ApaSan Proiectul Elveţiei de Apă şi Sanitaţie în Moldova

Guideline for Use of Products from Institutional Ecosan Toilets for Crop Cultivation in Moldova

Provisional guideline

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Introduction

The Swiss Water and Sanitation Project in Moldova, ApaSan, has supported a range of schools and households in rural areas of Moldova with the construction of ecosan toilets. Ecosan toilets offer a hygienic and comfortable sanitation solution, while transforming urine and faeces into products that can be safely used for fertilizing crops or decorative plants.

The present guideline has been produced for school administrations and local communities who are directly involved in the management of ecosan toilets and the products from the toilets. The guideline provides practical advice on how to use the products from ecosan toilets as fertilizer and gives recommendations on how to exclude any health risks from this practice.

The guideline is mainly aiming at use of products from school ecosan toilets; however the recommendations can also be used for using products from household toilets.

The present guideline is a practical guideline, not a scientific document. However the recommendations are all based on scientific experience, both on extensive international experience, as well as on results of research conducted in Moldova by partners of ApaSan (WISDOM, ECOTOX/Academy of Science, AGROinform). The scientific documents that justify the recommendations are listed in the reference chapter.

The present guideline is provisional. It will be updated based on results from ongoing research and practical experience gained by partners of ApaSan. The guideline will also be continuously discussed and improved in cooperation with relevant national authorities.

Suggestions on improvements of this guideline are welcome! Please send your comments to info@apasan.md

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Part I: Short guideline

1 Guidelines for school administration

The school administration is the owner of the ecosan toilet and is therefore responsible for removing the products from the ecosan toilets and organise their use as fertilizers.

Organise removal and safe use or disposal of products from ecosan toilets:

- Regularly (monthly), check the level of filling of faeces collection chamber and urine collection tanks. Based on the observations, estimate the time when the second faeces chamber or urine tanks will be full and the first one needs to be emptied
- At least half a year before the second urine tank will be full, identify one or several farmers in the village to use the urine as fertilizer.
- Discuss and agree with the farmer on the modalities of emptying the urine tanks and using the urine. It is recommended to allow the farmer to use the urine for free and the farmer in turn covers all costs for emptying and transport.
- Seek to establish a long term agreement with the farmer, which foresees that the urine is emptied and used every year.
- As an alternative to the use of urine in agriculture by local farmers, urine can also be used in school gardens or for fertilization trees and flowers in school or municipal parks.
- At least half a year before the second faeces chambers will be full, discuss and decide on the way of use or disposal of the compost. This can be done by the same farmer that takes care of the urine or by the caretaker of the school (the amount compost is very small)

Guarantee safety:

- Educate children and teachers who use the ecosan toilets that no faeces should fall in the urine collection compartment in the toilet pan. Make sure that toilets are cleaned frequently.
- Store urine in the collection tank for at least 6 months after the tank is full and sealed. Store faecal material in collected chamber for at least 1 year after the chamber is full and sealed. Never handle fresh urine or fresh faecal matter.
- Instruct the farmers and care takers on necessary safety measures to avoid risks to public health during urine and faeces handling as well as in use for crop cultivation.
- Supervise the process of emptying of urine tanks and faces collection chambers, as well as the application of fertilizer. Make sure that all necessary safety measures are employed.

2 Guidelines for farmers on how to safely use urine for crop cultivation

Bring urine from the toilets to the fields:

- Pump the urine from the storage tanks to a mobile container (large containers mounted on a track or cart, or smaller containers that can be hand carried). As pumps, simple vacuum pumps like installed in many tractors can be used.
- Apply urine to the field. Fertilizing before planting of field crops, a uniform distribution on the field is best done by a distribution device connected to the valve of the container. Fertilizing of vegetables or flowers during the growth period is best done manually by a hose or watering can directly to the soil near the plants.

- Dilution of urine not recommended for large urine quantities, because it increases the volume that needs to be handled. For small quantities of urine, dilution is not necessary but may be done if desired.

Make sure that use of urine fertilizer is safe:

- Only handle urine that has been stored in a closed container for at least 6 months. Never handle fresh urine.
- Use protective clothing (gloves, boots, clothes) when handling urine. Avoid spilling and spraying of urine during handling
- For crops to be eaten raw, apply urine close to ground, avoid application on edible parts of the plants and stop fertilizing 4 weeks before harvest; no such precaution measures are required for crops that are processed before consumption, or for flowers and trees.

How much and when apply urine on the fields: see tables

3 Guidelines for farmers and care takers on how to safely use or dispose off compost

Removal and handling of compost from faecal matter

- Keep faeces inside the toilet collection chamber as long as possible and only remove them from the toilet shortly before the second collection chamber is full.
- Remove compost from faecal matter manually with shovels and rakes. Compost can be transported by hand carts, buckets or bags. Avoid direct contact with the material, use protective clothing, and clean tools carefully after completing the work.

Option 1: Storage/composting of faecal matter outside the toilets and use in cultivation

- Place compost from faecal matter on a heap outside of the reach of people. Optionally the compost from faeces can be mixed with plant material for further composting. The heap should be covered by a soil layer of at least 20 cm. Store the compost on that heap long enough to make sure that the total storage time is at least 2 years, including the previous storage time inside the toilet chamber.
- After the 2 years storage, the compost can be used as fertilizer and soil improvement material by applying the faeces in a similar way as normal compost. As additional precaution, the compost should be covered by a layer of soil and not be used for plants where edible parts come in contact with soil (e.g strawberries or cucumbers).

Option 2: Burying of faeces

- In a location not frequented by people, dig a hole deep enough for the entire amount of compost from faecal matter from the toilet and cover the hole with a soil later of at least 30 cm.

  Optionally, a tree or a bush can be planted on top. The compost will be support the growth of the tree over several years.

4 Tables

Table 1: Minimum crop area that can be fertilized with a certain quantity of urine

Crop	10 L	20 L	50 L	1 m3	4,6 m3	8 m3
Maize, wheat	3 m2	7 m2	17 m2	330 m2	0,2 ha	0,3 ha
Potatoes	3 m2	6 m2	15 m2	300 m2	0,1 ha	0,2 ha
Tomatoes	2 m2	5 m2	12 m2	240 m2	0,1 ha	0,2 ha
Cucumber	6 m2	12 m2	30 m2	600 m2	0,3 ha	0,5 ha
Pepper	2 m2	4 m2	10 m2	200 m2	0,1 ha	0,2 ha
Grapes (yields < 10 t/ha)	15 m2	30 m2	75 m2	1500 m2	0,7 ha	1,2 ha
Grapes (high yields)	5 m2	10 m2	25 m2	500 m2	0,2 ha	0,4 ha

Table 2: Maximum amount of urine needed to fertilize a certain area of crop

Crop	m^3 urine / 1 ha	L urine / 1 m^2
Maize, wheat	30	3
Potatoes	33	3
Tomatoes	42	4
Cucumber	17	2
Pepper / Flowers	50	5
Grapes (yields < 10 t/ha)	7	1
Grapes (high yields)	20	2

Table 3: Time of application of urine fertilizer

In general, urine fertilizer should be applied at the same times as mineral nitrogen fertilizer. The table gives the amounts of the fertilizer dosage to be applied at different times in per cent of the entire dosage.

Crop	Application time
Maize, wheat	100% before planting
Potatoes	100% before planting
Tomatoes	20% before planting, 27 % 3 times during the growth period
Cucumber	Evenly split over the growth period, with doses every 2 weeks
Pepper	33 % before planting, 77 % split in 3-5 times until after the fruit set
Grapes (yields < 10 t/ha)	100% in late winter or in spring
Grapes (high yields)	100% in late winter or in spring

Table 4: Fertilizing of decorative plants

Crop	Amount of urine fertilizer and application time
Flowers	If no specific recommendations for the type of flower are available, do as for tomatoes
Trees	If no specific recommendations for the type of tree is available, do as for grapes (high yields)

5 Example

The ecosan toilet in school A was put in service in May 2009. It has 2 urine tanks of 4,6 m^3 each. The first urine tank was full in August 2010, the filling took a bit more than one school year.

The tank was then sealed and the valve switched to fill the second tank. Levels in the tank were then checked monthly. In December 2010 the second tank was 20% full, in January it was 30 % full and it was calculated that the second tank will be nearly full by the end of the school year in summer.

In spring 2011, the school administration with some support of ApaSan engineers, identified a farmer of the village who was interested in using the urine in autumn, on a field where he planned to seed winter wheat.

The school administrator and the farmer estimated the area of wheat that can be fertilized with the 4,6 m^3 of stored urine from table 1: 0,2 ha or 2000 m^2. Table 3 indicates that wheat should be fertilised once before seeding.

The farmer borrowed a cart with a 2 m^3 tank and a tractor from another farmer in the village, equipped with a vacuum pump valve connected to the exhaust pump. The farmer pumped the urine from the tanks, transported it in three runs to his field and distributed it evenly on 0,2 ha.

Part II: Detailed guideline and justifications

1 Role and tasks of the school administration

Responsibilities

The ecosan toilets in schools are owned and managed by the school.

Periodical removing the products from ecosan toilets, urine and compost from faecal matter, and taking care of their safe use in agriculture or their safe disposal is one of the most important maintenance tasks of ecosan toilets.

It is the responsibility of the school administration to make sure that the products of the ecosan toilets are removed and used or deposed off.

The task for removing the products and for using or disposing them may be delegated to a persons of the community, a farmer, or to a service provided. However, it is in the responsibility of the school administration to initiate the use or disposal of the products from ecosan toilets, to agree with farmers or service providers on modalities, and to supervise the activities to assure that no harm to the environment and public health is caused.

Tasks

The required actions to be taken by the school administration are described in the following:

Monitoring levels of filling in urine tank and faeces chamber

The level of filling of faeces collection chamber and urine collection tanks need to be regularly monitored (monthly), in order anticipate the moment when the second faeces chamber or urine tanks are full and need to be emptied, and to prepare for the necessary actions.

Organisation of urine emptying and use

At least half a year before the second urine tank will be full, one or several farmers in the village need to be identified for using the urine as fertilizer on their field.

The modalities of emptying the urine tanks and using the urine need to be discussed and agreed on with the famer. Different arrangements are possible, e.g. the farmers can use the urine for free and in turn cover all costs for emptying and transport. In some cases it may be necessary that the school administration pays a small amount to the farmers to cover his costs. However, costs involved will be small in most cases, as required equipment is usually easily obtainable in the villages or nearby.

It is recommended to establish a long term agreement with the farmer, which foresees that the urine is emptied and used every year. Emptying of the urine tank can then be timed according to the needs for crop cultivation, e.g. every spring, one urine container can be emptied.

The school administration needs to instruct the farmers on the safety measures described in this guideline and supervise their implementation.

Alternatively, the school can also organise the use of the products from the ecosan toilets in the school garden or for fertilizing trees and flowers in the school or municipal parks.

Organisation of faeces emptying and use

At least half a year before the second faeces chambers will be full, the school administration needs to decide on the way of use or disposal of the faecal matter.

The removal and use or disposal of the compost from faecal matter can be done by a farmer of the community as part of the agreement for removing and using urine.

As the amounts of compost are rather small compared to urine, it is also possible the care-taker of the school does the necessary steps himself.

As for urine use, the school administration needs to instruct the farmers or the care taker of the school on the safety measures described in this guideline and supervise their implementation.

2 Legal aspects of the use of urine and faecal matter for crop cultivation

Use of urine and dried faeces as fertilizer is allowed in Moldova, as there is no legal provision prohibiting such use [8].

Products from ecosan school toilets or household toilets are being used for free within the community, commercial selling of products is not practiced. An official registration according to the law on the use of plant protection and fertilizing products is therefore not required.

3 Use of urine fertilizer

Nutrient content of urine

Urine is made up of more than 95 per cent water, with the remaining constituents made up of inorganic and organic compounds or salts (nutrients). Urine contains significant quantities of the main macro nutrients required by plants; nitrogen, phosphorus and potassium.

Nitrogen occurs in high concentration (mostly as urea), whereas phosphates and potassium occur in comparatively lower concentrations, in dissolved plant available forms. Therefore the amount of urine used for crop fertilizing is usually calculated based on its nitrogen content.

The nitrogen concentration of urine depends of on the amount of liquid a person drinks and transpires per day. Urine collected from ecosan toilets may also be diluted by water from flushing or cleaning the facilities or rainwater infiltrating the tanks, nitrogen concentrations will be lower in such cases. Nutrient concentrations of urine are also influenced by storage, some sediment containing a large amount of nutrients accumulates on the bottom, and some nitrogen will be lost as gaseous forms during storage.

Data collected from different countries worldwide suggest that 3-7 g of nitrogen (N) per litre of urine can be expected [2,3].

Analysis of urine from ecosan school toilets in Moldova conducted by ECOTOX (Laboratorului de Hidrobiologie şi Ecotoxicologie al Institutului de Zoologie of the Academy of Science) indicated that the nitrogen concentrations varies from 4 to 12 g/L [5,6], while analysis conducted by AGROinform (Laboratorului de Incercari “Agrochim” al Centrului Republican de Pedologie Aplicada) indicated an average nitrogen concentration of 2 g / L [7]. The average of all known samples from ecosan school toilets in Moldova is of 6 g N/L.

Considering the observed variability of nitrogen concentration in urine, ideally the nitrogen content should be tested prior to agricultural use in order to determine the ideal application rates. However due to costs and complexity of urine analysis, this will usually be not possible in practice. Therefore it is recommended to use the average figure of 6 g nitrogen per litre of urine for calculating fertilizer application rates.

Nutrient requirements of plants

Plants require light, water, a structure for roots to grow in and nutrients for growth. In general, supplying nutrients by fertilizing will increase plant yield. However, if factors other than nutrients are limiting, e.g. water, light, pH, salinity, light or temperature, then adding more nutrients will not increase the yield.

The amount of nutrients required to fertilize crops depends on the crop and the nutrient reservoir in soils. Ideally, the nutrient reservoir in soil is analysed to calculate the required amounts of fertilizers. However in the case of urine use from ecosan school toilets, soil analysis will normally not be feasible as it is too expensive to be justified for the small scale usage. Fertilizer dosing has therefore be based on average values of nutrient requirements of crops.

The following table gives recommendation for nitrogen fertilization for the crops most commonly cultivated in Molodva, as well as the recommended application times. The data is taken from BASF World Fertilizer Use Manual [9].

Table 5: Recommendation for nitrogen fertilization for common crops in Molodva

Crop	Maximum Crop Requirements [kg N / ha]	Application time
Maize, wheat	180	1 time before planting
Potatoes	200	1 time before planting
Tomatoes	250	50 kg before planting, 3 times 66 kg during the growth period
Cucumber	100	Split, every 2 weeks
Pepper	300	100 kg before planing, 200 kg split in 3-5 times until after the fruit set
Grapes	40 (for yields of less than 10 t/ha) 120 (for higher yields)	1 time in late winter or in spring

Studies on urine use in agriculture in Moldova recommended the following Nitrogen dosages, which are in similar range as the above listed values:

- 100 to 170 kg N/ha for wheat and sunflowers, ECOTOX [5,6]
- 180 kg N/ha for wheat, AGROinform [7].

Rate of urine application on fields

Table 6: Maximum urine application rates per crops, based on fertilizer recommendations from the world fertilizer manual and average nitrogen content of urine measured in Moldovan school toilets

Crop	Max. crop requirements	Average nitrogen concentration in urine	Urine application rate per crop cycle	
	kg N / ha	g N/ L	m^3/ha	L/m^2
Maize, wheat	180	6	30	3
Potatoes	200	6	33	3
Tomatoes	250	6	42	4
Cucumber	100	6	17	2
Pepper	300	6	50	5
Grapes (yields < 10 t/ha)	40	6	7	1
Grapes (high yields)	120	6	20	2

The rate of the urine to be applied on fields is calculated based on the nitrogen concentration of the urine and the nitrogen requirements of the plants:

$$Application\ rate\left[L/m^2\right] = \frac{plant\ nitrogen\ requirements\left[kg/ha\right]}{nitrogen\ concentration\ in\ urine\ \left[g/L\right]\cdot 10}$$

Table 6 summarizes the maximum urine application rates in absence of measured values of urine concentration and nutrients in soils.

Note that the application rates refer to the total rate per crop cycle. If several applications per crop cycle are recommended, the application rate has to be split respectively.

Dilution of urine

Urine can be applied without dilution or diluted with water. Dilution implies increasing the volume to be spread and thus the labour, equipment needed and energy use are all increased [2,3].

The advantage of dilution is that it decreases the risk of -applying too much urine to such an extent that harms the plant crops. Dilution with water also reduces smell to some extend as urine is infiltrated faster into the subsoil.

It should be noted, however, that urine has very similar characteristics as mineral fertilizer, and is in no way more toxic to plants or soil than commonly used mineral fertilizer. If undiluted urine fertilizer is applied according to recommended rates, there is not risk of harm to plants.

For large volumes of urine such as from urine tanks in school toilets, dilution is not recommended because dilution makes the use more expensive.

For smaller urine quantities such as from household toilets, urine may be diluted if desired.

How to get urine fertilizer from the toilets to the fields and how to apply it on fields

Urine collected from school toilets is usually stored in large underground tanks. Urine needs to be pumped into a transport container, which is usually a container mounted on a truck or on a cart that can be pulled by a tractor or horse. Best suitable for urine transport and later application is equipment such as used for the transport and application of farm slurry (animal manure).

Pumping can be done either by vacuum pumps connected to the exhaust pipes of tractors, vacuum pumps mounted on the container, or by separate mobile equipment.

Care should be taken that not only the liquid in the storage container is removed but also the nutrient rich sediment on the bottom, stirring before pumping may be helpful.

If large truck or chart mounted containers are not available, the urine can also be filled into smaller containers that are hand carried or transported on hand-pushed carts.

Urine is either applied on fields prior to crop planting or at crops during the growth period.

Application to fields prior to crop planting can be done efficiently directly from the cart mounted container. Urine is then distributed as uniform as possible and according to the calculated application rate. This is best done by installing a pipe with regular openings at the valve of the container.

Figure 1: Top: pumping stored urine from school toilet to mobile tank. Middle: vacuum pump connected to tractor exhaust pipe. Bottom: using improvised device to distribute urine fertilizer uniformly to field prior to seeding winter wheat.

Application to crops during the growth period needs to be done close to the soil, near plants and avoiding spreading urine on the plant itself. This is best done manually with a hose connected to the container or with a watering can.

If large urine quantities are available, it is most efficient to use urine for crops such as maize or potatoes, where urine can be applied in one single dosing prior to planting. Urine application can then be done entirely with mechanised equipment.

For smaller urine quantities, application may more easily be done manually. In this case urine can also be applied to vegetables requiring several doses throughout the growth period.

If urine is to be used in school gardens or for fertilizing trees or flowers in parks, urine can be taken from the storage tanks in several batches throughout the growth period.

Health considerations and risk management

Urine is essentially sterile when it leaves the body and does not contain any disease causing germs (bacteria, viruses, protozoa, worm eggs). However, some cross-contamination with faecal matter containing germs may occur in the toilets. Potentially a certain health risk from handling and using urine in agriculture therefore exists. This risk can be minimized by various safety measures.

The following safety measures help minimizing health risks from urine use [1,2,3,4]:

Urine separation: urine itself is usually sterile; the main risk results from cross-contamination by faecal matter in the toilets. Minimizing contamination of urine by faecal matter will greatly reduce the content of germs in urine. Cross-contamination mainly happens when faecal matter enters the part of the toilet pan where urine is collected. Good education of users on how to properly use the toilets, as well as frequent cleaning of toilets, are effective measures to reduce faecal cross-contamination

Urine storage: When disease causing germs leave the human body, they die after a certain time. Storing urine for prolonged period will provide for sufficient time for germs to completely die off. Stored urine develops high pH values which additionally helps killing germs. A 6 month period is generally recommended for urine from public facilities (in family toilets 1 month is sufficient) and will allow for complete die off of germs contained in urine. Analysis of stored urine from school toilets in Moldova has found that no disease causing germs are present [5,6,7].

Avoid handling of fresh urine: ecosan toilets have two parallel storage tanks. This allows for filling one tank first, and storing urine in the tank for at least 6 months after complete filling and sealing. The second unit can then be filled during the storage period in the first tank. This system makes sure that at no time fresh urine that potentially contains active germs needs to be handled.

Minimizing direct exposure of people to urine: Health risks from germs possibly contained in urine only occur when people get into direct contact with urine. Excluding direct contact of people with urine will therefore minimize the risk of infection. To exclude direct contact to urine at all steps of urine handling, as well during fertilizer application, protective clothing (gloves, boots, clothes) have always to be used and unnecessary spilling and spraying of urine during handling be avoided.

Minimize exposure of agricultural products to urine: In order to minimize the health risks of consumers of products fertilized with urine, application of urine on edible parts should be avoided and urine should be applied close to the ground, application of urine should also stop 4 weeks before harvest.

Crop restriction: industrial crops, crops that are processed before consumption (e.g. wheat, maize), flowers and trees do not cause any risk to consumers, the above described safety measures are therefore not required if such crops are fertilized with urine.

Multiple barriers: applying not only one but several of the above listed measures provides for additional safety.

4 Use or disposal of compost from faecal matter

Characteristics of compost from ecosan toilets

In ecosan toilets, faeces are collected together with a drying and disinfecting agent such as sawdust, ash, lime or soil and undergo a drying and to some extend a decomposition process. The product from this process is called compost.

While the total amount of nutrients excreted with faeces is lower than with urine, the concentration of nutrients, and especially phosphorous and potassium is high in faeces and, when used as a fertilizer, compost from faecal matter can give significant increases in plant yield. In addition, compost contains organic matter, which increases the water-holding and ion-buffering capacity of the soil, as well as soil structure.

Fresh faeces can contain high concentrations of pathogens such as bacteria viruses and worm eggs. Storage in the collection chamber will greatly reduce the pathogen content in compost. Pathogen die off is accelerated by hostile conditions in the collection chambers such as high temperatures, low moisture content and high pH from ash or lime. However, some pathogens, in particular worm eggs, are quite persistent and may remain infective for prolonged time. A storage time of at minimum 2 years is therefore required to assure complete pathogen die off and allow for safe use of compost [1,4].

Handling, reuse or disposal of compost from faecal matter

Collection chambers of ecosan toilets are designed for allowing storage of faeces for 1 year or more from the time the chamber is full and sealed, until emptying. This system allows to avoid handling fresh faeces, which are potentially infective. It is recommended to use the available storage capacity in the toilet collection chambers as long as possible and only remove compost from the chamber once the second parallel chamber is near to being full.

Compost has to be removed manually using shovels and rakes. Compost can be transported then by hand carts, buckets or bags. It is important to avoid direct contact with the compost, so using protective clothing is imperative. Tools used to move compost have to be cleaned carefully after completing the work.

For ecosan school toilets or ecosan household toilets, the following two options for use in cultivation or disposal of dried faeces are recommended:

<u>Option 1: Storage of compost and use in cultivation</u>

The compost from faecal matter has to be stored for at least 1 year inside the toilet chamber after the time of sealing the chamber.

After 1 year, the compost can be removed from the toilets and be placed on a heap outside of the reach of people, where is has to be stored 1 more year. Optionally the faeces can be mixed with plant material for composting. The heap should be covered by a thick (>20cm) soil layer.

If the compost can be stored for at least 2 years inside the toilet chamber, additional storage time outside the toilet is not required.

After the 2 years time of storage (2 years inside the toilet, or 1 year inside the toilet and 1 year outside on a heap) the compost can be used as fertilizer and soil improvement material by applying the faeces in a similar way as normal compost.

As additional precaution, the compost should be covered by a layer of soil and not be used for plants where edible parts come in contact with soil (e.g strawberries or cucumbers).

<u>Option 2: Burying of faeces</u>

After 1 year storage inside the toilet, compost can also be buried in a hole dug in a safe location not frequented by people. The hole should be deep enough to receive the entire amount of compost from the toilet plus a covering soil later of at least 30 cm.

A tree or a bush can be planted on top. The compost will improve the growth of the tree over many years.

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