of the bowl), other barriers as described below are imperatively necessary.

Multi-Barrier Approach



Pic 54: WHO Multi-Barrier Approach

BARRIER II: Storage & Treatment

Although urine can be considered an almost sterile medium, it is always recommended to treat and sanitize the urine through proper storage in closed containers to reduce any potentially remaining microbial health risks. The storage at ambient temperature is considered a viable treatment option and the actual storage time depends on the scale of the system and the level of fecal cross-contamination that may occur during the collection.

At household level, a storage time of around 1 month is recommended to make sure that the urine is free of pathogens. Usually after 1 month in a closed container, all pathogens in urine will be destroyed due to the formation of ammonia that increases the pH up to 9 and the urine can then be safely reused as a liquid fertilizer in agriculture.

In larger-scale systems where urine is collected from different users, the microbial risk is high. Recommended storage time - depending on the size of the system – would be between 1-6 months. If fecal cross-contamination is likely to occur, the storage time should be adjusted upwards. As a rule: The longer the storage, the better (RICHERT et al., 2010).

Urine should always be stored in sealed containers to prevent direct contact with humans as well as for animals. Urine should not be diluted while stored to provide a harsher environment for microorganisms and to increase the die-off rate of pathogens. The mode of collection, transport, and emptying of the urine may cause exposure to humans. Spill should be avoided while transporting urine to the field or transferring to a secondary storage container. Containers for transport should have a tight-fitting lid (RICHERT et al., 2010).

BARRIER III: Application Techniques

Urine should always be applied close to the ground. This reduces the possibility of direct contact with the edible parts of the plants. Urine should not be applied to the edible or foliar parts of vegetables. Urine should be incorporated into the soil either mechanically or by subsequent irrigation with water. If urine is applied before or during sowing/planting, a further die-off of potentially remaining pathogens will occur.

BARRIER IV: Crop Restriction

When treated urine is used, no particular crop restrictions need to be applied. However, as an additional safety feature and to increase local acceptance, urine use may be restricted to non-food crops (flowers), crops that are processed or cooked before consumption (e.g. eggplant), crops that need to be peeled before consumption (bananas) as well as crops or trees that allow for a minimum distance between soil and harvested part of the crop (all kinds of fruit trees). In addition, it is less risky if the time between application and harvest is kept longer. Thus, for crops with short rotation times (e.g. petchay, spinach, salad crops), the risk is higher, hence the pretreatment should be made better. However, the risk from urine can be non-existent for crops (e.g. pineapples) with longer rotation times (1-2 years).

BARRIER V: Withholding Period

A withholding or waiting period between the last urine application and the harvest is an additional barrier that provides time for pathogen die-off. The longer the time between last fertilization and harvest, the better. However, a minimum waiting period of 1 month should always be observed. Vegetables with a relatively short rotation period like lettuce or petchay (around 3-4 weeks after transplanting) should only be fertilized with urine once during transplanting to allow for the necessary withholding period.

BARRIER VI: Protective Equipment

Although there is no higher risk associated with treated urine, it is recommended that agricultural fieldworkers wear appropriate protective clothing like shoes and gloves as an additional effective barrier to reduce potential health risks.

BARRIER VII: Handwashing with Soap after Urine Handling

Handwashing with soap after urine handling is an additional barrier in the system. Basic hygiene practices like handwashing after toilet use and prior to meals should always be observed.

BARRIER VIII: Food Handling and Cooking

Harvested crops should always be washed before consumption. Cooking or peeling of fruits/vegetables is another effective measure to considerably reduce the associated health risks.

BARRIER IX: Health and Hygiene Promotion

Local growers and food handlers (in markets, restaurants, home and food kiosks) should be taught on the proper way of washing and why they should wash agricultural produce fertilized with urine.

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Useful Links, Further Information and Contacts

Further Reading Materials

- DOH 2010: Philippine Sustainable Sanitation Sector Roadmap, Department of Health, Manila, Philippines
- GENSCH, R., MISO, A., ITCHON, G., SAYRE, E. (2010): Low-Cost Sustainable Sanitation Solutions for Mindanao and the Philippines – A Practical Construction Field Guide. Xavier University Press, Cagayan de Oro, Philippines
- PUVEP (2008): Philippine Allotment Garden Manual with an Introduction to Ecological Sanitation. Periurban Vegetable Project, Xavier University Research and Social Outreach, Cagayan de Oro, Philippines
- RICHERT, A., GENSCH, R., JOENSSON, H., STENSTROEM, T., DAGERSKOG, L. (2010): Practical Guidance on the Use of Urine in Crop Production: EcoSanRes Programme Stockholm Environment Institute Kräftriket 2B, Stockholm, Sweden
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- WSP-EAP (2008): Economic Impacts of Sanitation in the Philippines, Water and Sanitation Program – East Asia and Pacific, World Bank & USAID, Manila, Philippines

Online Discussion Groups

- Ecosan-Philippine: http://tech.groups.yahoo.com/group/ecosan-philippines
- EcoSanRes (globally): http://tech.groups.yahoo.com/group/ecosanres

Websites

- XU SUSAN Center: http://susancenter.xu.edu.ph
- Philippine Ecosan Network (PEN): www.ecosan.ph
- Center for Advanced Philippine Studies (CAPS): www.caps.ph
- WAND Foundation: www.wandphilsorg.com
- Periurban Vegetable Project: http://puvep.xu.edu.ph
- Sustainable Sanitation Alliance (SuSanA): www.susana.org
- EcoSanRes Program of Stockholm Environment Institute (SEI): www.ecosanres.org
- Ecosan Program of German Technical Cooperation (GTZ): www.gtz.de/ecosan
- Sustainable Sanitation and Water Management (SSWM) Toolbox: www.sswm.info

Resource Organizations in the Philippines

- **Sustainable Sanitation Center (XU SUSAN Center)**
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- **Center for Advanced Philippine Studies (CAPS)**
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  phone: +63-2-4339042
  website: www.caps.ph
  contact persons: Dan Lapid, Dr. Lilia Casanova, Leo de Castro

- **Water, Agroforestry, Nutrient and Development Foundation (WAND)**
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  website: www.wandphilsorg.com
  contact person: Elmer Sayre: empower_8@yahoo.com

The reuse-oriented sustainable sanitation approach and the consideration of urine and feces as valuable resources that can be productively used as fertilizers and soil conditioners in agriculture, are slowly gaining popularity in the Philippines. Several good practice examples from all over the Philippines show that human waste can be turned into effective community assets. Particularly the easy-to-treat and nutrient-rich human urine has a high potential to provide a permanent liquid fertilizer source that is freely and immediately available. It can help reduce the dependence on expensive synthetic fertilizer resources and can have a considerable impact on the mitigation of poverty, malnutrition and food insecurity.

This field guide has been developed to accommodate the ever-increasing demand for more detailed and scientifically backed information on how to use urine in agricultural production. It is intended primarily for practitioners and experts in the water, sanitation, planning, and agriculture sectors, as well as local and national government officials from the various sectors, NGO and individuals interested and working in the field of agriculture and sustainable sanitation in the Philippines and the wider Southeast Asian region.

The manual has been produced as a collaborative effort of the Sustainable Sanitation Center, the Philippine Sustainable Sanitation Knowledge Node, the Philippine Ecosan Network, and the Sustainable Sanitation Alliance (SuSanA) working group on food security and productive sanitation.

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