Title	**Human Urine Harvesting in the Municipality of Tepoztlán, Morelos**
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Photograph attached (jpg)	

Human Urine Harvesting in the Municipality of Tepoztlán, Morelos

A. BACKGROUND

The **TepozEco Municipal Ecosan Pilot Project** was established in 2003, with core funding from the Stockholm Environment Institute (SEI/EcoSanRes). Sarar Transformación SC, an NGO based in Tepoztlán, is responsible for managing the integrated district program, which targets an overall population of more than 35,000 and includes ecological toilet promotion, water supply and greywater management, organic residue recycling for urban agriculture, and environmental education.

During the first year, TepozEco, together with a local farmers group, began field tests of urine use on different crops and inaugurated a Municipal Composting Center. By demonstrating the virtues of urine as an agricultural fertilizer (i.e. on prickly pear cactus, corn, and avocadoes), TepozEco has begun to demystify its use and generate demand by local farmers. To meet this increased demand it would be necessary to develop a sustainable system of urine collection, transportation and storage.

The **urine harvesting (UH) subproject** began formally on February of 2004, with financial support from the Swiss National Institute Center of Competence in Research – North/South (NCCR-NS / PAMS), and technical backstopping from SANDEC/EAWAG. The main objective, therefore, became to introduce a urine collection and reuse system in an urban context, as a strategy to recover and recycle valuable nutrients and thus stimulate local agriculture production and self-reliance. Decreasing soil fertility, escalating prices of fertilizers and consequently increasing food insecurity characterize current agricultural practices. Farmers, often painfully aware of the lack of sustainability of conventional approaches, lack clear, affordable alternatives.

GENERAL OBJECTIVE: To introduce a urine harvesting and reuse system in the urban context of Tepoztlán, Mexico, as a strategy for recovering and recycling valuable nutrients to stimulate local agricultural production and self-reliance.

B. ACHIEVEMENTS

Urine collection at major public events

The initial idea for ***public urine collection*** was focused on taking advantage of the many festivals and festivities that are a part of the cultural life in Tepoztlán. One of the main events, which attracts thousands of visitors during a 5-day weekend, is Carnival. Early 2004, at the request of the local government, TepozEco prepared a proposal for two 8-urinal waterless modules, including the removable structure design; O&M guidelines; logistics for storage, transport, and application of urine, as well as the costs involved. It was estimated that as much as 4500 liters of urine could be collected during carnival week. Although the TepozEco proposal was not accepted (the local government opted for portable chemical toilets offered free-of–charge by a state agency), the initiative and urinal design provided the foundation for the modules that were later developed.

For example, also during Carnival 2004, the team designed and installed a prototype collection system consisting of three permanent urinals and an 1100-liter storage tank in a busy private parking lot. After the event, the large tank was replaced by the 20-liter containers, which are now currently in use and the collected urine is applied to the lot's green areas. This positive experience led to a thorough survey of all parking lots and feasibility visits to those expressing interest in adopting waterless urinals as an additional service to their clients. Although very encouraged by the results, the project team has concluded that

before installation a reliable transport system must be in place. This system still needs to be created (see below).

In March 2004, TepozEco was presented with a second significant public UH opportunity, an internationally promoted open-air Opera-Concert, organized by a partner civil association Tepoztlán Valle Sagrado, with a projected attendance of 2000 people. Since the site for the concert had no existing service infrastructure, the association had initiated the construction of water-based sanitary facilities –in a severely water stressed area. In order to conserve valuable water, to be trucked to the site, and alleviate some of the ground pollution that would be generated (a below-standard septic tank had been built), TepozEco was invited to readapting the planned system by adding eight waterless urinals (four for men, and four for women) to the facility, with gravity fed drainage into a buried 1100-liter storage tank. To assure adequate use of the system, TepozEco recruited and trained a group of local students to provide user orientation and maintenance during the event. An information booth and posters helped explain the beneficial uses of urine in agriculture. TepozEco's intervention in this event was unprecedented since there had not been previous experiences with waterless urinals for women in Mexico, particularly for such a large, unfamiliarized public audience. Although turnout for the event was somewhat lower than expected, 400 liters of urine were collected and later applied at the Municipal Composting Center.

Development of a portable collection module

The first portable module tested at a local festivity consisted of two male urinals for men inside a simple bamboo structure. As there are no public restrooms in the community of San Juan Tlacotenco and the annual "fiesta" draws hundreds of visitors from neighboring communities, the initiative was welcomed by the auxiliary mayor and attended by members of the local environmental youth group. Beyond the 60 liters of urine that were collected, the real success of this experience, however, was to confirm that there was public acceptance of the portable waterless urinal.

Encouraged by the positive response in San Juan, the team decided to design and construct a portable module with two male urinals mounted on a lightweight wooden platform with two 50-liter collection containers. A calendar of local festivals was drafted and the team established guidelines for transport, mounting, maintenance, and demounting of the portable module.

In all, the module, along with a booth providing information about the project, was installed in five festivities and one private event with excellent response. A total of 480 liters of urine were collected, then stored at the TepozEco Demonstration Center and subsequently applied at the Municipal Composting Center. Besides the urine collected, the portable module allowed for more contact with the local community and provided an opportunity to raise awareness regarding water-saving devices and closed loop systems in general. It is important to note that once the *mayordomos* (deacons) from other neighborhood churches saw the module in operation, they would request its installation at the time of their own festivity.

Given the overall positive experience from the portable waterless urinals and following an internal evaluation by the TepozEco team of the pros and cons regarding installation logistics, it was decided that a unit for commercial purposes should be viable. The public urine collection activity could thus be oriented towards a micro-enterprise that would rent these units. A more durable, lighter and more manageable single-urinal prototype unit for men was designed, constructed and tested during the February 2005 Carnival, just one year after the initial attempt. As a result of the success of the trial, the Project has constructed 10 additional portable public urinals (including 2 for women). In addition to leasing to parking lots, community churches and other public spaces, it is anticipated that businesses that rent

chairs and tables for private events will be interested in purchasing these structures. The project is presently investigating possible micro-credit arrangements that can facilitate their acquisition.

Urine harvesting in schools

The team has focused on two primary schools that already have a urine-diverting dry toilet. One of them was visited by request of the principal and a set of recommendations to rehabilitate the dry toilet was drafted –as well as a plan for converting the current water-based urinals in the boy's bathroom to waterless ones.
In addition, the principals from two kindergartens requested TepozEco collaboration. In each school two waterless urinals for boys were installed, and also in one a urine-diverting seat for girls' use. The urine is applied on site. TepozEco facilitated workshops on organoponics, with an attendance of 30 children.

Additional achievements

- Urine application on the major soccer field to demonstrate the beneficial uses of urine, and installation of a urinal on the facilities to capture a potential public of 1000 people.
- Urine collection in a private business that employs 15 women. The dry toilet was converted to a de-facto women's urinal by installing a default UD seat. Urine is collected in a 250-liter tank.
- Workshops on urine application in backyard gardens. Three workshops were facilitated with an attendance of 40 people.
- Product design work with Gerali, a waterless urinal manufacturer and distributor, to upgrade their product with an innovative South African odor trap technology and to develop a waterless urinal for women.
- Negotiate ion with the inventor of a low-cost (<US$10) domestic waterless unisex urinal to reproduce (through a local micro-enterprise) and promote this water saving alternative, as a key element in a transitional ecosan retrofitting strategy.
- Several of the project staff have developed their own domestic systems for collection, storage and application of urine.

C. LOGISTICAL CONSIDERATIONS [i]

Unlike in Sweden, where urine collection systems have been high-tech using large tank trucks, the focus in Tepoztlán has been on the use of smaller mobile systems with components that are readily available on the local market.

Collection: Containers for both collecting and transporting the urine have included the ubiquitous plastic 20 ltr container, which can be fairly easily managed by on person, 50 ltr containers with handles on both sides that 2 men can mange between them, as well as 100, 200, 500 and up to 1000 ltr tanks. As the larger storage tanks cannot be manually moved when full, they must be filled from the 20, or 50 ltr containers, one at a time.

Transportation: The stored urine is then transferred to a 1100-ltr container mounted onto a pickup or larger truck -- preferably of at least 1-ton capacity – using an electric or diesel pump such as those used for septic tank maintenance, since they are non-corrodible and designed to permit passage of solid or semi-solids. The full containers are then transported to the fields for storage in 1,100 – 2,200 containers or applied directly by hose deep into the compost piles.

The future challenge when there are a greater number of collection points will be to establish a monitoring system and collection route which will maximize efficiency and minimize costs.

Since there is already a extensive system for tank truck potable water distribution from the local wells we consider that urine could be collected and transported in a very similar manner – the primary difference being that the potable water goes from one collection point (the municipal well) to multiple delivery points, whereas the urine would be probably collected from a number of sources (public and institutional toilets and multiple household storage tanks) to a limited number of delivery points. This idea is perhaps less strange when one considers that at the present time the downtown sewage is presently transported by tank-truck from collection tank to be emptied at the city dump,

Storage: As mentioned above, source-separated urine is collected and stored in plastic containers ranging from 20 – 1000 ltr, depending primarily upon how many toilets or urinals are located within the "urine catchment basin". Users are encouraged to keep the containers capped with an airtight lid in order to minimize ammonium losses. The 1,100 ltr containers are optimum size for storage centers.
If urine is to be fermented[1] for use in *orinoponics* (organoponics), the container must be kept at least partially uncapped in order not to inhibit the aerobic formation and cultivation of the beneficial actinomycetes, to. Nevertheless, it is important to note that the fermentation process should not extend beyond one month, as the beneficial actinomycetes, which help to accelerate the decomposition of cellulose, hemicelluloses and lignin in leaf mold and compost, will begin to be replaced by other organisms as the limited Carbon in urine has been consumed.

Sediments: Some of the nutrients contained in urine – e.g. complex inorganic phosphorous based compounds such $MgPO_4$, $MgHPO_4$, NH_4HPO_4, $NaHPO_4$ [ii]. -- tend to precipitate and accumulate at the bottom of the containers (and in pipes and hoses if they are not installed and maintained properly). When emptying the containers, it is therefore convenient to stir and/or dilute the contents at the bottom. Another possible option might be to store the urine with the greatest quantities of sediments in separate containers of be applied to crops that have a high phosphorous demand, such as cucurbitaceous (broccolis, cabbage, etc.)

Application techniques: As with any fertilizer, it is essential to apply the urine uniformly and in adequate quantities. At his stage in the Project, where volume and fertilized surfaces are relatively limited limited, application techniques have been kept simple, involving manual watering cans and/or buckets, or hoses connected to elevated tanks. The concentrated or diluted urine, as the case may be is applied to an open furrow or shallow hole and then the fresh earth is quickly covered over with a hoe. Commercial fertilizer applicators, involving a hose and tube applicator attached to a small tank carried on shoulder straps, have also been used with some success. Future trials will involve small tanks on wheeled carts or trailers.

Conclusions on collection, transport, storage and application

- The technology components for collection transport and storage of human urine is readily available on the local Mexican market. The 20 liter plastic containers are the most practical for the domestic dry toilets, as they are relatively easy to handle for application on household horticultural or ornamental gardens.
- Nitrogen loss can be minimal if the urine is stored in airtight containers.
- The warm local climate and high pH assure complete pathogen destruction in the urine and thus minimal health risks. One month storage time prior to application is adequate for complete sterilization. As a further security measure, we recommend harvesting food crops at least a month after the last urine application.

[1] Urine is fermented by "inoculating" with 1 soupspoon of rich soil &/or compost per liter of urine and left uncovered for a month. Arroyo Francisco, "Manual de Organoponia" *(Organoponic Manual)*. CEDICAR-ANADEGES, México, 2000.

- For maximum efficiency, the fertilizer should be applied at planting time or at the beginning of the summer when crops are growing -- preferably late on cloudy or rainy days, particularly where irrigation is not an option.
- It is advisable to stir the urine prior to application in order to dilute and distribute the precipitates. The dilution will be further enhanced by adding water to the urine 1:10.
- Although urine has a notable odor when it is being applied, this will disappear within 24 hours and is hardly noticeable at a relatively short distance from the field. If the urine is covered with earth or water immediately after application, the odor will disappear within 30 minutes or less.

D. LEGAL AND REGULATORY ASPECTS[iii]

Whereas there are various laws and regulations (e.g. health, public services, water and agriculture) that might involve aspects of collection, transportation, treatment and/or reuse of human urine –and feaces-- at the moment, there appear to be no direct, overriding prohibition of such activities. (In fact, licensed certifiers for "organic" agricultural produce seem to have had no specific objections when hearing about the TepozEco UH experience.) We are therefore considering strategies for inclusion of UH within existing legal and regulatory frameworks so as to permit as well as encourage activities that would close the nutrient loop while maintaining acceptable standards with regard to environmental and health risks. For example:

- At **federal** level, UH –and ecosan—strategies could be specifically mentioned in the evolving National Waters Law, as ways to prevent the contamination of surface and ground water.
- The Morelos **State** Health Law could (and should) establish specific ways to regulate the sanitary measures for handling, storing and utilizing urine and feaces.
- Revision of **municipal** regulations to establish clear guidelines for domestic and public urine --and feaces-- harvesting should go hand in hand with the establishment of appropriate institutional framework to provide the necessary support services and monitoring of the system.

C. LESSONS LEARNED

The activities carried out through this UH subproject allowed us to:

- increase public awareness of water-saving devices and strategies;
- demystify urine by increasing its acceptance as a viable fertilizer;
- conserve significant amounts of water;
- gain important experience in systems for closing the loop at domestic, neighborhood and municipal levels; and
- obtain more knowledge and insight on the potentials and constraints of urban/periurban UH and application in urban agriculture (see Appendix[iv])

Among the most important conclusion we can draw from the urine-harvesting subproject in Tepoztlán are:

1. Household collection of urine is not logistically or financially viable at the present time in small towns of 20-50 thousand, where large communal housing developments are still uncommon. Therefore, for urban ecosan programs, it will be important to stress a household-centered strategy that will encourage closing the "urine loop" at domestic level through backyard fertilization, organoponic gardens, and composting.
2. Public collection of urine could provide a significant source of nutrients for urban agriculture. Whereas schools offer an excellent opportunity for UH, public toilets at markets, government buildings, restaurants, hotels, bas and gasoline stations, etc. also have a tremendous potential.
3. If we focus only on public collection, the total potential amount of urine in the municipality

would not be sufficient, if used alone, to substitute all commercial fertilizers given present agricultural practices. Therefore the urine collection effort must be geared towards goals other than just closing the loop (such as water conservation, and the provision of low-cost sustainable public toilets) and that application of urine must include promotion of sustainable, organic agricultural practices (use of manure, compost, etc).

Finally, although it is clear that public UH is culturally acceptable, logistically feasible with relatively small investment, and environmentally and socially beneficial, particularly in terms of the potential to gradually substitute or, perhaps more realistically, complement other fertilizers, the long term drivers of such an initiative have not been clearly established and realized. Certainly the costs of the system might be shared by the users of the public toilet facilities, at one end, and the farmers who could be expected to pay a reasonable price for the fertilizer, at the other.

The municipal government also should have a key role to play, not only to establish the appropriate incentives and guidelines to encourage environmentally friendly and water saving sanitation systems, but also as a provider public toilet and municipal collection services. Unfortunately, it now seems increasingly apparent that the local government has limited capacity to follow through effectively on anything other than business as usual.

In fact, these lessons go much beyond the UH project itself and involve another major thrust of the TepozEco project that involves an Interinstitutional review of existing regulations and the eventual possibility of establishing a para-municipal institution that would facilitate sustainable municipal services, including water supply, solid waste, sanitation –and, of course, urine harvesting.

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[i] Arroyo F. w/ Bulnes M. “Lo que sabemos de orina humana como fertilizante” *(What we know about human urine as a fertilizar).* TepozEco Project / Sarar Transformación SC, Tepoztlán, México. 2005.

[ii] Ronteltap M., et.al. “Thermodynamics of struvite precipitation in source separated urine”, en ““2nd international symposium on Ecological Sanitation”, GTZ/IWA, Alemania, 2003.

[iii] Ramos Bustillos LE., Cordova A., Sawyer R “Legal constraints and possibilities for ecological sanitation in Mexico: Constructing a regulation for the Municipality of Tepoztlán”, Sarar Transformación SC, for VERNA Ekologi AB / EcoSanRes, Sweden, Nov. 2003